Cleaner Production and Industrial Ecology;

Dynamic Aspects of the Introduction and Dissemination of New Concepts in Industrial Practice

Schonere Productie en Industriële Ecologie; dynamische aspecten in de introductie en de verspreiding van nieuwe concepten in de industriële praktijk

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Contents

Executive Summary

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Deed de schilder beseffen, dat het nooit af was

This thesis addresses the awareness-raising processes related to the development and dissemination of new concepts such as pollution prevention, cleaner production and industrial ecology. The concepts of *Cleaner production* and *Pollution prevention* can both be described as: `the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment'. *Industrial ecology* is described as: `an integrated system, in which the consumption of energy and materials is optimised and the effluents of one process serve as the raw material(s) or energy for another process'.

As a process of dissemination of new concepts, the cleaner production paradigm was introduced to industrial leaders as a prevention-oriented paradigm for achieving cleaner industry and more sustainable communities; this was viewed as an important way to supplant or supplement the old paradigm of pollution control. In the cleaner production paradigm, the conceptual approach was to catalyse the transition from *waste management policies and approaches at the end-of-the-pipe,* to *`environment included'* in *industrial innovation policies for waste prevention* and *waste minimisation* at the sources of the problems.

This thesis analyses and discusses the concepts of cleaner production and industrial ecology around the following central question: Which actors and factors – and under which conditions – have influenced the dissemination and implementation of these preventive environmental protection approaches in production and product development within and between companies? It also addresses the question of whether this is a practical paradigm shift in concept innovation and whether the implementation of the new concepts contributes more effectively to sustainability.

After the initially successful development and implementation of the pollution prevention-oriented approaches within American companies such as 3M and Dow in the 1970s, some companies in other countries also started to experiment with similar preventive initiatives during the 1980s and 1990s. The concepts and approaches of cleaner production were spread worldwide via personal presentations, conference presentations, special promotional efforts from organisations such as UNEP and UNIDO and through intermediary organisations such as the U.N. National Cleaner Production Centres during the 1990s and early 2000s. Key actors such as academics (in the case of cleaner production) and industrial engineers (in the case of industrial ecology) helped to disseminate and facilitate implementation of the concepts through presentations and demonstration projects. The concepts were presented as being attractive win-win approaches that would improve corporate profitability and at the same time reduce environmental impacts and risks.

As a result of the in-depth assessment performed during the research for this thesis, it became clear that the anticipated continuing use of the prevention approach has not occurred and corporate actors have usually reverted back to the old, pollution control mentality and routines. One of the reasons for this is that most promoters relied solely upon the so-called *single loop* learning approaches.

This thesis explores the dissemination of the concepts of cleaner production and industrial ecology in two ways. Firstly, the impacts of the dynamic evolution and introduction of concepts are evaluated, such as professionalisation and specialisation of cleaner production, eco-design, total cost/benefit accounting and industrial ecology. Secondly, the impacts of some of the competing concepts are addressed, such as the roles of responsible care, environmental management systems, eco-auditing, integral chain management, eco-efficiency, green productivity and eco-industrial parks. During this exploration the author sought an answer to the following question: In what way do these different approaches compete with or complement each other?

It was found that in the early stages of introduction of these concepts, most company leaders emphasised that because environmental issues are not their core business they were not very interested in these approaches. However, as increasing numbers of companies began to work with the integration of environmental aspects into company management, interest in these more preventive approaches also increased.

As a result of this growing openness, the traditional perception of companies as *black boxes, having their own responsibility* has changed towards a more open, *stakeholder approach.* In particular, since many of the multi-national corporations are becoming involved in *corporate social responsibility (CSR)* there is an increasing need for a stronger embedding of sustainable industrial production within society.

The development of the preventive approach in industrialised and industrialising countries has been taking place within dramatically different contexts. Presently, in many developing countries, industry faces *command and control* government policies. But the implementation of these policies is weakly enforced and a high degree of corruption exists that further weakens the environmental protection potential of government environmental regulatory processes. The introducers and disseminators of cleaner production concepts in these countries have learned that in order to be successful, they must be active in the development, dissemination and implementation of cleaner production policies too.

In the Netherlands and in some other Western European countries, the process of engaging industry with environmental protection mainly occurred through the establishment of emission standards, the granting of environmental permits and implementation of corporate environmental management systems. In some cases these were implemented either through government coercion or within voluntary agreements (covenants). In other situations they were implemented under the pressure of coercive and mimetic isomorphism.

In the case of the dissemination of cleaner production and industrial ecology, the findings relating to how industry translated these new environmental concepts were different. When the cleaner production concepts were introduced, society was not really ready for them. Although university researchers presented the cleaner production concept as a business-fit approach, industry perceived the concept as an environmentally-driven approach. The corporate employee(s) responsible for environmental issues fulfilled a liaising function in the cleaner production demonstration projects that were heavily based upon an engineering approach – with assessment loops based on environmental problems. That approach did fit into the institutional framework but did not adequately recognise and support the new innovative business economics approach of cleaner production.

The main conclusion of this thesis is that although cleaner production is defined in integrated terms, in practice the corporate integration of environmental aspects with quality, safety and energy is weak. It was found that the interpretation and implementation of cleaner production is fragmented into different practical paradigms (organisation, technology, policy) for which an integrating theoretical framework is missing: each of the paradigms themselves are limited and flawed. The application of the cleaner production concept was frequently restricted to a few good housekeeping practices and was not based on a new, more holistic and preventive corporate worldview.

It was also found that specific types of cleaner production professionals were trained in separate disciplines, for example: technologists working with cleaner and sustainable technology, financial specialists working with cleaner production cost/benefit accounting and designers working with life-cycle assessments within eco-design processes. Little truly multidisciplinary work was observed during the implementation of cleaner production.

It needs to be emphasized that the concepts of cleaner production and industrial ecology have not become sufficiently deeply embedded into most corporate systems to have the system-wide impacts that would be optimal. This is because they were perceived as non-core business concepts and as such were not usually addressed at the policy and strategic decision-making levels within companies.

Dissemination mechanisms, such as the publication of corporate cleaner production results in scientific and professional journals and stimulation by government and industrial sector organisations, helped to encourage some managers to apply cleaner production approaches such as *good housekeeping* in daily practice. This process revealed that there was more success at the micro level of single organisations if they were reinforced at the macro level by government and industrial sector organisations. As a result of such top-down and bottom-up approaches, the operational activities, in particular, of cleaner production were increasingly being acknowledged as the dominant design and the good-housekeeping dimension was approaching a critical mass in the Netherlands.

It was found that methods used until now have not been sufficient to bring about the necessary radical breakthroughs within corporations. The main findings were:

1. The implementation of cleaner production was mainly limited to *good housekeeping*, because only single-loop learning interventions were used and these only affected a few employees with learning processes at the level of first-order changes.

   Learning processes: When cleaner production assessments only lead to the implementation of selected options and no organisational follow-up is developed, the learning process is limited to tactical, individual, and single-loop learning by doing.
2. The introduction of new knowledge requires vertical support and horizontal learning in organisations.

   Learning processes: Cleaner production projects were often set up by assessment teams that found that their results and recommendations for change were not adequately supported by commitment from the company manager at the end of the assessment loop; as a result only limited organisational learning occurred because the conditions for integration of the new knowledge with the old were absent.

3. In order to achieve far-reaching and radical transitions, commitment and involvement of individuals at different levels of the organisation and from several professional disciplines is essential.

   Learning processes: transitions are a time-consuming process, laying the foundation for radical change. To achieve change, it is essential to use multi-loop learning tools and dissemination policies designed to encourage wider social learning about cleaner production (beyond the learning agendas of industrial organisations), to engage diverse stakeholders and the entire educational system.

When focusing upon industrial ecology, promoters attempted to more fully understand the dynamics of its application in several geographic and cultural settings. With regard to the criticism that industrial ecology generates a closed system and therefore impedes innovation, conditions to prevent this must be defined. Although companies are respected as single entities with their own identity and dynamics, they can integrate external purchasing and co-operation with other companies into their organisation. It was found that there were a variety of views within organisations that need special attention. Rather than seeking to impose a dominant model, the healthier response was found to be: build on diversity. That means that companies' management systems must be sensitive and in continuous interaction with their surroundings to make renewal in an open system development possible.

Disseminators and the receiving organisations perceived the dissemination of the cleaner production and industrial ecology concepts differently. The disseminators had a desired state of business innovation in mind, while the involved organisations perceived the intervention as a non-core business issue. When the organisation met the requirements of the environmental regulatory agency, there were no incentives for change. This was one of the assumed causes for the industrial practice of *going back to normal* after the *one hit* intervention to foster implementation of cleaner production in the company had occurred.

Furthermore, cleaner production assessments require commitment (and not only the involvement of the centre of an organisation) to horizontally tested concepts within a small-scale project. The strategic choices made by organisations and institutional reluctance to change often strain or decrease the motivation of the people involved within the company to generate further assessment loops (incremental steps of growing awareness and involvement that generate the incorporation of continuous improvement activities).

The situation was different for industrial ecology projects: a co-ordinator or a project team established a type of decision-making system, in which several actors participated. Progress appeared to take place on the basis of a garbage-can model: the outcome of the input by various stakeholders was moving in the direction of acceptance of both contingency and control as elements shaping the process of change.

When discussing change and learning processes in institutionalised systems, the history of the company and the region are crucial factors that need to be addressed. This is especially significant in terms of *lessons* (What can we learn from this?), *constraints* (What capabilities are already developed and cannot be changed easily?) and *resources* (What is the knowledge and competence that are embedded in distinctive routines and practices?). Much of the knowledge is tacit and not easily transferable. Besides that, the presence of often *piecemeal* or condoning approaches both within government and industry does not provide the proper foundation and framework for taking the essential, big steps. Persons involved in making or influencing key decisions require substantial support to ensure that they can effect the changes that are required. That level and type of consistent support is essential for effecting the societal transition to sustainability.

The answer to the question of whether the concepts of cleaner production and industrial ecology have gained credibility is related to the depth of the learning processes used to facilitate their implementation. The cleaner production and industrial ecology concepts are faced with business economics routines of the general *rule of thumb* approach that environmental investments should show a pay back of the investment within a maximum of three years. Although the concepts are being promoted as the *common good* for the economy and ecology of organisations and describe the relationship between the costs of environmental protection and the efficiency of the production process as a *win-win* concept, this has usually triggered an *environment* perspective instead of the intended *innovation* perspective.

At the level of single-loop learning, incremental steps such as good housekeeping and regional efficiency improvements have gained credibility as part of these new concepts. In order for radical breakthroughs to sustainability to occur, the approach needs to be different. Regional learning that involves multi-loop learning processes within and among organisations is essential. Until now this more integrated approach has scarcely been used in an optimal way anywhere in the world.

Therefore, it is recommended that in order to make more effective progress with cleaner production and industrial ecology in the future, the following should be done:

⇒ All cleaner production efforts, in the case of application in the design, start-up and growth life cycle phase, need to be made with a comprehensive organisational support and involvement and should also include the stakeholders throughout the life cycle of the products and services that the organisation provides to society;

⇒ Multi-loop learning processes should be used both within single companies and between clusters of companies. This should also increasingly involve the wider citizen population in sustainable regional development planning and implementation;

⇒ Cleaner production and industrial ecology concepts and approaches should be integrated vertically and horizontally from the policy and strategic levels down to the detailed operational levels of both individual companies and clusters of companies;

⇒ The implementation of industrial ecology should be integrated within the regional economy, ecology, technology, culture, and sustainability plans of the region;

⇒ Trust, transparency and confidence must be developed through an open, reflective and on-going dialogue designed to ensure real involvement of diverse stakeholders in charting the future of their organisations and regions as part of the transition to sustainable societies.

All together, the ecological, economic, social and cultural dimensions of corporate activities are best combined in the label *Corporations Taking their Responsibility for Working towards Social, Economic, Environmental and Cultural Sustainability*.

Samenvatting

Dit proefschrift gaat in op de bewustwordingsprocessen bij nieuwe concepten als *pollution prevention*, schonere productie en industriële ecologie. *Schonere productie* en *Pollution prevention* kunnen beide worden omschreven als: `de voortdurende toepassing van een geïntegreerde, preventieve milieustrategie om bij zowel processen als producten de risico's voor *mens en natuur* te verminderen'. *Industriële ecologie* wordt beschreven als: `een geïntegreerd systeem waarin het gebruik van energie en materialen is geoptimaliseerd en de emissies van het ene proces dienen als grondstof, materiaal of energie voor een ander proces'.

Schonere productie werd bij de verspreiding als nieuw concept in de industrie geïntroduceerd als een preventiegericht paradigma om schonere bedrijven en duurzamere samenlevingen te verkrijgen. Dit werd gezien als een belangrijke manier om het oude *pollution control* paradigma te vervangen of aan te vullen. De conceptuele benadering van het schonere productie paradigma was gericht op het katalyseren van de transitie van enerzijds *afval management* en *`end-of-pipe' beleid* naar anderzijds *`milieu-inclusief' innovatie beleid voor afvalpreventie* en *afvalvermindering* bij de bronnen van de problemen in de industrie.

Dit proefschrift analyseert en bediscussieert de concepten van schonere productie en industriële ecologie rond de volgende centrale vraag: Welke actoren en factoren hebben, onder welke voorwaarden, de verspreiding en implementatie van deze preventie concepten zowel binnen als tussen bedrijven beïnvloed?

Het proefschrift besteedt verder aandacht aan de vraag of er sprake is van een paradigma verandering in concept innovatie inde praktijk en voorts in hoeverre de implementatie van de nieuwe concepten bijdraagt aan duurzaamheid.

Na de eerste succesvolle ontwikkelingen en de implementatie van de *pollution prevention* benaderingen in Amerikaanse bedrijven als 3M en DOW in de 70-er jaren, is een aantal bedrijven in andere landen met soortgelijke preventie initiatieven gaan experimenten gedurende de 80-er en 90-er jaren. De schonere productie concepten en benaderingen werden wereldwijd verspreid door presentaties, conferenties, speciale promotie activiteiten van organisaties zoals UNEP en UNIDO en door intermediaire organisaties zoals de U.N. National Cleaner Production Centres in de decennia rond de eeuwwisseling. Sleutel actoren zoals academici (in het geval van schonere productie) en ingenieurs in de industrie (in het geval van industriële ecologie) hebben de verspreiding en implementatie van de concepten door middel van presentaties en demonstratieprojecten gefaciliteerd. De concepten werden voorgesteld als attractieve win-win benaderingen die de bedrijfseconomie zouden verbeteren en tegelijkertijd de milieubelasting en risico's zouden verminderen.

Uit de analyse van dit onderzoek voor dit proefschrift werd duidelijk dat de verwachte voortgang in de preventieve benadering niet vanzelf tot stand kwam, maar dat bedrijfs-medewerkers veelal terugvielen op de oude *pollution control* mentaliteit en routine. Één van de redenen hiervoor is dat de meeste promotoren van het preventie concept alleen vertrouwden op zogenaamde *single loop* leerprocessen.

Dit proefschrift onderzoekt de verspreiding van de schonere productie en industriële ecologie concepten op twee manieren. Ten eerste worden de effecten van de dynamische evolutie en introductie van concepten geëvalueerd, zoals professionalisering en specialisatie van schonere productie, *eco-design*, *total cost/benefit accounting* en industriële ecologie. Ten tweede wordt aandacht geschonken aan de effecten van met elkaar concurrerende concepten zoals de rol van *responsible care*, milieu management systemen, *eco-auditing*, integraal keten beheer, milieu-efficiency, groene productiviteit en duurzame bedrijventerreinen. Tijdens deze zoektocht wordt een antwoord gezocht op de volgende vraag: op welke wijze beconcurreren of complementeren deze verschillende benaderingen elkaar?

De meeste bedrijfsmanagers benadrukten in de beginfase van de introductie van de preventie concepten dat zij niet erg geïnteresseerd waren in deze benaderingen omdat milieu aspecten geen kerntaken zijn. Toen echter een toenemend aantal bedrijven de milieu aspecten in de bedrijfsvoering begon te integreren, nam de belangstelling voor de preventie benadering toe. Als gevolg van de groeiende openheid is de traditionele perceptie van bedrijven als *`black boxes' die hun eigen verantwoordelijkheid hebben* veranderd in een transparante *`stakeholder' benadering*. Zeker nu vele multi-nationale ondernemingen betrokken zijn geraakt bij het *corporate social responsibility (CSR)* concept, ontstaat een toenemende behoefte aan een sterkere inbedding van duurzame industriële productie in de maatschappij.

De ontwikkeling van de preventie benadering in geïndustrialiseerde en zich ontwikkelende landen heeft zich voltrokken in een zeer verschillende context. Vandaag de dag wordt de industrie in zich ontwikkelende landen geconfronteerd met *command and control* beleid van de overheid. Maar de implementatie van dit beleid wordt zwak gehandhaafd, terwijl er een grote mate van corruptie bestaat die de potentie van milieubescherming door de overheid verder verzwakt. Degenen die de concepten van schonere productie in deze landen introduceren en verspreiden, hebben geleerd dat succes samenhangt met zich actief inzetten in de ontwikkeling, verspreiding en implementatie op het gebied van schonere productie beleid.

In Nederland en in enkele andere West-Europese landen is het proces om de industrie te betrekken bij milieubescherming vooral tot stand gekomen door het instellen van emissie-standaarden, het toekennen van milieuvergunningen en het implementeren van bedrijfs milieu management systemen. In sommige gevallen waren deze maatregelen door overheidsdwang, of binnen vrijwillige overeenkomsten (convenanten) geïmplementeerd. In andere situaties werden zij onder de druk van de neiging tot nabootsing van andere bedrijven geïmplementeerd.

De bevindingen over de wijze waarop de industrie deze nieuwe milieuconcepten vertaalde, waren in het geval van de verspreiding van schonere productie en industriële ecologie verschillend. Toen de schonere productie concepten werden geïntroduceerd was de maatschappij er niet ontvankelijk voor. Hoewel wetenschappelijke onderzoekers de schonere productie concepten als een bedrijfsbenadering presenteerden, zag de industrie het concept als een milieu benadering. De voor milieu aspecten verantwoordelijke medewerker(s) vervulde(n) de voornaamste verbinding vanuit het bedrijf met de schonere productie demonstratie projecten. Die projecten kenmerkten zich door een ingenieursbenadering met *assessment loops* gebaseerd op milieuproblemen. Deze benadering paste in het institutionele raamwerk maar gaf weinig inzicht in de innovatieve bedrijfseconomische benadering van schonere productie.

De voornaamste conclusie van dit proefschrift is dat, hoewel schonere productie is gedefinieerd in integrale termen, in de praktijk de integratie van milieu aspecten met kwaliteit, veiligheid en energie in het bedrijf zwak is. Er werd gevonden dat de interpretatie en implementatie van schonere productie gefragmenteerd is in verschillende praktijk paradigma's (organisatie, technologie, beleid), waarvoor een integraal theoretisch raamwerk ontbrak: ieder paradigma is impliciet beperkt en vertoont zwaktes. De toepassing van het concept van schonere productie was regelmatig beperkt tot *good housekeeping* praktijken in plaats van gebaseerd te zijn op een nieuwe, holistische en preventieve wereldbeschouwing door bedrijven. Er werd ook gevonden dat professionals op het gebied van schonere productie waren getraind in afzonderlijke disciplines, bijvoorbeeld: technologen die met schonere en duurzame technologie werken, financiële specialisten die met schonere productie kosten/baten analyses werken en ontwerpers die met levenscyclus assessments in *eco-design* processen werken. Er werd weinig echt multi-disciplinair gewerkt gedurende de implementatie van schonere productie.

Benadrukt moet worden dat de schonere productie en industriële ecologie concepten in de meeste bedrijfssystemen onvoldoende diep zijn ingebed om de systeem-brede effecten te kunnen optimaliseren. Dit komt doordat zij werden gezien als concepten die niet tot de kern-activiteiten van het bedrijf behoren en als zodanig gewoonlijk niet werden besproken in de beleids en strategische besluitvormingsniveaus in bedrijven.

Verspreidingsmechanismen, zoals de publicatie van resultaten op het gebied van schonere productie in bedrijven in wetenschappelijke en beroepstijdschriften, alsmede stimulering door de overheid en branche organisaties, hielpen bij de aanmoediging van sommige managers om schonere productie benaderingen zoals *good housekeeping* toe te passen in de dagelijkse praktijk. Dit proces gaf aan dat er meer succes op het micro niveau van de afzonderlijke organisaties bereikt werd, wanneer een prikkel door de overheid en industriële branche organisaties op macro en meso niveaus aanwezig was. De operationele activiteiten, in het bijzonder van schonere productie, waren als resultaat van dergelijke *top-down* en *bottom-up* benaderingen in toenemende mate erkend als het dominante ontwerp. Zo benaderde de *good housekeeping* dimensie een kritische massa in Nederland.

Er is voorts gevonden dat de gebruikte methoden tot nu toe onvoldoende zijn om de noodzakelijke radicale doorbraak naar duurzaamheid binnen bedrijven tot stand te brengen. De voornaamste bevindingen waren:

1. De implementatie van schonere productie was voornamelijk beperkt tot *good housekeeping*, omdat slechts *single-loop learning* interventies werden toegepast waarbij slechts een paar medewerkers met leerprocessen op het niveau van 1^e^ orde veranderingen betrokken waren.

   Leerprocessen: Wanneer schonere productie assessments alleen tot de implementatie van geselecteerde opties leiden en er geen vervolg in de organisatie wordt ontwikkeld, blijft het leerproces beperkt tot tactisch, individueel en *single-loop learning by doing*.
2. De introductie van nieuwe kennis vereist steun vanuit het top management en leerprocessen in alle afdelingen van organisaties.

   Leerprocessen: Schonere productie projecten zijn meestal opgezet door assessment teams die hebben ervaren dat hun resultaten en aanbevelingen voor veranderingen niet adequaat werden ondersteund door betrokkenheid van de bedrijfsmanager aan het einde van de *assessment loop*. Het resultaat hiervan was slechts een beperkte lerende organisatie, omdat de belangrijkste voorwaarde, integratie van nieuwe kennis met de bestaande kennis, afwezig was.

3. Persoonlijke betrokkenheid op verschillende organisatieniveaus en van verschillende professionele disciplines is essentieel om verreikende en radicale transities te bewerkstelligen.

   Leerprocessen: Transities zijn tijdrovende processen die het fundament voor radicale verandering leggen. Om verandering te bereiken, is het essentieel om *multi-loop learning* instrumenten en disseminatiebeleid te gebruiken, die ontworpen zijn om een breder maatschappelijk draagvlak voor het leren over schonere productie (uitstijgend boven de *leerproces* agenda's van industriële organisaties) aan te moedigen, om de diverse stakeholders en het gehele onderwijssysteem te betrekken.

Bij hun focus op industriële ecologie hebben promotors geprobeerd de dynamiek van de toepassing in verschillende geografische en culturele omstandigheden beter te begrijpen. Om tegemoet te komen aan de kritiek dat industriële ecologie een gesloten systeem genereert en daardoor innovatie belemmert, moeten voorwaarden worden gedefinieerd. Hoewel bedrijven worden gerespecteerd als afzonderlijke entiteiten met hun eigen identiteit en dynamiek, kunnen zij bijvoorbeeld externe inkoop en samenwerking met andere bedrijven in hun organisatie integreren. Er is vastgesteld, dat een variëteit aan inzichten binnen organisaties aanwezig is die speciale aandacht vereiste. Het antwoord hierop is dat het beter was om `te bouwen op diversiteit' dan door het opleggen van een dominant model. Dat betekent dat management systemen van bedrijven sensitief en in voortdurende interactie met hun omgeving moeten zijn, om vernieuwing in een open systeem ontwikkeling mogelijk te maken.

Verspreiders en ontvangende organisaties percipieerden de disseminatie van de concepten van schonere productie en industriële ecologie verschillend. De verspreiders hadden bedrijfsinnovatie als gewenste situatie in gedachten, terwijl de betrokken organisaties de interventie als een *non-core business* activiteit zagen. Wanneer de organisatie bovendien voldeed aan de eisen van de milieu-inspectie waren er geen prikkels voor verandering. Dit was één van de veronderstelde oorzaken van het feit dat bedrijven *terugvielen op hun routines* na de afronding van de éénmalige interventie om de implementatie van schonere productie in het bedrijf te bevorderen.

Voorts vereisen schonere productie assessments blijvende betrokkenheid (en niet alleen de toestemming van het management van een organisatie) voor het testen van de concepten met een kleinschalig project in verschillende afdelingen van de organisatie. De strategische keuzes door organisaties en institutionele weerstand tegen verandering geven vaak spanning of verminderen de motivatie van de medewerkers die betrokken zijn om verdere *assessment loops* in het bedrijf te genereren (incrementele stappen van groeiende bewustwording en betrokkenheid die de internalisatie van voortdurende activiteiten tot verbetering genereert).

De situatie bij industriële ecologie projecten was anders dan bij schonere productie projecten: een coördinator of een project team stelde een type besluitvormingssysteem vast waarin verschillende actoren participeerden. Vooruitgang scheen plaats te vinden op basis van een *garbage-can model*: de uitkomst van de input van verschillende stakeholders bewoog zich in de richting van acceptatie van zowel *contingency* en *controle*, als elementen die het proces van verandering vorm geven.

De historie van het bedrijf en de regio zijn bij de discussie over verander en leer processen in geïnstitutionaliseerde systemen cruciale factoren waaraan aandacht moet worden besteed. Dat is vooral significant in termen van: *lessen* (wat kunnen we hiervan leren?), *beperkingen* (welke bekwaamheden zijn al ontwikkeld en kunnen niet gemakkelijk worden veranderd?) en *hulpbronnen* (wat is de kennis en kunde die is ingebed in de diverse routines en praktijken?). Veel kennis is *tacit* en niet gemakkelijk over te brengen. Daarnaast voorziet vaak het slechts beetje bij beetje accepteren of gedogen van benaderingen door zowel overheid als industrie niet in de juiste fundering en het juiste raamwerk waarop essentiële, grote stappen kunnen worden gebaseerd. Personen die bij het maken of beïnvloeden van belangrijke besluiten betrokken zijn, vereisen substantiële ondersteuning om zeker te zijn dat zij de vereiste veranderingen kunnen effectueren. De consistente steun van hogere managementniveaus is essentieel om invloed te kunnen hebben op de maatschappelijke transitie naar duurzaamheid.

Het antwoord op de vraag in hoeverre de concepten van schonere productie en industriële ecologie krediet hebben opgebouwd, hangt samen met de diepgang van de leerprocessen die gebruikt zijn om hun implementatie te faciliteren. De schonere productie en industriële ecologie concepten worden geconfronteerd met de algemeen toegepaste *vuistregel* in bedrijfseconomische routines dat milieu investeringen een terugbetaling van de investering binnen maximaal drie jaar moet laten zien. Hoewel de concepten worden bevorderd als *goed* voor de economie en ecologie van organisaties, terwijl de relatie tussen de kosten van milieu bescherming en de efficiency van het productie proces als een *win-win* concept wordt beschreven, worden de concepten doorgaans vanuit een *milieu* perspectief in plaats van het bedoelde *innovatie* perspectief gekwalificeerd.

Op het niveau van *single-loop learning* hebben incrementele stappen zoals *good housekeeping* en *regionale efficiency* verbeteringen krediet opgebouwd als onderdeel van deze concepten. Om een radicale doorbraak naar duurzaamheid te bewerkstelligen zal de benadering anders moeten zijn. Regionaal leren dat *multi-loop* leer processen in en tussen organisaties betrekt, is essentieel. Tot nu toe is deze meer geïntegreerde benadering zelden op een optimale manier toegepast in de wereld.

Uitgaande van een effectievere vooruitgang op basis van de integratie van schonere productie en industriële ecologie concepten in organisaties, wordt aanbevolen het volgende te doen:

- Alle schonere productie inspanningen, in geval van toepassing in ontwerp, start en groei levens cyclus fase, moeten worden gedaan met uitgebreide ondersteuning en betrokkenheid in de organisatie en zouden ook de stakeholders in de hele levenscyclus van producten en diensten, die de organisatie aan de maatschappij levert, moeten betrekken;
- *Multi-loop* leer processen zouden zowel in afzonderlijke bedrijven als tussen clusters van bedrijven toegepast moeten worden. Deze benadering zou ook in toenemende mate de burger populatie in de planning en implementatie van duurzame regionale ontwikkeling kunnen betrekken;
- Concepten van schonere productie en industriële ecologie zouden in verticale en horizontale verantwoordelijkheidslijnen van de beleids- en strategische besluitvormings-niveaus tot de gedetailleerde operationele niveaus van zowel individuele bedrijven als clusters van bedrijven geïntegreerd moeten worden;

- De implementatie van industriële ecologie zou geïntegreerd moeten worden binnen de economie, ecologie, technologie, cultuur en duurzaamheidsplannen van de regio;
- Vertrouwen, transparantie en overtuiging moeten worden ontwikkeld in een open, reflectieve en constante dialoog. Die dialoog moet zodanig worden opgezet dat de werkelijke betrokkenheid van diverse stakeholders wordt verzekerd om de toekomst van hun organisaties en regio's als onderdeel van de transitie naar duurzame samenlevingen te betrekken,

Alles bij elkaar, zijn de ecologische, economische, sociale en culturele dimensies van duurzame bedrijfsactiviteiten het best verwoord in het label *Bedrijven die hun verantwoordelijkheid nemen om sociale, economische, milieu en culturele duurzaamheid te ontwikkelen en integreren in hun activiteiten*.

Preface

This thesis addresses the following research question: "*Does the dissemination of preventive approaches in production and product development within and between companies contribute effectively to a paradigm shift towards sustainability?*" There is a personal inspiration and a history behind this question: the awareness of human health problems that can be caused by environmental problems (Hommes, 1984) and my own experience of living on contaminated soil that can generate negative lifelong consequences.

In the second half of the twentieth century, mankind faced growing environmental problems due to its activities, for instance those experienced in a physical way such as diffuse health problems. We also learned that a lack of knowledge prevented the identification of the sources and impacts of environmental pollution on human beings. For instance, the effects on humans of exposure to low concentrations of polluting substances in the air, soil, and water are still very difficult to track down, identify and document in terms of causal relationships. Most people do not display any ill-effects at all.

However, some people are very sensitive to exposure to pollutants. Exposure to toxic substances can result in severe restrictions to (social) life, as a consequences of health problems such as swollen joints and burning eyes – in cases of the sick building syndrome or of chemical compounds found in fabrics used for clothing (Svoboda, 1997). It has also been found in the USA that approximately 15% of the inhabitants suffer from a Multiple Chemical Sensitivity (MCS) syndrome (Piasecki & Asmus, 1990).

At the community level, the life cycles of various environmental problems display certain similarities, according to Downs (1972): the problem comes into public view, it captures centre stage for awhile, it begins to fade from public attention, partly because of public recognition that the problem is more complex and costly than was first thought, and it is replaced by another crisis issue. The occurrence of incidents and accidents plays an important role in setting environmental issues on the political agenda (although nobody would wish to create accidents just to facilitate awareness-raising, people do seem to be fundamentally driven by reactions to crises). The breakthrough for the acknowledgment of soil pollution in the Netherlands took place in 1980 (one year after the Love Canal dioxin soil contamination disaster in the United States) with the evacuation of inhabitants in a new residential area of the small Dutch town of Lekkerkerk (6700 inhabitants), when it was discovered that they were living on contaminated soil and using contaminated drinking water. It was the first case of a large number of subsequently discovered contaminated areas in the Netherlands and in the rest of the world. Discovered is not the right word; some experts had known about the general problem of soil pollution for many years, but were not able to get any political attention for the issue. Gaining recognition for the severity and urgency of the problems, and thus turning them into issues for the political agenda, is a better way of expressing the *discovery of the problem*.

Against this background I wish to share some of my personal experiences. As a victim of living on contaminated soil, I was directly involved in social processes to solve the problem (being the intermediary between the citizens and the government, I had a perfect *participating observation* position). I published observations (Baas, 1982, 1986) and recommendations based on analysis of these observations. I used other research methods such as questionnaires, in-depth interviews and content analysis (Baas et al., 1985, 1986) to analyse these social processes.

However, the impression that emerged from this period was that of a limited acceptance by officials and their consulted scientists about the objectivity or inter-subjectivity of my findings. In other words, a *two hats* problem (being both a victim and an independent observer) was a latent stumbling block for several government officials. This is curious, because in certain theoretical/epistemological perspectives, it is the ideal type position for a social science researcher (becoming so directly involved in the real situation that one can scientifically observe from that position: Blumer, 1969; a back stage position: Goffman, 1969, Ten Have, 1977). This was never openly expressed but apparently a border had been crossed. An observer without any personal concerns can gain societal and scientific acceptance; the position of an observer with personal concerns is questionable.

Another finding was that the involved government officials could not deal properly with social problems caused by soil pollution. The government officials had a natural science background that made them focus on the technical solution to the problem under the assumption that by working on certain technological solutions, the social problems would also be solved. The formal, official approach to finding solutions for inhabitants living on polluted soil was centred on the production of manuals for soil pollution management. These manuals described a systematic approach, starting with historical research before moving to the sanitation of the area.

However, there was no description of how to deal with the social aspects of the crisis: families confronted with an undesirable situation, with very limited freedom to move to environmentally safe areas. For me this was a confrontation with the clear imbalance between engineering and social system approaches.

Furthermore, no attention was paid to the causes of the pollution, the bad management of industrial waste in many situations, and the illegal dumping. The issues of pollution generation and the inadequate control of pollutants by industry and government had already aroused my interest earlier. I was involved in discussions about effluents in the dairy industry before my personal involvement in soil pollution became a lifetime event.

My interest became driven by the desire to influence the existing environmental policy approach and to change its focus: from cure to prevention. My emphasis was, and continues to be, to seek influence because environmental policy is the continuously changing result of many countervailing variables that seldom lead in a straight line to an ideal type approach. Furthermore, I learned from organisational change processes that certain unintended effects could also occur. Against this background, my first project at the Erasmus Studiecentrum voor Milieukunde[1] at Erasmus University assisted me in my quest for pollution prevention oriented research: a policy research project whose objective was the substitution of toxic materials in five different products without their losing any function, capacity or quality (Baas and Spoel, 1987).

After that project, I was fascinated by the concepts of pollution prevention brought to Europe by Prof. Dr Donald Huisingh in 1986. However, I was somewhat unsure whether the

[1] Erasmus Centre for Environmental Studies (ESM). The name changed into `Erasmus centre for Sustainability and Management' in September 2003.

pollution prevention concepts could fit in the Dutch situation. The concepts became the basis for testing the preventive approach in a number of research projects in companies. In that way, my commitment to solving human difficulties created by soil pollution problems developed into the commitment to avoid future environmental and related health problems through research that would explore whether the concepts of pollution prevention could be successful in the Netherlands and how they could be disseminated.

The principles of this research approach were twofold: providing information about pollution prevention and performing research on what is being done with the information at the same time. Many respondents expressed their gratitude spontaneously: `it is a good initiative from universities to develop such an approach, because the future of a bad environment for my children and grandchildren is worrying.' (Baas, 1989).

The cure of environmental pollution has improved over the past two decades; however the preventative approach still needs to make a definitive breakthrough to facilitate sustainability. The corkscrew curl pathway (as metaphor for steps forward and fall-backs of the preventative concept development, Hafkamp, 1996) to that situation is the subject of this thesis.

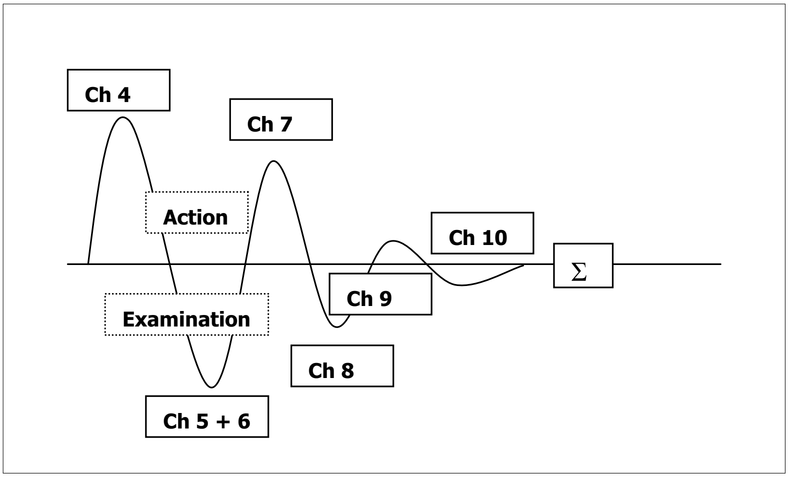
It is remarkable that the (initially threatening) influence of soil pollution on my life has also made it possible to produce this thesis. The contacts with AVR-Caldwell Environment Netherlands B.V., later renamed, AVR Milieutechniek B.V. has made it possible to receive funds from the Stichting Technologie en Wetenschap (STW: Association for Technology and Science). I would like to express my thanks for the fact that this made it possible to work part-time on this Ph.D. thesis during four years.

For comments on the contents, I am fully indebted to Frank Boons, who has constantly been willing to give feedback on my complex associative thinking. Wim Hafkamp was able to provoke the implicit associative thinking and writing in such a way that the general line of analysis became more explicit, and Don Huisingh has, as ever, stimulated my work and stressed that my observations provide necessary documentation designed for sustainability education.

1 Prevention in Action; Evidence in Examination

This thesis deals with the introduction of the cleaner production concepts at the micro level and industrial ecology concepts at the meso level, as well as the emerging concept of sustainable regions[2] at the macro level, in the period 1980 - 2000. Chapter 1 presents the objectives and the structure of the thesis, focusing on the emergence of these new concepts of preventive environmental management strategies such as cleaner production and industrial ecology in production, product and service development within and between companies and society. After this introductory chapter, the discussion area for the new concepts of cleaner production, industrial ecology and sustainability are outlined in Chapter 2. Chapter 3 addresses the situational context in which the new concepts and the research have been carried out to accelerate their dissemination. Starting in Chapter 4, a social science research method designed by Ragin (1994), provides the framework for analysis of the research data contained in Chapters 4 - 9. The method is based on a conception of theory as conceptualisation that makes it possible to consult and to redevelop theory in a close relationship with empirical information that, in this thesis, is already collected. The empirical information is identified by the metaphor of the *bouncing ball* (Figure 1.1), whereby the description and analysis of actions are followed by reflections and considerations based on social theories and analytical frames that lead to conclusions about representations of social life (see Section 2.6.2).

Figure 1.1 **The *bouncing ball* metaphor pertaining to testing of images against evidence and coming progressively closer to the real meaning**

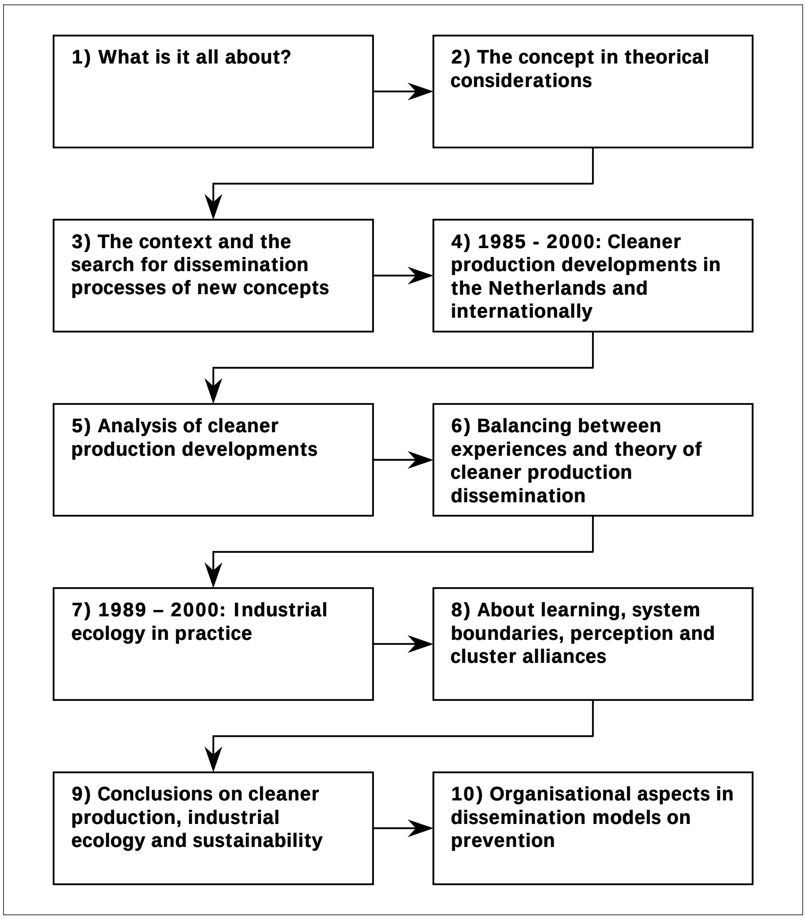


2 In this context a sustainable region is conceived as a region in which stakeholders are striving to co-ordinate their activities in a sustainability framework for the exploration of renewable energy and resources.

Survey data and observations provide evidence of the cleaner production and industrial ecology research projects that were performed by university teams in the 1990 decade. Images of the survey data and evidence are an idealisation of all case studies or aspects, based on abstractions. Ragin's model (1994) is pragmatic in that it catches the main elements in the social research process with an intuitive appeal: through comparing ideas and evidence in case studies with similarities and diversity, the insight and understanding of the process and of the facts evolve into a more coherent and consistent pattern. The distance between images and evidence guide the remainder of the research presented in this thesis. This distance is shortened in the successive phases of this thesis research until the representations are explained.

The design of this thesis and the main topics of each chapter are provided in Figure 1.2:

Figure 1.2 **Overview of the Ph.D. thesis design**



The results of the case studies presented in Chapters 4 and 7 are based on action-research and dissemination of the new concepts. The data and images are tested within analytical frameworks on the basis of social theory concepts (see Chapter 2). The outcomes are representations of social life that are developed in a confrontation between evidence (sense making processes, Weick, 1996) and images (see Chapters 5, 6 and 8). Following this approach, Chapter 4 addresses respectively action-research and analysis of cleaner production developments in the Netherlands and internationally in the period 1980 – 2000. Chapter 5 analyses those developments from a theoretical perspective and Chapter 6 elaborates a second-loop analysis of the experiences and theory of cleaner production dissemination. Chapters 7 and 8 applies the same patterns of analysis to the concept of industrial ecology: Chapter 7 provides an overview of industrial ecology developments in practice in the INES projects and internationally in the period 1985 – 2000, followed by an analysis that is presented in Chapter 8. I present my conclusions concerning the dissemination of cleaner production and industrial ecology in Chapter 9, and make recommendations in Chapter 10. Chapter 11 is an afterword based on personal experience.

Although the cleaner production concept is presented as a positive thing both for business economics and the environment, the core of *prevention thinking* is idealistic at the value level. The analysis of the dissemination developments in the period 1985 – 2000 provides further insights into whether these concepts have made a substantial contribution to the concept of sustainability.

In Section 1.1, the difference in people's perception of the imbalance between the natural and social system is described. Those different perceptions are part of the different attitudes that influence the recognition and acknowledgement of new concepts. That includes the assumption that policies covering that imbalance must take into account the fact that the introduction of new concepts is not a value-neutral or easy process.

Section 1.2 briefly introduces the concepts that are the basis for analysis followed by the structure of the thesis that is presented in Section 1.3. The scientific and societal relevance of the thesis is justified in Section 1.4, followed by an overview of the main features of the thesis in Section 1.5.

1.1. Differing perceptions of environmental problems

The huge mountains of the Andes, the wide polder landscapes in the Netherlands, the rolling fields of sunflowers in the Provence (France) are some of the landscapes that have inspired many painters to express deep emotions when painting those images of nature and traditional farming. Nature possesses a power of attraction for recreation and relaxation as a break away from the busy daily life for many people, as well as for the study of biology and bio-diversity and their dynamics. In a nutshell, these illustrations represent **functions of the intrinsic value of nature,** as such.

Stortenbeker (1990) showed the importance of a balanced and sound nature as a reflection of other functions that provide the living conditions for the human species, such as:

- The **bearing** functions: the environment as a substrate for towns, transport links and other technological objects, recreation facilities and as a sink for waste;
- The **production** functions: the production of bio-mass on land and in water, the agricultural, silvicultural and aquacultural dimensions plus the energy aspects;
- The **regulation** functions: such as purification and effect stabilisation;

- ➢ The **information** functions: a supply of scientific information, a reservoir of genetic information, and a source of inspiration, education and recreation.

Human activities have influenced nature in many ways and are continuing to do so, thereby causing environmental pollution, which is part of the problem. The unlimited growth of industrial activities out of balance with nature's assimilative capacity was the basis for citizen's awareness-raising about the threat of some human activities at the end of the 1960s and the beginning of the 1970s. Pollution in industrial countries became physically tangible owing to its smell and visibility, and the pollution-related ecological and human health illnesses that became evident. The causal relationship between pollution and health problems was effectively discussed (Hommes, 1984). Illnesses such as respiratory problems, bleeding noses, unspecified headaches in high-risk categories (such as young children and older people) were not alarming for the mainstream medical world or for politicians. But for citizens they were very real and disturbing!

As these health problems were neglected or denied by the authorities, the environmental protest movement was increasingly able to mobilise awareness of environmental problems (Boender, 1985, McCormick, 1989). Similar neglect had occurred in 1962 when Rachel Carson was the first to publish work about the invisible dangers of DDT and other pesticides and chemicals to a broad audience. As became usual in such `early environmental warnings', she was accused of being hysterical and extremist. Similarly, the generation of environmental whistle-blowers in the USA in the late 1960s/early 1970s were even called *Prophets of Doom* (McCormick, 1989).

Nowadays, it is broadly acknowledged that the broad spectrum of world-wide human activities should be brought in equilibrium with the environment, both in the present and the future. The World Commission on Environment and Development (WCED, 1987) stressed the need for sustainable development and stated that sustainable development is `..not a fixed state of harmony but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future and present needs..' (p. 48).

Pathway of Understanding (1992), the report of the Consortium for International Earth Science Information Network (CIESIN)[3] is the first international scientific policy document that presented a framework that fully reflects on the role of social sciences in determining environmental policies as the outcome of different attitudes to nature and the environment. In that framework, it is stated that industrial and economic growth throughout the whole world are placing a growing burden on the assimilative capacity of nature and that the social sciences have a role in knowledge development designed to influence the transition from life-styles and activities that are currently out of balance with nature.

As human beings behave differently when taking risks in relation to perceived rewards in general, a united view on the definition of environmental problems is not expected. The human perspective is, among other things, related to the type of discipline and the developed body of knowledge influencing views within, between and across disciplines about environmental risk-taking. This is illustrated in reflections from natural system and social system scientists presented in the following paragraphs.

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3 An international group of scientists that challenged social scientists to research the interactions of humanity in relation to global environmental problems

The political philosopher Vermeersch (1990) considers that Science, Technology and the Capitalist economy (the *STC complex*) are responsible for an autonomously running system with a strong consumption tendency that has a disastrous impact on the environment and culture. He sees the development and application of science and technology as the major force behind industrial and economic growth, urbanisation, migration, life expectancy, and as the cause of a growing disruption of the environment. Furthermore, he states that the political system is tending to produce a unified system world-wide (everything becomes the same under the influence of the Northern culture) and to strive to equity for all (access to the same goods: on the basis of consumption patterns).

The worldview of this political system involves a bias based upon the premises that an economically sound country is characterised by economic growth, that access to natural resources and welfare are inequitably divided owing to world-wide historical, religious and business developments that are not easy to change, and that regional priorities and practices are not necessarily commensurate with regional needs. The description of the political system in this way reflects the mainstream assumptions of current thinking, including the recognition that this approach has led to many inequities.

The basis for preventive concepts is their utilisation of the cleaner production worldview to counter this imbalance. This means that the context of concepts such as pollution prevention, cleaner production, sustainable development and corporate social responsibility has to change too. It assumes, for instance, greater inter- and intra-generational equity and a dynamic improvement in the balance between economy and ecology. This social system perspective is different from a natural science perspective that includes the assumption of an unbridled exploitation of the natural system for bringing economic prosperity to some parts of the social system.

Changing the subject from the system levels to the consequences of environmental pollution, it is often said that the introduction of organic chemistry into mass production has caused the current environmental problems. Many chemists deny this, referring to the fact that the building blocks of nature are carbon, hydrogen and oxygen, of which many human-made substances are formed as well (van Heel, 1989). In this perspective, the issue is the good management of hazardous substances. Also, before the organic chemistry era, human activities already caused pollution problems such as the tar waste of the ropes for merchant ships on the quays of Amsterdam in the 17th century, and cyanide pollution as a result of the burning of coal in electrical power stations in the 19th century. Cadmium, a by-product of the refining process of zinc-ore, was used for more than a century. Lead was used in many useful applications until it was discovered that it could cause health problems (such as in the use of lead in drinking water pipes or as a component of paint). And what about the natural product, asbestos, that until recently was used for thermal protection in brakes and as an insulation material in buildings?

But besides that, the chemical industry is causing the catalytic destruction of the ozone layer, by producing compounds such as chlorofluoro carbons (CFCs) and severely toxic compounds such as hydrogen fluoride (HF), numerous kinds of pesticides and indirectly more than a hundred toxic isomers of dioxins and dibenzofurans as a result of incomplete incineration. Furthermore, there is mounting evidence that human exposure to some chemicals, even at very low levels, can have adverse biological effects including endocrine disruption, chemical sensitivity and cancer (Ashford & Miller, 1998).

Claude Hughes (Colborn *et al*., 1996, 81-82) worries about the mounting number of hormone-disrupting chemicals, emphasising that humans' lack of evolutionary history with these synthetic compounds has not ensured that they have the capacity to detoxify them; as a result many are causing a wide array of diseases. The body is able to break down and excrete natural oestrogenic substances, while many of the man-made compounds resist normal breakdown and accumulate in the body, exposing humans and animals to low-level but long-term exposure (El-Mubarak, 2003). Also, it is feared that some might be tempted to jump to the conclusion that because so many natural oestrogens already exist in nature, there is no need to worry about synthetic chemicals that interfere with hormones (Colborn *et al*., ibid, 82).

However, it can be observed that in the United States attention for issues such as Labour & Health, Endocrine disrupters and Green chemistry is developing towards an integrated Chemistry and Health approach as recognition of the link between chemicals and new public health problems that challenge the tenets of traditional toxicology and medicine (Ashford & Miller, 1998).

Furthermore, at the 22 - 23 May 2001 Stockholm Convention on Persistent Organic Pollutants (POPs),[4] an urgently needed convention on POPs was adopted and opened for signature as a global United Nations treaty to protect human health and the environment from persistent organic pollutants. The `Strategienota Omgaan Met Stoffen' (SOMS) (Strategy Document on Handling Materials) of the Dutch Government (2001) illustrates the development and implementation of public policies in answer to the growing concern about the management of hazardous materials. Geiser (2001) refers to the fact that `..the conventional process by which the "acceptable" threshold of exposure to a hazardous substance is established often involves a political negotiation based on differing views of the scientific evidence..'. Because such processes are long, complex, and contentious, Geiser (2001) states that more of the resources of science might better be spent on finding or developing less hazardous substances.

Although the unrestricted application of technology is part of the environmental problem, technology is also perceived as part of the solution. The technological solution is perceived as a crucial instrument at two levels. First, it provides the means to control pollution, and second, the role of technology illustrates a dominant issue in the environmental policy debate: the techno-centric thinking (O`Riordan, 1976) that technology can solve environmental problems. O`Riordan contrasts the eco-centric thinking to the techno-centric approach. The eco-centric thinking uses the primacy of nature and focuses on the continuity of ecosystems. Hommes (1988), on the other hand, states that it is not possible to return to a primitive society. The current world population makes it impossible to produce enough food according to the rules of nature. Last, but not least, such a transition is sociologically inconceivable.

Meadows, receiving more than average criticism on bold statements in the report to the Club of Rome in 1972, told participants in a workshop in Noordwijk (the Netherlands) in 1992 that the real data in 1991 for his limited 1972 model were worse than he and his colleagues had anticipated. Nevertheless, Meadows also saw technology as essential for the functioning of modern societies. Meadows *et al.* (1991) developed four scenarios with different assumptions concerning environmental policy and technology, in which the clean

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4 POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissues of living organisms and are toxic to humans and wildlife.

technology scenario leads to the survival of mankind. In these four scenarios, two opposite approaches are constructed as extremes in a continuum from:

- **The line of technological pessimism**: technology will not be able to circumvent fundamental energy and resource constraints; to
- **The line of technological optimism**: clever development and deployment of technology can eliminate the energy and resource limits to growth (Perrings *et al*., 1993).

Toning down the function of technology, Ed Ayres (1999) states with respect to the critique of high-tech development at the end of the twentieth century that, `..Yet no technology has ever been anything but a tool, an extension of the bio-mechanical and communications capabilities we already have - of our hands, eyes and ears..'. Also, even the WCED report (1987) is criticised by Trainer (1990), who argues that the faith in technical solutions for solving resource problems through the connection of technical development, efficient use of resources, re-use and conversion to achieve sustainable resource management is not a mechanism. Further, already thirty-five years ago, Ehrlich & Ehrlich (1970) asked: `..Should we believe the technical optimists, who hold that science and technology can solve resource problems? Or should we listen to those, who argue that mineral resources are exhaustible and irreplaceable?..'. Gray & Mathes (1975) expressed another concern in that period, namely that the Northern industrialised society has embraced a pseudo-religion of technology with an uncritical belief in technological progress. So, overall, within the mainstream belief in technical solutions to environmental problems, many scientists asked divergent questions in the second half of the 20th century.

Environmentalists who spread the message about environmental problems in the 1960s and 1970s, were often accused of two things:

a) They threatened the welfare of people by opposing industrial development and technological improvements because of environmental pollution;
b) They wished to go back to the Stone age in order to regain a healthy environment; in this approach they were compared to the Luddites,[5] textile labourers who opposed and occasionally destroyed new textile machines that led to the phasing out of demand for their handwork in the early 19th century (Albrecht, 2000, Fox, 2002).

During several decades environmental advocacy organisations grew to maturity with a differentiated strategy including a mixture of protesting, lobbying, bargaining and co-operating to reach their targets. As an illustration of a more radical approach, a critical Dutch environmentalist is quoted as stating: `..It is the ultimate time to sharpen the environment policy. Central in that policy should be the term Sustainability that has a long tradition. The intellectual source of the term lies in the nineteenth century. The liberal economist, John Stuart Mill, wrote most eloquently about it. He introduced the term *stationary economy*: an economy in balance with the natural resources. He found it wise to develop such an economy long before humans were forced to do so. In that way, humans will have the enduring availability of a relatively large *environmental capital*. In light of the actual knowledge, it is

[5] The Luddites is a label for groups of *technophobians* who destroyed production machines on a large scale at the beginning of the 19th century; they were named after Ned Lud who once destroyed two small weaving looms in an individual action to stop mechanisation.

an advantage to develop such an economy also for reasons of pollution. That means that the emission of very slowly degradable compounds into the environment must end and that the human-caused poisoned locations with a long life (toxic dumpsites, the fading Ozone layer) must be sanitised..' (Reijnders, 1997).

However, critiques about a stationary economy are often one-dimensional, saying that a stationary economy is static and that economic growth is needed for a sound economy. Other dimensions of an economic system, such as human values and quality, are neglected in that approach. That leads to several questions such as: is more in-depth thinking needed to fulfill societal needs? Does radical analysis inevitably lead to the Stone Age romantics? Has the economy - ecology dichotomy evolved into a traditional confrontation? Who are the most influential and powerful actors in decision-making processes, in which the environment seems to be relevant, for assessing the conditions and not the content of economic decisions? Can the core philosophy of the Sustainable Enterprise and Corporate Social Responsibility concepts in relation to environmental health, sound business economics and social responsibility provide the dynamics at different levels in the stationary economy versus economic growth debate?

This overview of the differing perceptions of scientists illustrates that a range of different outcomes can be the answers to the same questions when the answer is provided on a one-dimensional basis. In addition to scientists, citizens, politicians, entrepreneurs, employees, consumers and so on also hold a wide range of perceptions. For instance in 1975, two anonymous representatives of industry and an environmental NGO were asked for comments on the findings that citizens placed criminality as the number one problem on their list of urgent problems, followed by a cleaner environment as number two and the future availability of energy and resources as number three (SMO, 1975). The industrialists stressed the difficult task of government to manage change and share common goods in the near future. The activists worried about the solutions for environmental problems that had the following characteristics in common: they are a) technical, b) short term, and have c) a one-issue focus (SMO, 1975). It would be interesting to learn whether that assessment has begun to change, now, early in the 21st century. Are we better equipped nowadays to solve environmental problems? Have we learned to integrate environmental issues in order to prevent pollution arising from our activities?

Those differing perceptions are part of divergent attitudes that influence the recognition and acknowledgement of new concepts. That includes the assumption that policies covering that range of divergent attitudes must take into account the fact that the introduction of new concepts will be influenced by, and in turn will influence, the dominant actors in the field. In that way it is assumed that the introduction of new concepts, such as cleaner production and industrial ecology, is not a value-neutral process and will both benefit from opportunities and face resistance to change.

1.2. Introduction to the concepts and research questions

In a heterogeneous industry, new approaches such as environmental management generate both resistance to change and differences in speed of change as well as front-runners and laggards issues. Nevertheless, the general public still shows - especially with respect to the chemical industry - a negative environmental focus on industry (Williams, 1997). Also, various governmental organisations have quite different perspectives on industry.

What is it all about? The thesis describes and reflects on developments towards a cleaner industry within the framework of sustainable development. The development, recognition and dissemination of the concepts of *cleaner production* (prevention within a company) and *industrial ecology* (prevention beyond the single company through clustering and utilisation of material streams between companies) are the research issues in the thesis. In the course of time, the definitions of these two concepts were translated into other terms, and modified and specified for reasons of extension and better feasibility. Some definitions will be briefly described in this section.

In 1975, the concept of *pollution prevention* was first developed and implemented by the Minnesota Mining and Manufacturing Company (3M)[6] through a programme they called `Pollution Prevention Pays' (3P) (Ling, 1984). The concept was 3M's answer to the many penalties for violations of water and air quality standards and to the pollution control approaches that were typically used by industry to try and comply with standards.

The US government elaborated their environmental policy using concepts such as pollution prevention, waste reduction and waste minimization. *Waste reduction* is defined as: `..Waste reduction refers to in-plant practices, that reduce, avoid, or eliminate the generation of hazardous waste so as to reduce risks to health and environment..' (US OTA, 1986); the definition of *waste minimization* is: `..The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either the reduction of the total volume or quantity of hazardous waste, or the reduction of toxicity of hazardous waste, or both, so long as reduction is consistent with the goal of minimising present and future threats to human health and the environment..' (United States Environmental Protection Agency - US EPA, 1986).

Cleaner production is a modification of the US EPA definition of *pollution prevention.*[7] A group of United Nations Environmental Programme (UNEP) experts developed a definition of cleaner production in 1988: `..Cleaner production means the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment..' (Baas *et al*., 1990). UNEP modified the definition in 1996 to state explicitly that products and services are also included within the concept of cleaner production.

The US EPA also modified their definition of pollution prevention frequently. In 1995 the US EPA Centre for Environmental Research Information introduced the following definition: `..Pollution prevention is eliminating the creation of pollution at the source and it also includes energy conservation, water conservation, and the protection of natural resources..'.

Information about, and the application of, the concepts of cleaner production developed throughout the world during the 1990s. For instance the Australian Environmental Protection Agency in conjunction with the Ministry of Science, Technology and Environment of

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[6] The 3M company originally mined what they thought was Carborundum, a mineral ideal for making sandpaper and grinding wheels in 1902. Currently, it is a diversified technology company centred on innovative office articles, display, graphics, electronics and telecommunication.

[7] The use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at source. The definition includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use, US EPA, 1990. Another definition, that was used briefly, was: `Pollution prevention is the prevention or reduction of pollution at source when feasible', US EPA, 1993.

Thailand formulated the following definition in 1996:[8] `..Cleaner Production is a strategy to continuously improve products, services and processes to reduce environmental impacts, and to work towards ecologically and economic sustainable development..'.

The second concept that is analysed in this thesis, *industrial ecology*, has also been defined, and redefined, in many ways. Industrial ecology provides a somewhat different perspective from cleaner production by broadening the scope from optimisation within companies to co-operation between companies (cascading, facility sharing, and so on). Frosch and Gallopolous (1989) re-introduced the concept in an article in the journal American Scientist, using the following definition: `..An industrial ecosystem is the transformation of the traditional model of industrial activity, in which individual manufacturing takes in raw materials and generates products to be sold plus waste to be disposed of, into a more integrated system, in which the consumption of energy and materials is optimised and the effluents of one process serve as the raw material for another process..'. Allenby (1994) formulated a more holistic approach in his definition: `..To manage the earth's resources in such a way as to approach and maintain a global carrying capacity for our species that is both desirable and sustainable over time, given continued evolution of technology and quality of life. The study of what this entails, especially in terms of existing (objective) and desirable (normative) patterns, is industrial ecology..'. The different levels of the concept of industrial ecology are elaborated in Chapter 3 of this thesis.

The integration of environmental issues in industry developed from an *externality problem* (we have to control the negative effects of our production processes) towards an *integrated management issue*. The thesis elaborates this development using the metaphor and theory of a *paradigm shift*. Especially in the transition process towards pollution prevention, the old paradigm is:

1) Environmental performance improvement measures always cost extra money;
2) Industry cannot afford these measures because they will negatively influence their competitive position.

In this approach, companies meet regulatory requirements by solving their environmental problems with end-of-pipe pollution control technologies, while at the same time fulfilling environmental regulatory requirements against extra production costs. From this vantage point, corporate leaders believe that if competitors in other countries do not have to meet the same environmental requirements, the competitive position of the company that has to invest in such measures deteriorates.

However, from the perspective of cleaner production, negative effects of the current production processes and the content of products are considered in advance. With a better insight into what happens, wasting and pollutants can be prevented or at least substantially reduced; therefore extra costs can be avoided, and greater efficiency can be achieved. Thus, the new (normative) paradigm for pollution prevention and cleaner production is:

1) Pollution prevention is better than cure;
2) Integration of prevention throughout the entire lifecycle of production processes and

[8] Australian Environmental Protection Agency & the Ministry of Science, Technology and Environment of Thailand, Industry Workshop, Bangkok, 1996.

products contributes to better economics and to a better innovation capability for the whole company.

Because there was no demand for new preventive approaches (Dieleman, 1999), Dutch company managers often allowed cleaner production demonstration projects at the beginning of the 1990s. *Allowed* in a way that they were either afraid of a negative image if they did not co-operate or curious without knowing the potential results. Moreover, regulators who either did not know the concepts or were afraid that a preventive approach would interfere with their strict regulatory concepts and instruments did not support or promote them.

On the basis of experiences in action research,[9] we can reflect on what was happening and what were the core variables and change mechanisms in the process of acceptance of a new paradigm. Such changes can be stimulated via change mechanisms such as selection or isomorphism (Boons *et al*., 2000) or via significant others.[10] At the macro level, politics and public opinion can steer or influence, in the mode of a top - down process of acceptance and internalisation. At the meso level, a person, an industrial sector, a community, an environmental NGO and an expertise centre can be a role model for change. These significant others can function in a bottom - up or in an equal level process. Some history is described in the following section.

It has been observed that the cure of environmental pollution has improved over the last two decades. The environmental policy approaches tend to be more integrated and preventive, although the preventive approach still needs to make a definitive breakthrough in the mainstream context of pollution control to facilitate sustainability. The desire to facilitate the achievement of better environmental performance that fits into business economics was the trigger for early concept adopters to disseminate an innovative concept such as cleaner production. The dissemination of this concept in the Netherlands started with university research at the end of the 1980s, followed by dissemination projects of newly established governmental institutes in the first part of the 1990s. From the mid-1990s, national cleaner production programmes generated a financial stimulus for branch organisations, labour unions and consulting firms to promote and to perform cleaner production assessments in small- and medium-sized companies.

This thesis examines the development of the *cleaner production* concept and its dissemination in the period 1985 – 2000. The concept of *industrial ecology* provides another development in the inter-relationship with the cleaner production concept itself in the period 1989 - 2000. As another dimension of the paradigm shift, the concept developments were not linear and not without antagonistic thinking. Taking the *ebb and flow* attention for, and the *corkscrew curl* development of the concepts into account, the following central (normative) research question was formulated:

Does the dissemination of preventive approaches in production and product development within and between companies effectively contribute to a paradigm shift towards sustainability?

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9 Action research can be described as a family of research methodologies, which pursue action (or change) and research (or understanding) at the same time (Dick, 1999).

10 Persons who have the greatest influence on an individual and the individual's self-evaluation and also on the individual's acceptance or rejection of certain social norms (Sullivan).

This central question is elaborated in three further sets of questions that describe and analyse the developments of the cleaner production and industrial ecology concepts:

1) What were the origins and the characteristics of the cleaner production and industrial ecology concepts and the intervention processes leading to the application of these concepts and accommodation with their implementation?

2) How and under what conditions did companies translate the concepts of cleaner production and industrial ecology into action? How did cleaner production and industrial ecology implementation processes deal with learning processes?

3) What can be concluded about the processes of change leading to the implementation of the concepts of cleaner production and industrial ecology? Do the developments provide evidence of a practical paradigm shift in concept innovation?

1.3. The design of the dissertation in more detail

In relation to the societal context, environmental awareness developed towards a high and visible level in the early 1990s and a high-internalised level (both latent and overt) at the end of the 1990s in the Netherlands. At the beginning of the 21st century, despite the fact that many environmental issues had been internalised in human activities, manifest attention to new or persistent environmental issues declined. Besides the fluctuating attention to environmental issues, we have to take into account the reasons behind this to answer the following question: why does solving environmental problems receive almost 100% emotional support, although our activities are often based on rational or pseudo-rational behaviour and are in contradiction to the positive verbal support given to solving the problems (Verhallen & van Raay, 1982)?

The Ph.D. thesis is written in four parts. *Part I* covers the design of the thesis (this chapter), theoretical considerations and the dissemination context of new concepts. Chapter 2 addresses the *concept transition* processes from a theoretical point of view. At the end of Chapter 2, attention is paid to the research methods that are relevant for this type of research. Both the theory on *practical paradigm* changes and learning processes and interactive research methods acknowledge and build upon the trans-disciplinary character of environmental sciences. There is not one method or one theory to cover all aspects of changes and innovations in production processes and products with respect to the environment.

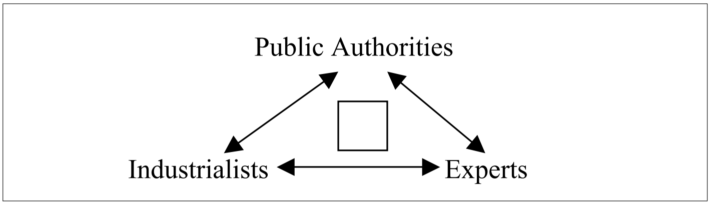
Several theoretical approaches are embedded in the conceptual model of this thesis. As Kuhn (1962) stressed in a natural sciences context, a new scientific paradigm usually emerges after a period of contradictions and eventually a period of crisis, called anomaly, in which a revolutionary breakthrough leads to a new paradigm and a new period of *normal science*. In addition to Kuhn’s theory, Van Strien (1980) designed a model for the description of developments in the social sciences. The essential point of Van Strien starts with the observation that developments within social sciences are comparable to developments in natural sciences (growth is not linear but convulsing). In addition to this similarity, social science developments are extensively influenced by changes within society and in particular by successful alternative experiments. As stated earlier in this chapter, despite the restrictions of strict regulation, no anomaly in environmental policy or need for a revolutionary breakthrough were experienced within society. Nevertheless, because several dimensions of a social paradigm shift towards a pollution prevention policy were/are needed, I will use the cleaner production practical paradigm shift as a metaphor for the transition to sustainability.

Chapter 3 presents the context of the new concepts and research on their dissemination, based on a brief overview of the Dutch Environmental management public policy. Furthermore the relationship between technology and the environment, the prevention field at the meso level and the relationship between cleaner production, integrative chain management and industrial ecology, are also discussed.

Part II, made up of Chapters 4, 5 and 6, deals with the cleaner production concepts. Chapter 4 reflects upon practical developments concerning the cleaner production concepts in the period 1985 – 2000 in the Netherlands and in different regions of the world under the label a *decade of cleaner production promotion*. The analysis of cleaner production dissemination projects in the last decade is performed with secondary analyses of research documents in the perspective of a longer timeframe. The dissemination of cleaner production internationally is illustrated through the UNIDO/UNEP National Cleaner Production Centres Programme, that is being promoted world-wide (UNIDO/UNEP, 1997).

I look at the actors who initiated the development of the new concept of cleaner production and how other stakeholders accepted that initiative within their normal practice. In other words, `who is following whom?' in the domains of public authorities, industrialists and experts such as researchers, educators and consultants. Figure 1.3 provides a simple view on the dominant category of actors. Are industrialists following public authorities and experts or are they leading the developments? Of course, such a situation is dynamic (for instance, persons can move from one category to another), but it is helpful to visualise the analysis.

Figure 1.3 **Leading and following categories of organisations: Who is following whom?**



Chapter 5 deals with new information needed for analysing and testing the data and images of the actions that were described in cleaner production projects addressed in Chapter 4. The social method and analytical frames were elaborated at the micro, meso and macro level in order to develop first the *bouncing ball-amplitude* conclusions for the representation of social life (Ragin, 1994, see Chapter 2).

In Chapter 6, the balance between cleaner production research findings and the relationship with learning processes at different levels is explained. For instance, at a national level, the content of the Dutch Chemical Industry journal on environmental issues in the volumes 1998, 1999 and 2000 was analysed.

Part III, made up of Chapters 7 and 8, covers the industrial ecology concepts. Chapter 7 reflects on the evolution of the industrial ecology concept in the period 1985 – 2000. It describes and analyses the industrial ecology projects in the Rotterdam Harbour (INES project, 1994 - 1997) and the follow-up project INES Mainport Rotterdam (1999 – 2002). In the INES project, the focus shifted from environmental management systems and cleaner production concepts towards industrial ecology, primarily from an environmental perspective. After the publication of the Dutch public policy document *The Environment and The Economy* (1997), the *Sustainable Industrial area* or *Eco-Industrial Park* approach developed in the same direction, primarily from a physical planning perspective. In addition to this, the chapter includes an overview of research on Eco-Industrial Park development models in several projects all over the world. Chapter 8 contains an analysis of the growing attention to regional types of industrial ecology in relation to learning processes, system boundaries, perception and cluster alliances.

Chapters 4 and 7 having *described* and *characterised* research activities and results of the dissemination projects of the two concepts under study, Chapters 5, 6 and 8 provide an *analysis* of these research activities. Together, these chapters allow images and evidence to be integrated in Chapter 9 that, together with the Chapter 10, constitutes *part IV* of the Ph.D. thesis.

The question is, what are the positions of the concepts of innovation and change management (including integral chain management), industrial ecology and sustainable regions, within the sustainability process? Furthermore, what about the ebbs and flows in interest, both for the environment (Downs, 1972) and organisational changes (Etzioni, 1968), that can strengthen or weaken ecologically-induced changes? What is their position in the development of a *concept innovation* theory for sustainability?

In Chapter 10, the final conclusions are used for the construction of: (1) typologies of a cleaner production-based change processes advisory model; (2) a cleaner production dissemination policy analysis quick-scan; (3) a typology of issues and dimensions in an industrial ecology framework; and (4) recommendations on more appropriate processes to support the dissemination of new concepts designed to influence the pathways to sustainable societies. The chapter ends with conclusions about the need for new institutional arrangements and a research tradition that facilitates the dynamic implementation processes of new concepts.

Finally, Chapter 11 is an afterword based on 15 years of experiences and observations of the emergence and dissemination of new preventive concepts.

1.4. **The relevance of this thesis**

This thesis reflects on the consequences for society of the development and adoption of new concepts, in this case cleaner production and industrial ecology (normative line). It also asks whether institutional changes (paradigm shifts), translating (Latour, 1986), framing (Goffman, 1969), and types of learning processes and mapping (Bateson, 1972) can be identified (scientific theoretical line). The scientific relevance is multi-level and refers to:

1) The theory-forming value from either a radical (Kuhn, 1962) or a gradual societal - breakthrough or a combination of both at different levels is assumed to be necessary for the analysis of Sustainability company management. The model of the practical paradigms of Van Strien (1986) can be transformed from engineering-dominant interventions to the integration of environmental aspects in organisational processes of change (this approach is also named environment-including thinking: Dutch Ministry of Environment, 1996, 1995 Annual Environment Report of the Rotterdam municipality, 1996). This is an interactive

(Ragin, 1995) and triple learning process (Snell and Chak, 1998) in which tacit knowledge also plays an important role.

2) In the Dutch National Environmental Policy Plan (1989) and the Dutch National Environmental Policy Plan Plus (1990), both the recognition and acknowledgement of environmental problems, and giving responsibility to target groups for good environmental performance, are stressed. It would be interesting to ascertain whether the up and down phasing of recognition and solution of environmental problems according to the theory of Downs (1972) can also be used in the practical paradigm change to Sustainability company management.

This thesis is socially relevant, thanks to the insights it provides into the factors and actors who are important to overcome the temporal and spatial dilemmas involved in Sustainability company management. Factors such as social dilemmas, stakeholders' perceptions of each other, the institutional framework, information processing and system boundaries in decision-making are covered in the thesis analysis. Also, the development of better inter-generational and intra-generational equity in the access to resources is an important societal variable. The reduction of material use and pollution are issues of societal relevance that can be directly influenced at the company level.

1.5. **The main features of this thesis**

In summary, the thesis addresses the prevention research projects used as awareness-raising processes related to the development and dissemination of new concepts such as pollution prevention, cleaner production, industrial ecology and sustainable development. In this approach, the pollution prevention paradigm as a concept innovation for a clean industry replaces the old paradigm of pollution control. In the pollution prevention paradigm, the exploration of resources is seen as part of an *environment included-industrial policy*, not of a *waste policy*.

The current institutionalised societal structure means that stakeholders increasingly need each other's co-operation to create the conditions, includes thinking in new related concepts, for sustainable development. In the past, a different focus during successive time periods can be recognised: environmentalists and citizen's groups brought the environmental problem on the political agenda in the 1960s and 1970s, government formulated environmental laws, policies and instruments in the 1970s and 1980s, then industry explored environmental management systems as instruments for their environmental policy – facilitated and triggered by economic and voluntary instruments that stimulated processes of self-regulation and responsibility. After the start within some American companies in the 1970s, more companies independently launched preventive initiatives in the 1980s and 1990s. At the beginning of the 21st century, the development of the concept of sustainable enterprises and corporate societal responsibility began to spread more widely.

Presently, in many developing countries, industry faces *command and control* government policies. The implementation of these policies is weakly enforced and a high degree of corruption exists that further weakens the environmental protection potential of regulatory processes. The introduction and dissemination of cleaner production processes in these countries have to take this context into account. As international corporations and organisations, in particular, have to face such situations, the ensuing question is: can the major societal partners be made aware of the economic and environmental benefits of the preventive approaches and learn how to work together effectively in developing partnerships for establishing sustainable regions? The question points to the awareness that cleaner production promoters have to be active in development, dissemination and implementation of cleaner production policies too.

The development and dissemination of cleaner production and industrial ecology concepts are not linear. There is turbulence in steps forward and fall-backs (Hafkamp, 1996). Turbulence can be a sign of fundamental change such as the anomaly phase in a paradigm shift. However, fundamental change is often gracious and diffuse (Kalders, 1998) and the question of `What is a relevant timeframe for an analysis of such a change process?' makes such a fundamental change difficult to detect.

This thesis is designed to cover the above considerations in answer to two views on the development of cleaner production (as part of sustainable company management at the micro level of companies) and industrial ecology (as part of sustainable regions at the macro level beyond companies):

- Firstly, the idea of successive concepts: the route of professionalisation and specialisation of cleaner production, eco-design, total cost/benefit accounting, and industrial ecology.
- Secondly, the idea of competing concepts: the route of responsible care, environmental management systems, eco-auditing, supply chain management, eco-efficiency, green productivity and eco-industrial parks.

During the process of providing information for awareness-raising and demonstration projects, the concepts are modified, specified and translated under different labels. The two views can either interfere or complement each other. Environmental management is not the core business of companies, but an increasing number of companies are working on the integration of environmental aspects into their company management. The traditional outside approach of companies as `black boxes, having their own responsibility' is changing towards a stakeholder approach. Multi-national corporations in particular are becoming involved in the sustainability discussion that requires a stronger embedding of industry in society. The joint environmental, social and business economics approach in some of the larger companies is increasingly being perceived as signifying their integration into sustainability (the triple bottom line).[11] The thesis tests whether this development has been taking incremental or radical steps as part of a *practical paradigm shift.*

[11] Originally, the painted lines on a ship indicating the maximum load of different types of goods (Oswick *et al*., 2003). Used as a metaphor, it means that the triple bottom line stands for an optimisation of the integration of the ecological, economic and social dimensions simultaneously on an on-going basis.

2 The Prevention Concept and Theoretical Considerations

This chapter proposes a theoretical framework for the structure of the research field in which the introduction and implementation of new concepts challenge the routines of the existing system. It is assumed that the new concepts challenge those routines as regards to their implementation. Two aspects are particular to the cleaner production concept: it has a strong value dimension and it is part of non-core business issues that strongly affect the core business of the organisation. The dimensions of the processes of change are explored at the micro, meso and macro levels of organisations and society. The research field is discussed in Section 2.1, where the location or need for transition processes of new concepts is visualised. Organisational change and learning processes are covered in Section 2.2, both in general and in the case of cleaner production – as the change and learning processes in the transition model meet both dimensions. Considerations about paradigm shifts are elaborated in Section 2.3, followed by an examination of social theory and practical paradigms in Section 2.4. Section 2.5 reflects on the touchstones of the analysis and Section 2.6 explains the methodology and methods that are used for the research of emerging concepts. Section 2.7 briefly recapitulates the theoretical considerations.

2.1. The research field of the concepts

Schatzman and Strauss (1973) simply apply the term *field* to a relatively circumscribed and abstract area of study. In this thesis however, in essence society as a whole is the research field of the emerging concepts of cleaner production and industrial ecology at a regional, national and global level. Overall, the dissemination of the concept of cleaner production takes place in a field best described as a type of market or network (the competitors market), where the visions of stakeholders (the key actors within the institutionalised framework of society) meet each other. In this market, the dissemination of the concepts and approaches is in the hands of people. In the translation process, in the words of Latour (1986), `..they can drop, modify, betray, add to or appropriate the concept..' (the modification of the rules of competition). The sustainability concept needs acknowledgement within the organisation as well as in its network. The sustainability concept is the elaboration of cleaner production and industrial ecology in which change processes such as concept innovations and their learning processes play an important role in the transition to sustainable company management and sustainable regions.

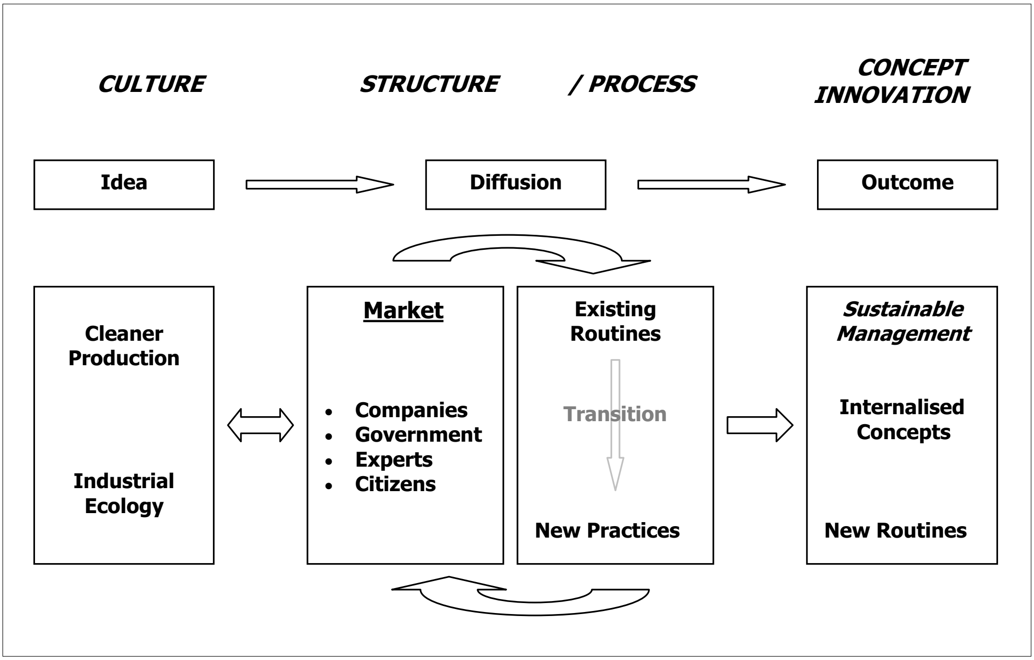
In this approach, society as a whole is a *market* in which different actors occupy different positions and play different roles. The possibility for each actor to influence societal processes is relatively dependent on the values, targets and interests of other actors. Government organisations at different levels can have important contacts with companies. At the same time, government is also part of society and can be positively or negatively influenced. The stakeholder approach can be used in the promotion and dissemination of new concepts, whilst co-ordination in the network cannot be imposed because of the different power, values, targets and interests of each actor.

The term *concept* is related to the approach of Karsten & Van Veen (1998), that contains four elements: a label (not a crystallised theoretical framework), a problem analysis, a solution, and the implementation of successes.

All considerations about the introduction of new concepts such as cleaner production and industrial ecology face an institutionalised market with routines on environmental performance that challenge *changes in routines* in the competition to achieve better market positions. As the preventive approach is presented as a better business practice, the link between the four elements of Karsten & Van Veen (1998) and the cleaner production concept provides *prevention as vision* as a label, the *cleaner production assessment* in an organisation as instrument for problem analysis, the *cleaner production options* and the integral approach of *continuous improvement* as solutions, and the *cleaner production demonstration projects* as part of a *cleaner production dissemination infrastructure* as the applications of successes.

The market of transition processes of new concepts is visualised in the following model:

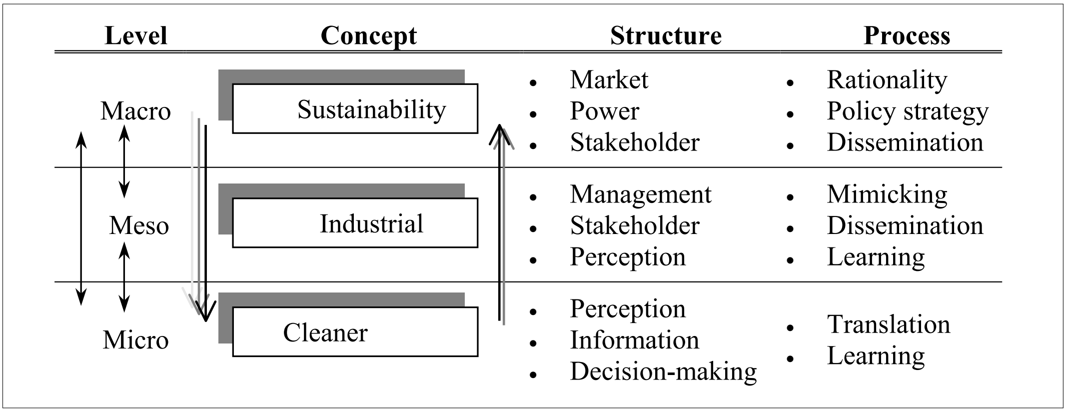
Figure 2.1 **The market of transition processes of new concepts**



It is assumed that a representative of one of the four societal categories in the market of concept transition processes figure will explore a new concept such as cleaner production and industrial ecology knowledge dissemination. Committed to the new concept, the introducing actor(s) will approach organisations to explore it. After the introduction, acknowledgement and acceptance of the concept, learning (explicit or implicit) and change processes connected to the new concept affect expertise at the individual and organisational levels. In this thesis, the concepts of cleaner production, industrial ecology and sustainability are connected to the micro, meso and macro levels. The different levels are used in relation to system boundaries such as single organisations, organisations located in regions or as members of an industrial sector, and society. There are also levels within an organisation that affect the dissemination of a new concept. For instance, for the introduction of cleaner production, the focus is on single organisations; outside actors can introduce the concept and the translation by internal actors might affect the routines. The introduction of industrial ecology goes beyond single organisations, which means that actors outside the companies will influence the overall processes in a dependent manner in relation to the individual company managers.

The dynamics of dissemination affect all levels of the concepts and their connections. For example, pressure from society as a reaction to the economic globalisation processes influences the integration of sustainability at all levels. The analysis reflects both the horizontal level of concept development and dissemination as well as the vertical levels of the inter-linking of cleaner production, industrial ecology and sustainability and their dissemination processes in the period 1985 - 2000. Perception, power and the related information processing are important variables for the rationality of the design and depth of translation and learning processes at all levels. They influence the relation between the existing structure and processes of change, either through the development of policy strategies at macro level or learning by doing approaches at micro level. Taking the main dimensions together (taking into account the fact that a dimension such as power influences all levels), the connection between levels and concepts, and structure and process, reflects the research field model in this thesis[12] and its further elaboration in this chapter:

Figure 2.2 **The 'research field' multi-level concept innovation model**



The capacity and capability to break through existing routines is part of an eventual organisational change. Learning processes related to the new cleaner production concept face the techno-structure based on an engineering perspective at the micro level that dominates its translation. The learning processes for industrial ecology face a (plant) management perspective that is limited to the system boundary of their organisation. At first glance, the translation of the new concept is mainly based on mimicking. Both mimicking and dissemination include learning processes. Mimicking involves above all the reception or passive translation of knowledge, while dissemination includes a process of knowledge

12 The thesis mainly discusses the dissemination processes of cleaner production and industrial ecology.

transfer. At the macro level policy strategy development, both at the private and public organisational levels, is subjected to the influence of translation processes of stakeholders.

The attention paid to *sustainability* company management and the social dimensions of the sustainable use of resources, energy carriers and environment stocks in this thesis is based on the practical paradigm shift[13] in social science theory (Van Strien, 1986) as an elaboration of the theory of Kuhn (1962). Societal, economic and technological paradigms and their potential transformation, according to Kuhn (1962), will be analysed in relation to an eventual industrial reorientation towards sustainability (CIESIN, 1992).

The societal context for new issues may become modified over time, but it is, in many cases, not new. Argyris and Schön (1978) wrote that halfway in the 1970s, `..Governments are torn by the conflicting demands of full employment, free collective bargaining, social welfare, and the control of inflation. Corporations have found themselves constrained by a web of increasingly stringent regulations for environmental protection and consumer safety, at the same time that we are most sensitive for jobs and for economic growth. Governments and business must learn to understand and accommodate these demands, and work together to solve these problems..'.

This analysis is, generally speaking, still relevant. In the 1990s many scientists wrote that sustainable development in the Northern hemisphere needed a breakthrough in societal, technological and economic practice. That change must go beyond environmental performance as such. It relates to the learning processes for the integration of economic, environmental and social performance: the *Triple Bottom Line*. As an elaboration of the Triple Bottom Line approach, I include innovation within the current practice: the principles of cleaner production (UNEP 1989, 1992), industrial ecosystems (Allenby, 1994, Graedel & Allenby, 1995, Lowe, 1996, Boons & Baas, 1997), social accountability (SAI, 1998, AccountAbility, 1999), sustainability (Rossi *et al*., 2000), processes of innovation and change within companies (Cramer, 1997, 2001, Roome, 1997, Boons & Berends, 1999, Dieleman, 1999), and corporate social responsibility (Cramer, 2003, GRI, 2003).

2.2. Organisational change and learning processes

Answering the question What is involved in organisational change?, Czarniawska and Joerges (1996) refer to two dominant images of organisational change: as a planned innovation or as an organisational (environmental) adaptation. The first image includes strategic choices, decision-making and organisational development as the execution of an intended change; the second image includes contingency theory, population ecology and institutional theory as an explanation for human activities leading to habit formation or routines. That habit formation is institutionalised. The institution provides a framework for activities.

The characteristics of organisational interventions are generally based on valid information about the organisation's functioning; they will provide organisational members with choices and gain members' internal commitment to these choices (Cummings and Worley, 1993). The interventions themselves can take different forms, but cleaner production projects are often limited to *technological* intervention, such as the production process

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13 Practical paradigm shifts are radical changes in routines in daily practice, based on new insights into social sciences (Van Strien, 1986).

assessments as the basis for options concerning production process changes. Furthermore, since the mutual exchanges of lessons learned are often vital for the creation and use of synergy, these learning processes have to be managed (Zwetsloot, 1994).

In a report for the American Academy of Management, Kofman and Senge (1998) noted the importance of dealing with the main dysfunctions in our institutions: `..such as fragmentation, competition, and reactiveness that are frozen patterns of thought to be dissolved..'. The solution they propose is a new way of thinking, feeling, and being: a culture of systems. It is interesting to document how companies translate the cleaner production intervention as a reformation of an external idea (`..the concepts and routines that fit with their existing practices..', Latour, 1986).

Normative concepts – such as the *prevention is better than cure* approach of cleaner production projects – assume implicitly the involvement of all members of the organisation in identifying and implementing both non-technical and technical improvements. Although, for many, environmental issues send out positive signals, approaches for tackling them should not only be trial and error research of new concepts that may lead to a lack of theoretical understanding of the social system. Also, `..some type of *theory of value* is needed to neutralise the moral dogma of the undeniable intuitive appeal to the nonconsequentialist claim that some things are right or wrong whatever their consequences..' (Goodin, 1982).

In the following paragraphs, attention is paid to individual and organisational learning processes, first in general, then through a theoretical linking with the concepts of cleaner production and the `research field' multi-level concept innovation model. It is the basis for a discussion of whether the new concepts are, radically or not, part of implicit learning processes.

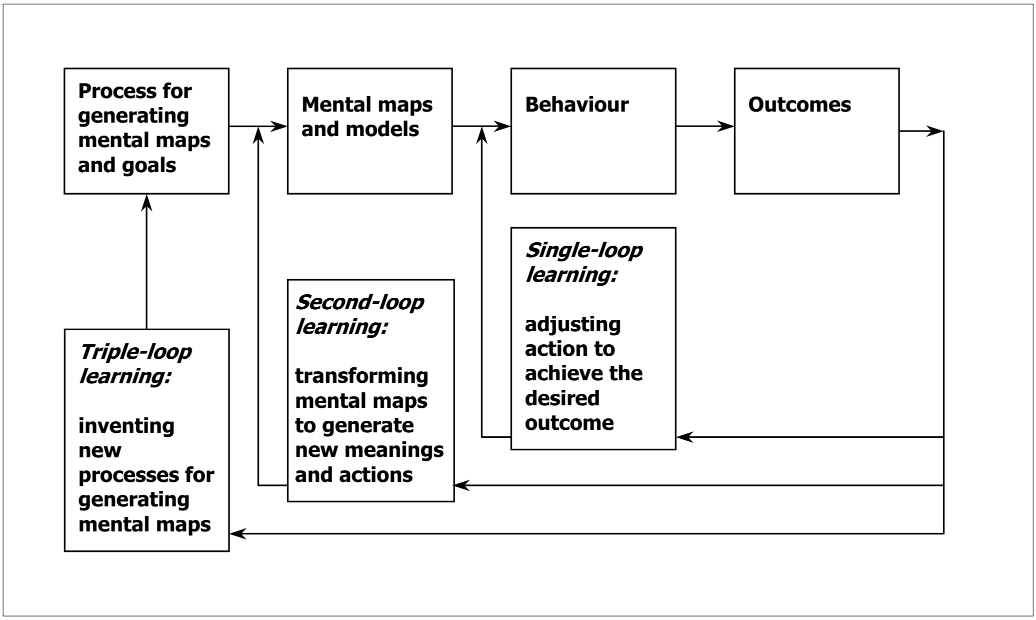
General learning processes

General organisational learning processes can be analysed according to different dimensions such as:

- Individual learning by members of an organisation to look after and cope with 1st and 2nd order changes in their organisations (Bateson, 1973);
- Four levels at the individual and organisational learning level with zero-, single-, double-, and deutero-loop learning processes (Snell and Chak, 1998);
- Four types of learning effects: *Learning by doing*, *Learning by interaction*, *Learning by using*, and *Learning by learning* (Vickers and Cordey-Hayes, 1999);
- Strategic or tactical learning (Dodgson, 1993).

Bateson (1972) applies his model to individual learning by members of an organisation. The model shows that individuals can look after and cope with 2nd order changes in their organisations. Usually organisations only deal with 1st order changes in issues of task operationalisation.

Figure 2.3 **Bateson's model of individual learning by members of an organisation**



In connecting individual and organisational learning processes, Vickers and Cordey-Hayes (1999) analysed four types of learning effects:

1) *Learning by doing* in manufacturing as a result of optimising the production process;
2) *Learning by interaction* as a result of contacts between supplier and contractor, or other external sources of knowledge and expertise;
3) *Learning by using* as a result of feedback from users;
4) *Learning by learning* where organisations develop the ability to be *reflexive*, such that institutionalised monitoring becomes an embedded characteristic of the system.

Furthermore learning can be characterised as either strategic or tactical (Dodgson, 1993):

- Tactical learning is of an immediate, problem-solving nature, i.e. relating to a product or an operational problem;
- Strategic learning is the development of managerial and scientific/ technological abilities that provide the basis for future innovation.

The combination of tactical and strategic learning (Dodgson, 1993) is very similar to the concept of learning by learning (Vickers and Cordey-Hayes, 1999). These approaches are based on feedback and evaluation of current activities and building reflexivity for finding new expertise.

Levels of learning

Argyris and Schön (1978) include what we can learn from mistakes in their approach. They define organisational learning as involving the detection and correction of errors. When the error detected and corrected allows the organisation to carry on with its existing policies or to achieve its present objectives, then that error-detection-and-correction process is single-loop learning. Double-loop learning occurs when error is detected and corrected in ways that involve the modification of an organisation's underlying norms, policies and objectives. These approaches narrow the learning processes down to reactions to errors.

Following the analysis of learning-loop processes by Argyris and Schön (1978), Snell and Chak (1998) broaden the reason for learning to improvements in individual and organisational learning categories. Within these two categories they distinguish four levels of learning with the following major characteristics:

Table 2.1 Characteristics of different levels of individual and organisational learning

Level	Individual learning	Organisational learning
Zero	When fresh imperatives arise or new control systems are devised, yet members fail to take corrective action	No changes are made in routines
Single-loop	When members make single, adaptive responses	Minor improvements are made
Double-loop	When members begin to see things in totally new ways	New structures and working practices are turned into general policy
Deutero or Triple-loop	Entails members developing new processes or methodologies for arriving at re-framing	Community brainstorms ideas on how future breakthroughs might be inspired

The triple-loop learning approach of Snell and Chak (1998) aims to arrive at re-framing the problems and implementing new approaches for solving them. It also requires that organisational brainstorms are regularly performed and that the ideas are implemented. It seems to be complementary with Schuyt's three layers of change in behaviour (1992): the transformation of norms and rules, institutional arrangements and cultural premisses and assumptions of a society. Schuyt sees synergy in the combination of the three layers, although a radical change in behaviour does not need to start in the first layer of norms and rules, but can also start in the third layer of cultural beliefs.

The overview of these learning and change in behaviour theories shows that general learning processes follow multi-loop and multi-level trajectories that after a period of time may result in 2nd order changes. Formulated in this way, learning processes can be incremental but can also have a non-intentional radical outcome. The gap (in linguistic terms) between *incremental* and *radical* changes seems to suggest that there is nothing in between and that only a paradigm shift can bridge the gap. Differences in the level and the character of learning processes can succeed, however, in narrowing the gap.

Nonaka and Takeuchi (1995) distinguish in their *knowledge creating organisations* four learning processes: socialisation (implicit knowledge is transferred between people through copying, mimicking, a teacher-learner relationship and trial and error experiences), externalisation (implicitly transferred knowledge between people is made explicit through models, dialogues and hypothesis), combination (explicit knowledge from different sources is combined through study, analysis, reformulation of information and integration) and internalisation (implicit knowledge is made implicit through learning by doing, the creation of routines and the enlargement of operational productivity).

Kolb (1984) sees a combination of four ways of learning as the best situation for his *theory of learning by experience*: divergent learning (analysis of observations), assimilative learning (modelling), convergent learning (empirical testing of models) and accommodative learning (observation of experiments). His theory defines an explicit learning process in which experiences with making and testing models are translated into individual knowledge.

This can be interesting for analysing cleaner production dissemination processes when it is combined with other levels of learning, such as the feasibility of linking these learning processes in the `research field' multi-level concept innovation model.

Linking knowledge and learning processes at the micro, meso and macro levels

Lam (2000: 487-489) illustrates a specific approach to linking knowledge and learning processes, namely the coherence and interdependence between the cognitive, organisational and societal level of analysis for our understanding of the nature of tacit knowledge[14] and its relationship with organisational learning. That understanding has been hampered by the lack of a coherent conceptual framework for integrating micro-level learning activities with organisational forms and macro-level societal institutions.

The knowledge of an organisation is socially embedded. The concept of social embeddedness bridges three levels of analysis:

1. At the *cognitive* level, the notion of social embeddedness underlines the tacit nature of human knowledge and the dynamic relationship between individual and collective learning. Knowledge of this kind is experiment-based: it can only be revealed through practice in a particular context and transmitted through social networks.
2. At the *organisational* level, it focuses on how the organising principles of the firm shape the social structure of co-ordination, and the behavioural routines and work roles of the organisational members within which the knowledge of the firm is embedded.
3. At the *societal* level, it draws attention to the way societal institutions shape organisational routines and co-ordination rules.

Lam (2000: 490-493) distinguishes the following dimensions in her analysis of human knowledge:

A. <u>Epistemological dimension</u>: human knowledge can be articulated explicitly or manifested implicitly (tacit). Critical differences occur in three main areas.

[14] Rosenberg (1992) defines tacit knowledge as the knowledge of techniques, methods and designs that work in certain ways and with certain consequences, even when one cannot explain exactly why.

Table 2.2 Critical differences between explicit and tacit knowledge (Lam, 2000)

Explicit knowledge	Tacit knowledge
Can be codified: ease of communication and transfer is a fundamental property	Is intuitive and unarticulated: is action-oriented and has a personal quality
Can be generated through logical deduction and is acquired by formal study	Can only be acquired through practical experience in the relevant context, i.e. learning-by-doing
Can be aggregated at a single location, stored in objective forms and appropriated without the participation of the knowing subject	Is personal and contextual, is distributive and cannot be easily aggregated, and requires close involvement and co-operation of the knowing subject

Polanyi (1992, 1996) argues that a large part of human knowledge is tacit. This is particularly true of operational skills and know-how acquired through practical experience. Knowledge of this type is action-oriented and has a personal quality that makes it difficult to formalise or communicate. The transfer of tacit knowledge requires close interaction and the build-up of shared understanding and trust between people.

The learning and innovative capability of an organisation is, in relation to this approach, critically dependent on its capacity to mobilise tacit knowledge and to foster its interaction with explicit knowledge. The richer the communication among the actors, the more knowledge (both tacit and codified) is communicated (Lundvall, 1992).

B. <u>Ontological dimension</u>: human knowledge can be articulated as individual versus collective.

Individual knowledge is that part of the organisation's knowledge that resides in the brains and bodily skills of the individual. It is a repertoire of knowledge owned by the individual, which can be applied independently to specific types of tasks or problems.

Collective knowledge refers to the ways in which knowledge is distributed and shared among members of the organisation (resembles memory or collective mind of the organisation). It can either be a stock of knowledge stored as hard data or be constituted by knowledge in a state of flow emerging from interactions. Explicit-tacit and individual-collective dimensions give rise to four categories of knowledge as depicted in Table 2.3 and further described in this section:

Table 2.3 Epistemological and ontological dimensions of explicit and tacit knowledge

Epistemological dimension	Ontological dimension: Individual	Ontological dimension: Collective
Explicit	Embrained knowledge	Encoded knowledge
Tacit	Embodied knowledge	Embedded knowledge

Embrained knowledge is dependent on the individual's skills and cognitive abilities. It is formal, abstract *or theoretical knowledge (knowing).*

Embodied knowledge is action oriented. It is a practical, individual type of knowledge that builds upon bodily or practical experience *(doing*).

Signs and symbols convey *encoded knowledge*. This is knowledge that has been codified and stored in blueprints, recipes, written rules and procedures *(information*). The abstraction of individuals' experiences and knowledge also facilitates centralisation and control in organisations (e.g. Scientific Management, Taylor, 1911).

Embedded knowledge is the collective form of tacit knowledge residing in organisational routines and shared norms: it is relation-specific, contextual and dispersed *(communities-of-practice)*. It is organic and dynamic: an emergent form of knowledge capable of supporting complex patterns of interaction in the absence of written rules.

All organisations contain a mixture of knowledge types. In general terms, organisations that are dependent on explicit knowledge tend to have formal structures of control and co-ordination and exhibit highly standardised tasks and work rules. Organisations with tacit knowledge will exhibit a decentralised structure and use informal co-ordination mechanisms.

Organisations can also depend on different knowledge agents. Those that rely heavily on the contributions of key individuals will tend to accord them a high degree of autonomy.

Learning processes for cleaner production dissemination

In this section some experiences with cleaner production dissemination are described. In analysing the dissemination of the cleaner production concept, Cebon (1993) points to the cultural assumption that routine technical expertise is the most important form of knowledge in industrial production organisations. That routine knowledge situation can be the cause of the occurrence of two kinds of errors:

a) The *you cannot find when you do not know where to look* theorem: engineers who are reasonably - but not intimately - familiar with the process may conclude that there are no cleaner production opportunities because they cannot see them;
b) When an organisation does not internalise cleaner production, the ability for changing a failure into a cleaner production opportunity cannot be seen.

Most of the world-wide findings in empirical research on the barriers to cleaner production dissemination are illustrated in research by Gunningham and Burritt (1997) in Australia. They found the following *internal barriers* in organisations: lack of information and expertise, low awareness of environmental issues, competing business priorities, in particular the pressure for short-term profits, bounded rationality in decision-making processes, financial obstacles, lack of communication in firms, middle management inertia, labour force obstacles, and difficulty in implementing cleaner technology. They also found the following *external barriers*: the failure of existing regulatory approaches, difficulty in accessing cleaner technology, difficulty in accessing external finance, perverse economic incentives, an absence of markets for recycled goods, and economic cycles. In order to change corporate culture, they drew attention to identifying the roles of information strategies, economic instruments, third parties, industry and regulation.

Whether the subject is change of behaviour, technology transfer, information gathering, or cleaner production, all processes are seen as multi-layer developments as illustrated in three approaches. Trott *et al*. (1995) argue that successful technology transfer requires that the organisation and individuals within it have the capability to manage:

- *Awareness*: search and scan the information that is new for organisations;
- *Association*: recognise the potential benefit of the information with respect to internal organisation needs and capability;
- *Assimilation*: communicate these benefits and assimilate them within organisations;
- *Application*: for competitive advantage.

This approach has a pro-active organisational attitude that involves looking for and applying information as a key variable for learning.

Gilbert *et al*. (1997) illustrate the dynamics of learning about cleaner production in a simplified model with four spheres. In this model, the consecutive acquisition-application-assimilation spheres are the drivers. The fourth sphere is feedback from the following levels of learning: *individual learning*, selection and transfer through individual association and awareness to the group that provides the basis for *group learning*, selection and transfer through application to the organisation that provides the basis for *organisational learning*. All three levels influence and are influenced by social learning.

Just as is the case with other new concepts, the dissemination of cleaner production is not self-sustainable. Bruce *et al*. (1994) analyse the dissemination process of new ideas in a corporation with the same type of establishments in several American regions. One of their findings is that the critical actors are the people who discover, apply and transfer the new ideas (Bruce, 1994: 130). General managers become concerned not only with the flow of materials but also with the flow of knowledge. Communication is an important variable: if plants are geographically dispersed and not linked by physical flows, little opportunity may exist for communication about current practices (Bruce, 1994: 131). Bruce identifies four critical phases as requirements for network information flow:

a) *Creation*: new management practices are developed at local plants;
b) *Identification*: requires that advances at local plants are recognised;
c) *Transfer*: disseminates the created and identified practices to other sites in such a way that they can be usefully applied;
d) *Application*: managers at other sites must be willing and able to apply the innovation to their local operations.

A description of these findings was not available when the cleaner production demonstration projects and dissemination policies were launched in the Netherlands. However, at the time of secondary analyses, this knowledge became available, and is now part of the existing body of knowledge. It is also used as a touchstone for the analysis of empirical experiences within this thesis.

2.3. **Paradigm shifts: love it or leave it**

The *paradigm shift* label is used as a metaphor for the introduction and diffusion of a new concept as in the model for research field multi-level concept innovation. The new concept does not constitute a neutral answer to a general interpretation of an anomalous situation, but an improved approach based on advancing knowledge about cleaner production. In a holistic approach, the new preventive paradigm deals, among other things, with the issue of cleaner production and industrial ecology as alternatives or potential partners in a larger set of processes within environmental approaches towards sustainable development. The new concept possesses some of the characteristics of a paradigm shift, such as the need for a different perception and a breakthrough in the institutionalised worldview and routines. New, emerging concepts that also contribute to the practical viability of the new paradigm of prevention are the concepts of eco-design, total cost (and benefit) accounting and green marketing. These environmental tools and concepts are being slowly integrated into several industrial sectors.

The organisational metaphor *a school of thoughts* of Morgan (1986) can be used for the analysis of the dissemination process of new concepts. The metaphor is comparable with the triple-loop learning approach of Snell and Chak (1998) to succeed in re-framing problems and implementing new approaches to solve them requires constant reflection. In the context of both the different levels of learning and the different types of human knowledge, and the levels of organisational change, the implementation of cleaner production and industrial ecology concepts is analysed in the Chapters 5 and 6 of this thesis.

The discussion about paradigm shifts revolves around several different conceptions. Kuhn (1962) stated with respect to natural sciences, that during certain periods of scientific development, doubt and uneasiness of the scientific community with the operative paradigms and theories is growing. A new paradigm usually emerges after a period of contradictions and eventually a period of crisis during which a revolutionary breakthrough leads to a new paradigm and a new period of *normal science*.

Popper's Logic of Scientific Discovery (1959) also rejects the evolution of scientific development. According to Kuhn (1977) Popper's ideas on revolutionary change are based on incidents. However, they both consider theories as imaginative statements, designed for application in nature. Because of that, new theories are often able to explain empirical data in the beginning, but face difficulties in a later phase. Kuhn reflected **on** the problem of binding criteria for a scientific choice that can block new theories. He asked rhetorically whether a scientific discussion could bring a solution (Kuhn, 1962). Lakatos (1970) criticised this approach as being more psychological than based on sound reasoning?. Lakatos stresses that one should search for the core issue by avoiding diversion through peripheral issues. Following this line of thought, Fuller (2001) states that `..Kuhn has bequeathed us more a general attitude toward theorizing about science than an empirically grounded theory of science..'. As a result Fuller believes that Kuhn's publication is the most widely cited work on the nature of science in the twentieth century.

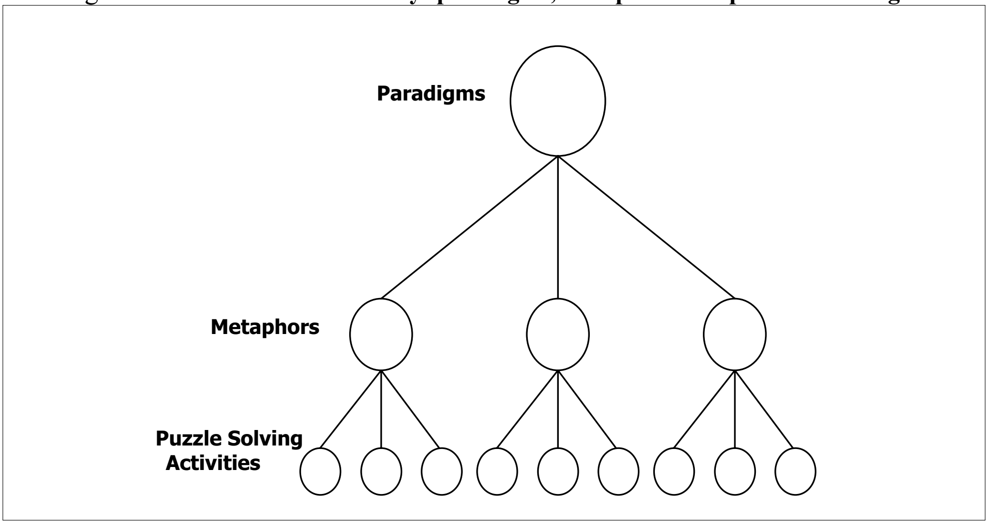
Morgan (1980) and Guba (1990) both refer to Masterman (1970), who discovered that Kuhn used the term of paradigm shift in twenty-one ways. According to Masterman, this is why many persons use different definitions. Guba sees this as intellectually useful and uses the term in a generic sense: `..a basic set of beliefs that guides actions..'. The various definitions can be characterised by the way proponents respond to three basic questions to which the answers refer to the basic belief systems or paradigms that are adopted:

a) *Ontological*: what is the nature of the knowable? What is the nature of reality?
b) *Epistemological*: what is the nature of the relationship between the knower (the inquirer) and the known or knowable?
c) *Methodological*: how should the inquirer go about finding knowledge?

Although the concept of paradigm has been subjected to a wide and confusing array of interpretations, Morgan (1980) perceives Kuhn's paradigm theory to be consistent with three broad senses of the term: (1) as a complete view of reality (or way of seeing), (2) as relating to the social organisation of science in terms of schools of thoughts connected with particular kinds of scientific achievements and, (3) as relating to the concrete use of specific kinds of tools and texts during the process of scientific puzzle solving. In this way, Morgan creates a cascade with the description of the Paradigm at the top level, the Metaphors at the middle level and the Puzzle solving activities at the operational level (see Figure 2.4):

- *Paradigm*: used in its meta-theoretical and philosophical sense to denote an implicit or explicit view of reality: **worldview**
- *Methaphor*: communities of theorists subscribe to relatively coherent perspectives, based upon the acceptance and use of different kinds of metaphor as a foundation for inquiry: **schools of thoughts**
- *Puzzle solving*: the identification of many kinds of research activities which seek to operationalise the detailed implications of the metaphor defining a particular school of thoughts: **normal science** (Kuhn, 1962)

Figure 2.4 **The view of reality: paradigms, metaphors and problem solving**



The use of a metaphor generates a heuristic function for studying a subject (Morgan, ibid). Grant and Oswick (1996) criticize the feasibility of scientific targets, because metaphors are not precise (a metaphor, per definition, does not cover the total nature of organisational life). However, the heuristic image can provide a basis for detailed scientific research using attempts to discover the extent to which features of the metaphor are found in the subject of inquiry. Much of the puzzle-solving activity of normal science is of this kind. Also the constructive approach of testing cleaner production concepts can be viewed as normal science within the category of applied science. The evaluation of cleaner production cases has provided the foundation for identical schools of thoughts in several universities worldwide.

Whether a practical paradigm shift emerged is more difficult to say; in any case, a worldview that this should happen is the conviction of many cleaner production advocates. In relation to intended processes of change, we must also be wary of creating the conditions for unintended transformations of concepts (this area is further explored in Chapter 4). Casti (1989, 11) also identifies unintended changes through the dynamics of systems in his description of science as: a set of *facts* and a set of *theories* that explain the facts, a particular *approach* (the scientific method) and whatever is being done by *institutions* carrying on scientific activity.

Because Kuhn developed his theory specifically for natural science, Van Strien (1980) designed a model that can be used for the description of developments in the social sciences. The essential point made by Van Strien is that developments within social sciences are comparable to developments in natural science (the growth is not linear but convulsing and in addition they are firmly guided by changes within society. As patterns for such a practical paradigm shift evolve, they support new knowledge development in a scientific discipline and provide new insights into societal developments that can be applied and integrated in social situations. The introduction of the new paradigm takes place via successful alternative experiments that serve as a useful illustration, and successful cases lead to further dissemination of the concepts. In this thesis, the dissemination of new concepts of cleaner production and industrial ecology are the main areas of intellectual enquiry.

As stated in the introduction to this section, the term practical paradigm is used in a normative way. It is assumed that the traditional pollution control approach will continuously increase the costs of pollutants management. The use of materials and energy will also increase. When an alternative concept can avoid the anomaly of growing materials use, pollution and costs, then the puzzle solving of pollution prevention can be explored. In this approach, a new paradigm can replace the previous one – used during twenty-five years of environmental protection activities – that focused on carrying on with the normal ways of production and adding cleaning technologies later on, when needed. In other words, pollution problems were treated within a paradigm of production that had developed at a time when adverse environmental effects were not yet recognised or accepted as significant.

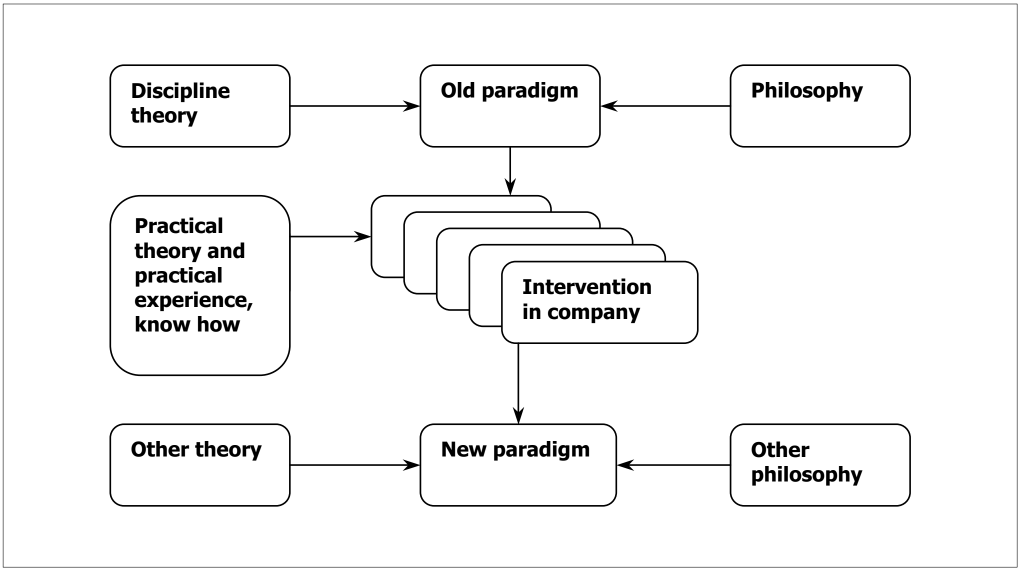
Van Strien (1980) has illustrated practical paradigm breakthroughs in management philosophy in general, and the classical example of the Scientific Management Paradigm, with its focus on humans as economic-rational actors in particular. In this practical paradigm shift, the scientific management paradigm – strongly rooted in the concern with detailed programming of the work of operators (Taylor, 1911) – was followed by the Human Relations Paradigm – with its focus on humans as social group actors – in which the informal social and psychological aspects of labour groups dominate (Roethlisberger and Dickson, 1939).

Whilst the scientific management paradigm was widely applied within industry, its primacy was challenged by the Hawthorne experiments (Roethlisberger and Dickson, ibid). Within this work, a research team was asked to experiment with labour conditions. These experiments resulted in changes in behaviour that the research team could not explain.

It was only at a later stage that a new research team was able to explain the changes in behaviour by using different theories that resulted in new insights and paved the way for a new practical paradigm. As the original Hawthorne team could not explain the results of their own interventions, a period of anomaly and uncertainty occurred, which ended by the introduction of new theories and a new philosophy and the resulting new paradigm.

This paradigm shift from scientific management towards human relations management presents an apparent similarity with the change from an end-of-pipe pollution control approach to a preventive and integrated environmental management approach. It is fair to discuss whether the end-of-pipe pollution control approach has led to an anomaly as such. Environmental problems can still be managed through that approach, although growing costs and use of materials, energy and space deliver a higher pollution load into the environment. Looked at in this way, the anomaly begins to be understood as a sub-efficient situation. However, in terms of sustainability, preventive approaches can be labelled as the preferred options. In the symbiosis between ecological, economic and social aspects, cleaner production concepts can constitute a `new paradigm' in analogy to Van Strien's practical paradigm (1980):

Figure 2.5 **Schematic diagram of change from the *old* to the *new* practical paradigms according to Van Strien**



To conclude this section, I turn to its title: Paradigm shift, take it or leave it. It stands for the question of whether organisations and actors are actively or passively involved in change processes leading to societal sustainability. Commitment, willingness, capability and responsibility are important variables that determine whether such involvement will lead to a strong or weak development of sustainability. I defend the perspective that sustainability company management is dependent on a radical change in worldview. Reflection on such a paradigm shift as a metaphor for sustainability company management is provided in Chapter 4 in the perspective of a secondary analysis of cleaner production in a number of case studies throughout the world; further analysis of these case studies is presented in Chapters 5 and 6.

2.4. **Theoretical focus: social theory and practical paradigms**

The focus on paradigm change does not include “shaping society”. However, how can confusion between moral and scientific judgements be avoided? Mainstream social sciences often have a traditional bias, being based upon empirical validation on the basis of the past as representation of the present and leading to the future. Possibilities for new thinking derived from the cleaner environment perspective ask the questions: “What do we wish to accomplish, and How can we achieve it?" These are normative societal questions that can be explored via traceable scientific regularities (science is conceived as the methodological approach to understanding how and why things function the way they do).

In a way, these questions are part of the micro - meso - macro link in this thesis. What role are individuals playing in the micro - meso - macro liaison with respect to conceptual (paradigm) changes in organisations and society? To what extent are the institutionalised frameworks of organisations and society effective for fostering and supporting change?

Several sociological mechanisms play a role at different levels in this connection, such as perception, rationality, information exchange, social dilemmas, power, institutional frameworks and policy networks. The mechanisms are working at different levels: the psychological concept of perception as observation of reality by an individual at the micro level can also work as an aggregated observation of reality by categories of people at the macro level (such as in The Established and the Outsiders, Elias & Scotson, 1972). The inter-linking of different levels has a strong connection with information processing that is performed at an individual level and also has impacts at meso and macro levels. With this in mind, the following sections describe mechanisms from micro to macro levels. The variables presented in Figure 2.2[15] are assumed to be part of the transition or (practical) paradigm change process (Kuhn, 1962, Van Strien, 1980) towards a sustainable society (WCED, 1987). The mechanisms described in subsequent paragraphs range from the micro to the macro level without meeting strict boundaries between separate levels.

2.4.1. *Perception*

In this thesis, perception is operationalised along dimensions such as urgency, understanding, responsibility and capability. The basic assumption is that some people in an organisation are very worried about environmental problems. Because they understand environmental problems and perceive their urgency (Mandler, 1984) they feel responsible for activities of their company that cause environmental problems. Both their personal and organisational capability for solving the environmental problems in the company are important variables. Capability includes commitment to the environment that goes far beyond lip-service.

The phrase `our company is doing so much for the environment’ often means that environmental problems are still viewed as externalities, and therefore require stand-alone engineering solutions that are not included in general decision-making. Crane (2000) found that the amorality in environmental issues is still a factor in British industry.

Verhallen and Van Raay (1982) reflect in their *Change of behaviour* model to five core variables in the relationship between attitude and behaviour. Education is a basic variable in

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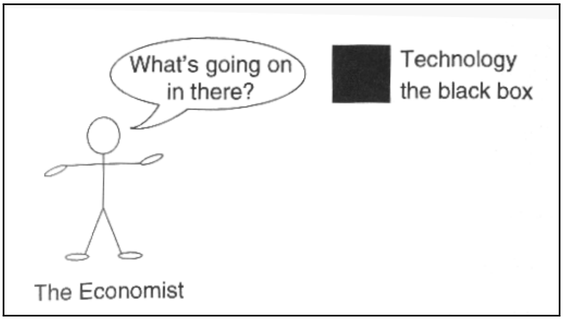
[15] The research field multi-level concept innovation model.

this model: firstly, because it enables one to understand cause – effect relationships in environmental issues; secondly, because it enables one to transfer information and education into activities designed to solve environmental problems. Another variable is the sense of responsibility: feeling responsible will create space for self-reflection about one's own environmental performance (instead of pointing the finger at other, larger polluters). This does not mean, especially in the case of medium- and small-sized companies, that organisations know about and are able to monitor their wastes and emissions. But when medium- and small-sized companies acknowledge this, it is a starting point for looking for environmental information and knowledge, often via significant others such as the municipality, industrial sector organisations and sometimes intermediary organisations. Alternatives for making changes have to be within the mental map framework of organisations, and this is the fourth variable. Finally, in the Change of behaviour model, technical and economic feasibility of the alternative is the fifth variable. Clearly, in this model, understanding, responsibility and capability for change are also important.

If we turn to linking perception to different levels of analysis, the findings of Elias and Scotson (1972) with respect to the perception of different categories of people (in their research work: The Established and the Outsiders) are interesting as an analogy for the analysis of the mutual perception of industry and government. Elias and Scotson have researched the settlement of new labourers in an industry town in the North of the United Kingdom. In this research work, both the autochthonous middle class inhabitants living at the core of the village and the autochthonous labour class inhabitants of the suburbs (the Established category) feel superior towards the non-autochthonous lower class inhabitants in newly-built suburbs (the Outsiders). The last category seems, after a while, to accept that perception according to Elias and Scotson's research. Furthermore they found that the Established profile themselves according to their best individual representative, while they perceive the Outsiders according to their worst individual representative. This profile provides a larger difference in perception than the distance between the average mean representative of the two categories. It would be interesting to find out whether perceptions in the industry-government relationship might be similarly based on a kind of moral superiority of one category or if they are more or less equal, as for instance in a football metaphor with the equally negative perceptions of the supporters of two competitive football teams. Such a perception can influence the industry-government relationship from one extreme – challenging the change processes – to taking the negative perception for granted and doing nothing different than meeting the formalised requirements.

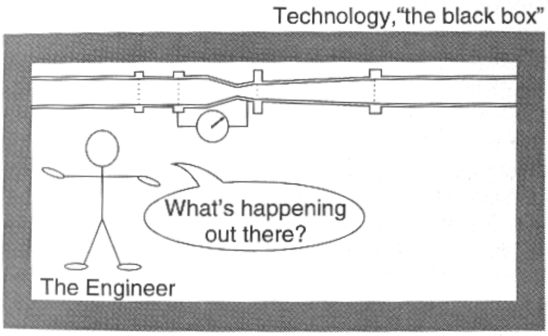
Kline (1995, 180-181) gives another basic disciplinary difference by considering different perceptions between the models of innovation in economics and engineering. Economists suggest that innovation occurs as the result of the spur of competition between firms. Economists are looking from the outside of these firms at technology development inside black boxes (*What's going on in there?*), as caricatured in Figure 2.6:

Figure 2.6 **The Economist's View of Innovation** (Kline, 1995)



The focus of "The Engineer" is inside the organisations (sometimes wondering: What's happening out there?). Engineers are primary actors in industrial innovation placing their attention on inside issues, as caricatured by:

Figure 2.7 **The Engineer's View of Innovation** (Kline, 181)



Kline (ibid: 181) considers both economics and engineering models as being too narrow: `..Each represents one level of aggregation in the socio-technical systems of manufacture, use and innovation. The economist' focus on the level of the firm, the market and the costumer; the engineers on the level of hardware. Both neglected, to a significant degree, the social aspects of the systems with which they were concerned. Neither seems to have seen the relevant socio-technical systems as wholes, at least much of the time..'.

2.4.2. *Information processing*

Lammerts van Bueren (1999) states that whilst processing information people tend to introduce distortion, or bias (often unconsciously), that blocks good judgement. Many people believe this is true in general, but not for them (Messick and Bazerman, 1996: 19). An illustration of this trust in their own infallibility is the finding that 80% of Dutch car drivers think that they are better than the average car driver. Baas (1989) found that entrepreneurs tend to think that the soil pollution caused by their own company is in average less extensive than that of other companies,[16] while Walley and Whitehead (1994) see a difference in the desired and applied priority of environmental issues in business management.[17] Four forms of bias are well-known according to Lammerts van Bueren (1999):

1) *Confirmation trap*: the obstinate search for the confirmation of a given opinion or position;
2) *Hindsight bias*: the *ex ante* judgement, whereby the correctness of the decision is judged against the background of the result;
3) *Regression-to-the-mean* phenomenon: this means in statistical terms that when mutually totally or partially independent events happen, extreme situations tend to return to `normal practice';
4) *Underestimation of the `exponential growth'* phenomenon: the characteristic of this type of growth is its explosive aspect, such as the doubling of flowers in a pond every day. It starts with the doubling of one flower into two, but on a certain day, half of the pond is filled, and …..tomorrow is another day ("but the pond is full!").

The social process in the industry-government relationship seems to lead to imprisonment in an end-of-pipe web (Cramer & Schot, 1991) as in the classical formulation of the Thomas theorem (Thomas & Thomas, 1928): `..If men define situations as real they are real in their consequences..'. Although this theorem reputedly is one of the great insights of modern social science, van Dun states that it is essential to get a firm grasp of its meaning, for that is by no means unambiguous.[18] A consequence of van Dun's statement is that the reality of the definition of the situation has to be analysed too, which means a growing complexity in large scale situations. However, Elias overcomes this complexity by describing research in a small scale situation as `..a mold, to use for similar, more complex figurations, by which we can develop a better understanding of the structural characteristics that are joined and the reasons of different functioning in other situations and therefore the development along other lines..'.

Finally, the process of information dissemination is addressed more frequently in organisational management literature. Dutton *et al*. (2001) research `issue selling' as the process by which individuals affect other's attention to and understanding of the events, developments, and trends that have implications for organisational performance. In this thesis therefore, questions such as Who disseminates?, What is disseminated about cleaner production and sustainability?, and the role of the significant other, are explored in relation to the horizontal and vertical dimensions of information dissemination in organisations.

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16 A survey in 1988 showed that industrialists estimated the probability of the soil of their site being polluted was 29%, while their estimation of the probability of soil pollution in other industrial sites was 86%.

17 92% of the interviewed business managers said that the environment is a top 3 management priority and 85% saw it as a part of the business strategy. 37% of the interviewed business managers claimed to have successfully integrated environmental issues in their daily practice and 35% said that they had successfully adapted business strategy to anticipated environmental developments.

18 The interpretation is based on the assumption that the theorem derives its meaning from the fact that the word *Real* occurs twice in it. This appears to be a reasonable assumption, but it does not bode well for the Thomas theorem. Indeed, on this interpretation the Thomas theorem is false (you will not get your creditors off your back by defining yourself to be wealthy) and even absurd (for what are the unreal consequences of a situation, if not those things that are not consequences of the situation?) - no matter how significant it might be if it were true (website http://allserv.rug.ac.be/~frvandun/Texts/Articles/ThomThe.htm, accessed 1 September 2001).

2.4.3. *Social dilemmas*

The convulsing development towards a `cleaner production paradigm' has much to do with a societal dilemma. This dilemma can take several shapes (Opschoor & van der Ploeg, 1990). In the first manifestation of the dilemma, there is a conflict between direct individual interest and community interest: the **social** (or prisoner's) dilemma. This is the core problem of Hardin's "Tragedy of the Commons" (1968): if everyone can enter the common meadow to graze their own cattle, every individual will expand her/his use of the common resource until it erodes because of overburdening. The consequence is that nobody can use it anymore.. Though some questions can be asked about the egocentricity of humankind in this description, the dilemma is clear: prudent or sustainable use of renewable and non-renewable resources is the most rational strategy for the community; maximal use of resources is the most rational strategy for individuals. The disadvantage for the community is larger than the sum of individual advantages.

The second shape the dilemma can take is the distance between the place of behaviour and the place of its impact: distance in **space**. Pollution and its effects as consequences of the use of resources are particularly noticeable in distant places. When the Dutch consumer starts his/her washing machine, (s)he notices nothing of the pollution caused by the extraction of Russian natural gas (s)he uses (or of the chemical pollution in production of the washing powder or of the pollution from washing their clothes).

The spatial dilemma is often more dependent on distance perception than real geographical distance. For the Dutch, the negative impacts in a country like Surinam, although geographically far away, are psychologically nearer than the impacts in another faraway country without any special links to the Netherlands. This spatial preference depends among others things on involvement in the concerned country, knowledge about that country and the experienced consequences of the impacts at such a distance (Vlek & Keren, 1992).

Distance between the moment when a given behaviour takes place and the moment of its impact can also lead to a third type of dilemma: distance in **time**. The disadvantages of our present behaviour become clear in the future: today versus tomorrow. As with space, expectations concerning the future are also dependent on the way of assessing future impacts (Vlek & Keren, ibid). How will the problem develop? How do we perceive the future impact of our present behaviour? Some say that problems will be solved by technological solutions: in that case it is rational to shift the responsibility for the problems to the future. Others say that a fundamental change in lifestyle can create the conditions for preventing the problems of the future. However, they also face the fact that fundamental changes not only take time, but that processes of fundamental change are also capricious and diffuse (Kalders, 1998).

The central essence of these three dilemmas is the contradiction between individual (micro) rationality and group (macro) rationality:

- Prisoner's dilemma: individual interests (e.g. consumer, citizen) versus collective interests (e.g., industry, community, country);
- Spatial dilemma: individual interests and/or own group interests versus faraway collective interests;
- Time dilemma: the interests of the present generation versus the interests of future generations (WCED, 1987).

Vermeersch (1990) emphasises that the present economic system is especially concerned with meeting the needs and wants of consumers as perfectly as possible; this is why, by definition, it is focused on micro-rationality. One can presume that the meso-rationality of companies focuses on profit enhancement and continuity in response to the micro-rationality of consumers. This means that sustainability company management that is also concerned with macro-rationality is confronted with traditional company management.

However, the traditional liberal *invisible hand* approach (Smith, 1778) does not consider that micro and macro rationality are contradictory. Following that tradition the micro-macro link is possible. It is essential that the individual (or community or the generation in power) recognises the problems and feels responsible for the solution of the dilemmas (under the condition that all do the same). Only when one is willing to sacrifice the individual for the collective advantages, either independently or via governmental measures, can a process of change behaviour emerge. When the problem is not recognised as one's own problem, the individual (or community or the generation in power) is not willing to change behaviour. Moreover, government will not see the need for taking active measures to address the issues. In this way, the responsibility for better-integrated environmental performance is abdicated (this is also called externalisation).

2.4.4. *Decision-making*

As a further elaboration of the social dilemma, the decision-making component needs attention because decision-making processes play a role at all levels of the transition model. As sustainability requires the involvement and commitment of all powerful key stakeholders, the gap in perception and its consequences for interpretation and translation has to be recognised as an important issue. Two sociological theorems, centred on the rationality principle and cognitive dissonance, influence the micro-macro link and are discussed in turn in this section.

1) <u>Rationality principle</u>

One of the major assumptions in the rationality principle is that `The more worthwhile a type of behaviour is for an actor, the greater the chance that this actor will actually perform this type of behaviour'. Until now, the dominant environmental behaviour of companies was to externalise costs to society, both with technology (pollution control approach with end-of-pipe technologies) and business economics (no or insufficient allocation of environmental costs). Nevertheless, individual employees have sometimes succeeded in influencing their company's environmental policy towards pollution prevention. Green marketing and cleaner production can, on the basis of a positive environmental profile, market incentives, greater efficiency and employee motivation, function as a vehicle for such changes. However, a target of zero-waste is still regarded as too radical and unachievable, although Dupont and the ZERI institute in Japan have used this as a goal for their activities for several years.

2) <u>Cognitive dissonance</u>

A major assumption of this theorem is that `The bigger the experienced cognitive dissonance is, the greater the likelihood of repression or denial of the least important cognition or the denial of contradictions between the cognitions' (Festinger, 1957).

The reluctance of Dutch farmers to change their individual manure management practices to avoid the collapse of the total system (brought about by exceeding the assimilation threshold) provides a good illustration of this in the 1990s. The perceived win-win relationship between ecology and economy with respect to the proposed expansion of Schiphol airport is another, still topical, example. The Schiphol airport management (with the consent of the Dutch national government, for economic reasons) rationalise their policies that the economic growth of Schiphol airport will provide a better environment,[19] while they place both neighbouring inhabitants, confronted with increasing noise annoyance, and environmental NGOs, in an Outsider position (Elias and Scotson, 1975). The cognitive dissonance stems from the results of a new noise nuisance monitoring system (that has not been developed in a balanced stakeholder dialogue): this system assumes that with the expanded landing strips the airport will remain within noise acceptation levels, and that technological improvement of airplanes (making them less noisy) will neutralise negative effects. Of course, economic growth in a qualitative sense might condition aircraft improvement, leading to a better energy and noise performance. These rationalisations are, however, dependent on the realism of the time frame for achieving these technological improvements and the experience in practice of reduced noise for the inhabitants of neighbouring houses. Furthermore, until now, no government has dared to start a discussion with the airline companies about a levy on aircraft fuel (this is an illustration of the actual gap between attitude and behaviour).

2.4.5. *Institutional framework*

Institutional theory argues that the surroundings of organisations define their general assumptions and belief systems (Meyer and Scott, 1992, Scott, 1995). According to Scott (1995), the presence of normative aspects of institutions can be detected by logic of appropriateness that determines the behaviour that is expected for any given social role. Key individuals increasingly understand and give meaning to social contexts, showing the increasing relevance of the cognitive elements of institutions.

Meyer and Rowan (1977) see elements of the formal structure of an organisation as manifestations of institutionalised rules and expectations within the environment of organisations, which become binding or obligatory. Stakeholders such as governmental regulators, environmental advocacy organisations (as spokespersons for nature and public opinion) and influential customers have put the positions, departments and procedures for the management of environmental problems under pressure.

Meyer and Rowan (1977) point to two problems that organisations may encounter when they are dependent on the adoption of institutionalised elements, rules or structures. The efficiency of the production process can conflict with compliance with institutionalised rules. It can conflict with costs and with the embeddedness of institutionalised rules at an abstract generalised level, while production activities are subjected to very specific conditions that must be addressed. Also, the inconsistency of incompatible institutional elements may cause severe conflicts. Meyer and Rowan observe that decoupling them may solve the conflicts between institutionalised rules and the efficiency of organisational activities. Through decoupling, organisations are able to maintain standardised, legitimate and formal structures.

In relation to the industry-government relationship the *new institutionalism* paradigm formulated by Jordan and O'Riordan (1995, 5-6) is interesting. They cluster various definitions of *institution* as a conglomerate of types of policy networks, standard operating procedures and barriers to rational decision-making, structures of political power and

[19] This approach seems to be focused on end-of-pipe solutions as it does not involve the possibility of zero-budget cleaner production improvements.

legitimacy, national policy styles, international regimes, and pre-determined social commitments. This means that many stakeholders influence developments in this conglomerate of positions and approaches on the basis of their power (the ability to get what one wants, usually at the expense of the interests of others, Lukes, 1974, 26-27) and/or status.

Power can be detected at the micro level of the individual in the organisation and also at the meso level of the company – EPA relationship. The actor's power (derived from expertise, involvement and participation in organisational activities) can mould the type of results for their own organisational interests (direct/indirect, passive/active) to blockade or support certain developments. Lukes (*ibid.*) also refers to a second dimension of power that operates more covertly to keep key issues off the political agenda and away from political scrutiny.

Along the same line, Lindblom (1977) explains that the Grand majority issues in political life - such as private property, enterprise autonomy and economic growth - are kept off the political agenda by processes of social conditioning and indoctrination.

Kitschelt (1986) defines political opportunity structures (POS) as specific configurations of resources, institutional arrangements and historical precedents for social mobilisation, which facilitate the development of protest movements in some instances and constrain them in others. According to Allison (1971), standard operating procedures are the rules by which things are done, and are developed as a means to deal with uncertainty, conflict and ambiguity in policy making. Cyert and March (1963) state that knowledge and information are stored in standard operating procedures. Clearly, it is inevitably easier for organisations to fit problems into an existing template of solutions than to continually work out new solutions to each new problem.

For the dissemination of new concepts, this means first that standard operating procedures and other routines (Saunders, 1976) have important consequences for decision-making processes regarding cleaner production – by regulating the access of participants and the patterns of negotiation and consultation. Regulation can entail affecting the participants' allocation of attention, their standards of evaluation, priorities and perceptions, identities, and resources. Secondly, in this process, the individual's motivations and perceptions are determined by their own preferences, but also by the importance of the role given to them by the company (Allison 1976, 171: `..where you stand depends upon where you sit..'). Third, standard operating procedures can become reifications into specific ideologies or worldviews within entire departments.

In the institutional context the ebb and flow of attention to issues affecting routines plays an important role. In relation to the processes of concept development and implementation, the thesis will pay attention to Downs (1972) who distinguishes a life cycle in solving environmental problems with the following phases at the macro level (problem-solving approach):

- *Pre-problem phase*: the problem is there, but is recognised only by a few people (experts, well-informed laymen);
- *Recognition & Acknowledgement and Excessive Enthusiasm phase*: an incident and/or threat (on a local scale, such as in the Dutch village of Lekkerkerk, where the soil pollution problem was viewed as a serious threat to public health, because of the permeation of benzene in drinking water pipes in 1980; or on the global scale, such as the decrease in the ozone layer) leads to a strong willingness in the public to tackle the problem;

- *The problem is bigger and more expensive to solve phase*: environmental problems, upon further research, are often found to be bigger and more complex than originally expected, especially as regards their consequences for society;
- *Diminishing attention phase*: the problem solving takes too much time and the costs are too high;
- *Marginalising phase*: a process of institutionalising of standard policy takes place.

In relation to management fads, Ettorre (1997) proposed a five phases life cycle, also based on a bell-shaped curve: discovery, wild acceptance, digestion, disillusionment, and hard core.

2.4.6. *Perception of stakeholders and translation*

A specific dimension of perception is how other organisations, in particular their stakeholders,[20] are viewed. More frequently, it is learned that stakeholders play an important role in the dissemination of new concepts. The step towards the involvement of new stakeholders means, on the one hand, that more societal commitment and better results can be achieved. The stakeholders can (directly and actively) bring in their interests and expertise and give support to the process. On the other hand, the stakeholders' interests, policies, targets and strategies to reach those targets can complicate the process by indirect and passive participation and the blockade of experiments. This has to be kept in mind when organising a new setting. Freeman (1984) states that stakeholder management comprises four steps: the identification of the relevant stakeholder groups, the determination of the stake of each group and how effectively the expectations of each group is presently being met, and the modification of corporate objectives and policy to take into consideration stakeholders' interests.

Together with institutional pressure, this will influence the translation of information for decision-making. Christine Oliver (1991) developed a typology of strategies (Table 2.4),[21] ranging from passive to active, and from conformist to resistant (1991:151). Oliver goes on to hypothesise on the factors that predict the response that will be chosen by an organisation confronted with institutional pressure. Thus, if conforming to pressure leads to greater legitimisation and brings economic gain, it will be an attractive strategy. On the other hand, when an organisation has multiple constituents, this provides an incentive to be more resisting. This is mediated however by the extent to which the organisation is dependent on these constituents. A further predicting factor is the extent to which the content of demands is internally consistent, and whether it leaves discretionary space for the organisation. Finally, the level of control exerted by institutional pressure is of importance.

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[20] Stakeholders can also be categorised as significant others following the classical definition of Freeman (1984): `A stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization's objectives'.

[21] Table 2.4 is explored in environmental performance examples in Table 5.2 (Section 5.1.3).

Table 2.4 Strategic responses to institutional processes (Oliver 1991:152)

Strategies	Tactics	Examples
Acquiesce	* Habit * Imitate * Comply	* Following norms that are taken for granted * Mimicking institutional models * Obeying rules, accepting norms
Compromise	* Balance * Pacify * Bargain	* Balancing expectations of multiple constituents * Accommodating institutional elements * Negotiating with institutional stakeholders
Avoid	* Conceal * Buffer * Escape	* Disguising nonconformity * Loosening institutional attachments * Changing goals, domains, activities
Defy	* Dismiss * Challenge * Attack	* Ignoring explicit norms and values * Contesting rules and requirements * Assaulting source of institutional pressure
Manipulate	* Co-opt * Influence * Control	* Importing influential constituents * Shaping values and criteria * Dominating institutional constituents & processes

In relation to the dimensions of power in an organisation, the internal individual position mainly determines her/his influence on information and interpretation as material for decision-making. Externally, the organisation experiences the vulnerability of their position in relation to stakeholders. Cleaner production policy networks meet actors with different targets and means to reach these targets. Features of the network are:

* An accumulation of actors: organisations, individuals and groups;
* The interests, wishes and targets of those actors;
* The issues and activities of the actors to meet their targets;
* The rules, norms and assumptions of the actions and interactions among the actors (procedure);
* The accumulation of (inter)action possibilities for each actor (means);
* The accumulation of results, costs and benefits of each action and interaction.

The institutional influence and pressure on companies have effects from internal routines and externally from the region as direct surroundings of a company and the industrial sector that are mostly oriented at a national level.

For cleaner production dissemination, the idea of *translation* can be coined as a socio-cognitive approach to organisational change (Czarniawska 1996). Cleaner production diffusion is seen as the promotion at a general *concept spreading* process level, while dissemination is seen as the activity of an actor in relation to a company. That actor can be a company selling environmental equipment, a governmental organisation providing information or an intermediary organisation such as consulting firms and knowledge institutes, that provide information, knowledge transfer or services. The whole activity is directed to the receiving company that will accept, or not, and in case of acceptation, modify or translate that activity.

The concept of translation can best be defined in relation to the approach to which it stands in contrast: the dominant model of the diffusion of innovations as a process of disseminating a discrete, unchangeable unit (the innovation). In this model, diffusion is studied by looking at the rate at which the innovation spreads, the barriers that prevent its diffusion, etc. By contrast, the idea of translation focuses on the fact that the adoption of an innovation implies that the actor adopting it uses it in its own way, for its own purposes, and may thus make modifications to it (Latour 1986). Although this is applicable to innovative artefacts, it is especially relevant for innovative ideas, including organisational innovations. The basic idea is that the innovation itself changes during the process of diffusion.

This way of looking at organisational change and interventions leads to some interesting thoughts. An innovation can be seen as an idea that in some way comes into contact with an organisation. This idea, which in this case is that of cleaner production, can as a result of this contact, bring about changes in the organisation, leading to actions from organisational members and eventually the institutionalisation of the idea and actions into the organisational routines. However, there are complications (Czarniawska and Joerges, 1996). Firstly, it takes many ideas to bring about a simple action and secondly, ideas tend to produce counter-ideas that may interfere with the translation process of the original idea. Another interesting perspective comes from the following questions: which ideas are more likely to bring about action in an organisation than others, and what kind of ideas are most likely to become diffused among a group of organisations? (Abrahamson, 1996; see also Blackmore, 1999).

2.5. **The touchstones in this thesis analysis**

The new concept of pollution prevention (and cleaner production) has been considered revolutionary (Hirschhorn, 1997), or evolutionary in caring for the environment (Geiser, 1997), or as leading to limited solutions to inefficiencies. The question whether this concept is a fashion (Abrahamson, 1991) and a substitute for traditional environmental regulations or a practical paradigm shift is analysed with the help of variables such as the number of employees in the organisations that are involved in the implementation processes, the embeddedness of the concept in a number of organisations and at different organisational levels, the involvement of stakeholders and inclusion in decision-making.

One of the difficulties in analysing change processes is the limited time frame to judge the spread and robustness of changes. The traditional quantitative growth thinking is heavily institutionalised, as is expressed in the view that only economic growth can provide the financial basis for environmental measures. This perception seriously stands in the way of qualitative growth and de-materialisation thinking. The question is whether the concepts of cleaner production and industrial ecology can play a driving role in sustainable development and if so, will that be an incremental and/or a radical role and how can it be recognised and monitored?

Goodin's (1982) concern is that the descriptive case for incrementalism rests on two foundations: firstly, we cannot anticipate the real effects of social interventions prior to actually experiencing them; secondly, even when we can anticipate the outcomes, we cannot anticipate our evaluative responses prior to actually experiencing those outcomes. Finally, Goodin distinguishes three forms of incrementalism, each with distinctive goals, strategic imperatives and rationales:

1) A *strategy of decision*: calling to continue the type of incremental intervention that is perceived to have yielded desirable results previously. In this way people decide to

repeat what is reinforced (slow, small changes, but sleeper effects mislead them by appearing late);

2) The *epistemic rationale*: claiming to be able to get by without any theoretical understanding whatsoever of the system into which we intervene; a research strategy using the policy arena as a laboratory (where incremental changes provide feedback against which hypotheses can be tested and theories refined);
3) The *adaption rationale*: by proceeding slowly and cautiously, we can correct mistakes and adapt future moves in the light of past experiences.

In contrast to incremental steps, radical events such as environmental disasters often lead to more strategic and substantially changed environmental management approaches. They often generate new developments in a whole industrial sector (such as the `Responsible Care' programme in the chemical industry after the Bhophal accident). New targets and the planning to achieve them are often organised in education programmes for individual members and learning loops at the organisational level. According to Nooteboom (2000) an innovation is radical when it is architectural: it entails a reconfiguration of activities or elements from previously separate architectures. An innovation is incremental when it preserves the existing architecture, whilst constituting a novel element in it.

For the implementation of cleaner production, Oliver's typology (1990) provides an interesting question regarding the phase during which an organisation is first confronted with new concepts: to what extent does the existing situation lead to the adoption of certain strategies and tactics, and to what extent do organisational capabilities determine strategy and tactics? In terms of individual actors, what is their performance at different levels of the organisational structures in relation to recognising, acknowledging, translating, disseminating, resisting, and/or neutralising the new concept?

The modification of the new cleaner production and industrial ecology concepts can be tested at the start of their dissemination using Oliver's typology. In relation to the different variables, an analysis of dissemination and translation can be based on qualitative dimensions as in the case of perception (that consist of urgency, understanding, responsibility and capability). The assumption is that when actors score higher on these variables, they are more open to, and ready for, sustainability information.

Against the background of the interconnections between major stakeholders at the macro level of society, the meso level of industrial regions and the micro level of companies, the issue of acceptance of new concepts such as cleaner production and industrial ecology and their further dissemination routes can be analysed. When the introduction of the new concepts is completed it can be analysed, whether acknowledgement of the concepts has led to institutional change and whether new routines internally in the organisations and externally in the relationship with stakeholders has developed.

Furthermore, the spread of the concepts and the type of learning processes of individuals and organisations at the different levels are part of the analysis. For such an analysis, Boons *et al*. (2000) formulated four criteria – or dimensions – for institutional change. When concept transformations are approached using the same framework, the following criteria can be applied:

1) *The level of the concept* (application): are the concepts far-reaching and radical enough to depart from the organisation's traditional mode of operationalisation?

2) *Is the concept itself a form of institutional change*? Are the concepts developed at different levels (e.g., operational, model, coalition and value) simultaneously?
3) *Is the concept widespread in the sector and society?* How well known are the concepts and how widely are they applied in organisations?
4) *Do the concepts change inter-organisational relationships/modes/regimes of governance?*

Besides the breadth and depth of dissemination of the concepts of cleaner production and industrial ecology as such, the concepts can also be applied as touchstones in relation to the overall concept of sustainability in the labels sustainability company management and sustainable regions. At the level of sustainability company management, the paradigm transition means that:

A. *Potentially successful alternative experiments such as cleaner production and industrial ecology have to be applied and implemented within industrial organisations*:

Since it is now clear that sole reliance upon pollution control approaches cannot solve environmental problems, the need for a paradigm shift to cleaner production has become evident. The description of cleaner production and industrial ecology provides an insight into the potential of a change agent concept. The functions of the environment, the kinds of resources, the issue of distribution of capital and the exhaustion of natural resources as societal dilemma (time and spatial dilemma) are analysed and elaborated upon within a theoretical framework of Sustainability company management.

An assumption for this process is that in the case of a positive ontological view by a key actor in an organisation, an epistemological process of interaction with cleaner production assessments could be started. The results of the outcome of the cleaner production assessment can create a possibility for change that can/needs to be enforced by other powers in the organisation. The number of employees involved (critical mass) and the embeddedness of the new concept, the inclusion of environmental issues in decision-making processes and the involvement of stakeholders are all elements involved in a cleaner production paradigm shift within an organisation.

B. *The concepts and philosophy of sustainable development must be internalised in the societal setting of the industry*:

The cleaner production and industrial ecology concepts include giving attention to the use of human, natural and economic resources, and to production processes and their products from a joint environmental and business economics perspective. With this approach, attention can also implicitly be paid to the social dimensions of the sustainable use of resources, energy carriers and environment stocks. In the industrial sector this means that sustainability company management needs an analysis of diverse practical paradigms (such as societal, psychological, sociological, political, economic and technological paradigms) in relation to the access and use of renewable, non-renewable and environmental resources.

Exploring cleaner production concepts can be important for the operationalisation of sustainability company management at the level of single organisations. My definition for this is: *Sustainability company management integrates economic, environmental and social policy in the careful use of resources for the production of environmentally responsible products and services, satisfying the needs of present and future generations, and respecting the cultures of their communities and sustaining the functions of their environment*.

The context of this definition – which is dynamic – contains two crucial sustainability elements:

* Societal, economic and technological developments have to be in balance with the environmental space; for instance no irreversible steps may be taken on the assumption that technology will create solutions in the future;
* Only a globally equitable utilisation of resources can create a basis for sustainability company management within a context of sustainable regions. This includes that a sustainable region with its own cultural identity may not be created at the cost of the introduction of an open global *one-culture* sustainability system.

It is said by several authors (Brown, 2003) that the conditions in the above definition call for a radical change in the strategic vision of industry, government and relevant stakeholders. Incremental steps can create commitment to the development of new strategic visions, but might often not be sufficient for a breakthrough. However, radical changes are not automatically achieved and can be based on different backgrounds, such as:

- Incremental steps leading to the new sensibility required for a radical breakthrough;
- Radical events, such as environmental accidents, bad communication and obsolete technology generating focused public pressure.

Research into the essential conditions for the societal paradigm shift towards sustainability is also needed at the level of the application of the industrial ecology concept. Touchstones at the level of sustainable regions are analysed in the case of an industrial ecosystem project in the Rotterdam harbour and industry complex with the help of variables such as the willingness to co-operate and the ability of company managers to participate in such constructions, the number of employees in the companies that are familiar with the concept, the embeddedness of the concept in a number of organisations and at different organisational levels, the number and quality of links between the companies, the type and involvement of stakeholders in the decision-making management system, and the organisation of the industrial ecology concept within the environmental regulation system.

A practical paradigm shift as a societal process of change towards sustainability provides the context of sustainability company management and sustainable regions. This paradigm shift that is necessary for a transition towards sustainability, needs insight into the relationship between present societal, economic and technological paradigms.

Changes in routines in the existing structure are analysed in the thesis, focusing on whether the results of interventions and their dissemination can form a basis for intended learning processes leading to the internalisation of such new concepts. The implementation of the new concepts as such and the depth and continuity of learning processes are also touchstones in this thesis.

2.6. **Research methodology**

In the exploration of the cleaner production case studies at the start of the demonstration projects in the early 1990s, empirical data were collected by means of action research.[22] Lewin (1946) stated that the research needed for social practice can best be characterised as research for social management or social engineering. It is a type of action research,

[22] Kurt Lewin (1946) is generally credited as the person who coined the term *action research*.

comparative research on the conditions and impacts of various forms of social action, and research leading to social action. According to Lewin, research that produces nothing but books will not suffice. His approach involves a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action.

Other definitions keep to the interactive character of action research, such as: `..a systemic inquiry that is collective, collaborative, self-reflective, critical and undertaken by participants in the inquiry..' (McCutcheon & Jung, 1990) and `..a form of collective self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out..' (Kemmis & McTaggert, 1988). Fleurke (1982) provided a practical definition: `..defines action research as research with focus on a contribution to both solving a practical problem as well as increasing scientific knowledge..'.

In the case of cleaner production a (quasi-)experimental type of action research was carried out, that combined the dissemination of a new concept with increasing scientific knowledge. Through action research, the cleaner production concepts are tested in experiments and assessments of the new concepts. The results of the testing provide the data for observation and analysis at a meta level; the results of that phase provide feedback for the elaboration at project level in turn. This approach can be labelled a constructive and positivistic one. The researcher inquiring into cleaner production concepts follows the preference of Guba (1990) for *reality as construction and out there*, that is inter-subjectively tested and empirically disseminated. Guba provides four arguments for the approach of What is out there?:

1) *The theory-ladenness of facts*: facts are facts only within some theoretical framework;
2) *The under-determination of theory*: no unequivocal explanation is ever possible. Reality can be seen only through a window of theory, whether implicit or explicit;
3) *The value-ladenness of facts*: if reality can be seen only through a theory window, it can equally be seen only through a value window;
4) *The interactive nature of the inquirer/inquired into dyad*: the results of an inquiry are always shaped by the interaction of inquirer and inquired. Knowledge is a human construction, never certifiable as ultimately true but problematic and ever changing.

Guba (1990) sees that as a consequence of these arguments constructivists feel that an entirely new paradigm is needed. The constructivist belief system can be summarised as follows:

a) *Ontological*: *relativist*. Realities exist in the form of multiple mental constructions, socially and experientially based, local and specific, dependent for their form and contents on the person who holds them;
b) *Epistemological: (inter)subjectivist*. Inquirer and inquired are fused into a single entity. Findings are literally the creation of the process of interaction between the two;
c) *Methodological*: *hermeneutic, dialectic*. Individual constructions are elicited and refined hermeneutically, and compared and contrasted dialectically, with the aim of generating one (or a few) construction(s) on which there is substantial consensus.

These considerations are especially applicable to initiating research with new concepts in relation to the researchability of results. The new concepts are explored in a setting of no concept knowledge. This means that in the beginning, information about the concept must be provided to respondents as a first step. The information must lead to the further steps of recognition, awareness raising, acknowledgement and education about the new concepts. After that phase, pilot projects have to test concepts such as cleaner production as concept-driven research. The heuristic approach of cleaner production started with demonstration projects based on the theory of pollution prevention and a cleaner production assessment method. The results of the demonstration projects provide the documentation for dissemination of the concept.

Cleaner production was introduced through case studies in companies under the supervision of cleaner production experts, using the following structure: information and education, a cleaner production assessment in the company, a brainstorm about the cleaner production options, ecological, economic and technical feasibility studies and the finalisation of the cleaner production intervention with a Cleaner production plan. The implementation of easy measures could be part of the intervention; however, if cleaner production options required more time for information, research and financing, dissemination was beyond the reach of many of the cleaner production experts.

This type of interactive research is analysed in a longer time frame: the period 1985 – 2000. This also makes it possible to analyse the evolution from limited cleaner production case studies up to the emergence of the issue of Sustainability company management. The concept of sustainability (along the lines of cleaner production and industrial ecology concepts) spread over long time periods (from decades to generations: DTO programme, Weaver *et al.*, 2000) and therefore also requires a longer analysis time frame.

Research on the human dimension of a process of change towards Sustainability company management requires an accommodation of the spatial and temporal aspects of the concepts, theory and methods of the social sciences. For the spatial aspects it can be observed that the nation often provides the research setting. Research on human activities with respect to the environment was often performed within one industrialised country (Jacobson & Price, 1990) until recently. Within developing countries, scarcely any research has been done. Within the European Union, international research programmes have been initiated in the past decade.

In practice, the analysis of Sustainability company management demands an international framework, of which the local framework is only a part. Both the interactions at a global and local level and the relations of micro, meso and macro company activities are elements in research on Sustainability company management. The elaboration of these interactions requires both exploratory research on relations between variables, followed by more finely-tuned data collection with respect to Sustainability company management. This is analysed through an inductive orientation on the specifics in the case studies. Inductive research has a history of approximately forty years in social sciences. In the next section both the general lines and the specific analytical framework are explained.

2.6.1. *Analytical framework*

Glaser and Strauss (1967) received much appreciation for their inductive approach, presented in the *Grounded Theory*. In this approach, phenomena are gathered in a data collection strategy in which researchers discover new aspects of a group during informal observation, which allows a generalised assessment of the phenomenon. They developed two key procedures for qualitative research: analytical induction and theoretical sampling.

Smelser (1976) argues that the method of systematic comparative illustration must be used when the number of relevant cases is small. For this reason Smelser considers the comparative method to be inferior to the statistical method. Ragin (1994) on the contrary considers the comparative method to be superior to the statistical method in three respects:

a) The statistical method is not comparable; each relevant condition is examined in a stand-alone manner;
b) Applications of the comparative method produce explanations that account for every instance of a certain phenomenon;
c) The comparative method forces the investigator to become familiar with the cases relevant to the analysis. The statistical method only requires the investigator to disaggregate cases into variables and then to examine relationships between variables.

Three features of social life that confound any attempts to unravel causal complexity affect issues of multiple and conjuncture causation:

1. An outcome has rarely a single cause;
2. Causes rarely operate in isolation;
3. A specific cause may have opposite effects depending on the context.

Already in 1843, Stuart Mill outlined two relevant methods for case-oriented scientific investigations with respect to the variables: the method of agreement and the indirect method of difference. Although both methods still form the useful core of the case-oriented strategies, they appear to be incapable of handling multiple or conjuncture causation. Nevertheless, case-oriented approaches are used for refining (and not rejecting) theory (Ragin, 1994): they are designed to uncover patterns of invariance and constant association; the method is relatively insensitive to the frequency distribution of types of cases; case-oriented methods force investigators to consider their cases as whole entities and stimulate a rich dialogue between ideas and evidence. Thus, case-oriented studies have unique strengths as well as their limitations.

Andersen *et al*. (1995) provide five reasons to conduct intensive field studies despite the methodological problem concerning the position of the individual researcher (interests, selective perception) and the domination of Northern societies' interpretations. They say that it is the only way to produce the type of knowledge desired because it may stem from a wish to explore a unique, complex case. A particular researcher may wish to use the research methodology he masters and because the phenomena to be researched can only be studied in their natural surroundings. Finally they observe that field studies are experiencing a renaissance due to the fact that social scientists within an increasing range of disciplines have lost faith in the Grand Theories.

Reflecting on the development of inductive research in social science, the two key procedures for qualitative research - analytical induction and theoretical sampling (Glaser & Strauss, 1967) – are also valuable for the analytical framework of research on the dissemination of cleaner production and industrial ecology. Researchers have introduced and tested the concepts in a new region performing case studies in a trial and error construction. A secondary analysis is related to that case study material on which new observations concerning the experiences are made. This is the basis for comparing case studies by testing ideas and evidence (Ragin, 1994). In a later phase when the concepts are mature, other research methods can also be used.

2.6.2. *Research methods*

According to Schatzmann & Strauss (1973), a method is seen as an abstraction of the ways the researcher handles, or might handle, the many real situations, problems and options which present themselves during the inquiry (p. 1). Often the field researcher is a methodological pragmatist, who concerns him/herself less with whether the techniques are scientific than with what specific operations might yield the most meaningful information. In the case of the secondary analysis of the introduction of cleaner production into industry, this consideration is not the only one that plays a role. The cleaner production concepts were new and unknown to industrialists. The introduction itself had a heuristic basis (Brezet, 1994) and needed an innovation framework. The heuristic basis is found in the social construction of a theoretical assessment method that had to be verified in practice. Demonstration projects as one-off interventions were welcomed by entrepreneurs with a personal involvement in environmental issues or a willingness to facilitate the experiment (because it was not part of core business acceptance was based on the belief that: `if it won't do any good, it won't do any harm either'); they could also be welcomed thanks to a mutually beneficial belief including the expectation that company performance might improve. But not all entrepreneurs were open to experiments and more in-depth research. The Why question could hardly be researched. So in these circumstances, a secondary analysis cannot have more than a limited focus on a heuristic basis. To go beyond that the comparative and interduction methods – designed to interlink the deductive and inductive approaches - have to be used, and are discussed here:

* *The comparative method*:

Ragin (1987) states `..while virtually all social scientific methods are comparative in a broad sense, in social science the term *comparative method* typically is used in a narrow sense to refer to a specific kind of comparison - the comparison of large macro social units..' (p. 1). In this approach, the term unit of analysis is used to describe two very distinct meta-theoretical constructs:

a) In reference to data categories - for example, the unit of analysis is a company, because the data are collected at that level;
b) In reference to theoretical categories - for example, the unit of analysis is the industrial or the environmental management system.

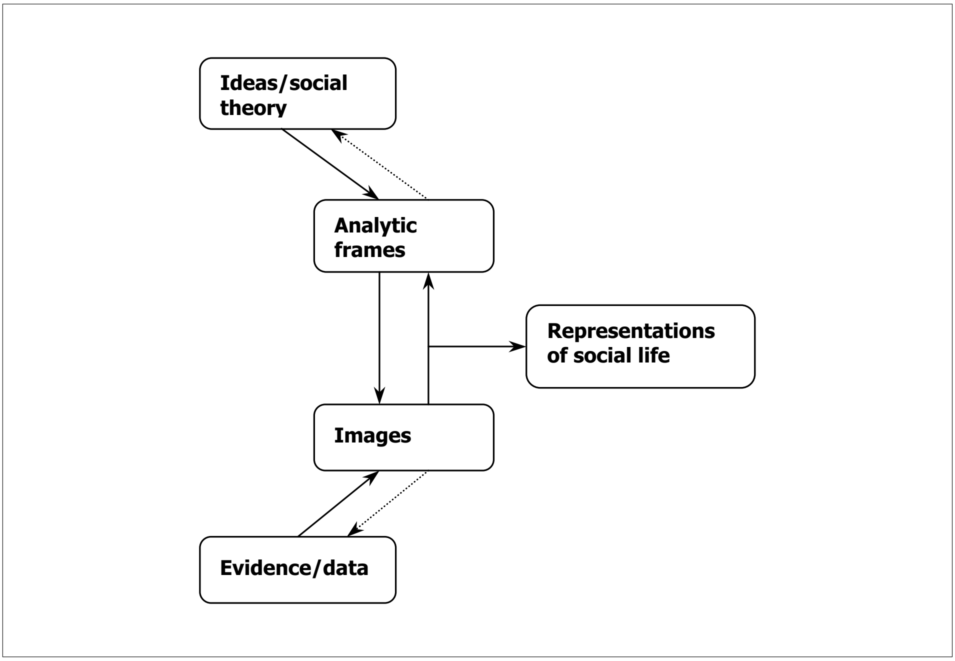
In order to make this duality clearer, a distinction is drawn between observation and explanation: *observational unit* refers to the unit used in data collection and data analysis, *explanatory unit* refers to the unit that is used to account for the pattern of results obtained.

* *The interduction method*:

In a further elaboration of social science methods, Ragin (1994) developed a simple model for social research (figure 2.8) that is based on a conception of theory as conceptualisation and makes it possible to consult and redevelop theory in a close relationship with empirical data. The model also includes the methodological tradition of retroduction in which all observations in the cases are used as data and evidence for images that are used during the analysis.

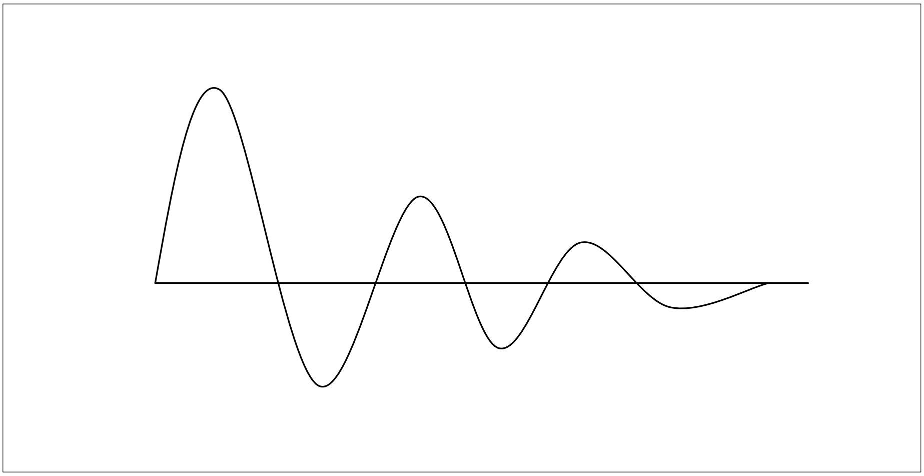
A unit of analysis in this analytical framework is selected by making a rational choice between framing by case and framing by aspect (Ragin: p. 61). Survey data and observations provide *evidence* of the research units of analysis. *Images* are an idealisation of all cases or aspects, based on abstractions. *Representations* are developed in a confrontation between evidence (sense-making processes) and images. The researcher implies and embodies explanations for the causes of the images. To draw eclectically on theory that relates to a series of empirical studies is more ontological than epistemological. The formulated questions – as (hidden) assumptions – are compared with the evidence. Ragin emphasises three goals in case studies: giving voice to marginalised groups, interpreting historically and culturally significant phenomena and advancing theory.

Figure 2.8 **Ragin's simple model of social research** (1994)



Ragin's model is pragmatic insofar that it catches the main elements in the social research process through an appeal to intuition; by comparing ideas and evidence in cases with similarities and differences, the intuitions grow consistent. The distance between images and evidence will guide further research, in general. In this thesis however, the next phase after the research the results of the case studies is based on involving increasingly more dimensions in the comparison of the case studies in order to draw analytical conclusions. The distance to the next phases of research will be closer until the representations are explained. This process can be identified by the metaphor of the extension of a *bouncing ball*.

Figure 2.9 **The *bouncing ball* testing of images and evidence**



The assumptions that pollution prevention is better than cure (pollution control) and that the concept is conducive to a better ecological, economic and innovative performance, provide the framework philosophy for heuristic research approaches in the field. In the case of the introduction of the preventive concept, at first information for awareness-raising was supplied in order to start the process of recognition and acknowledgement of the new concept's value. Later, cleaner production education and assessments were provided. Through the use of comparative and interduction methods, the case studies resulted in the image of cleaner production as a business-fit concept that generates its representation in the industry. The distance between evidence and images will be explored in the formulated research questions.

Because I was directly involved in the real situation from the beginning of the research, I could take a crucial position in the scientific observation of sustainability processes within a longer time frame. That position required following the conditions set by Welford (1997) to mind bias, such as the elaboration on the clarity and transparency of the researcher's position. To unmask several possible contradictions, Welford identifies the discovery, awareness, action, policy debate, and goal-setting phases as characteristics of knowledge development in the sustainability approach. On the contrary, Berger and Luckman (1966) state that a discovery will be based on knowledge, often socially constructed. When contradictions are found, a return to basic questions is needed. In this thesis, emerging knowledge about prevention is applied and analysed.

Welford (1997) prefers comparative approaches to research. He goes beyond positivism (the traditional approach in social sciences) and inter-positivism, because of the problem of generalisation. Critical theory addresses the unfolding of contradictions in structures and power relationships via an action orientation in case studies, interviews and statistics, a combination of all methods. The introduction of, and research on, a new concept at the same time will challenge the possibility of data reproduction. It is not the dissemination process itself but the interpretation of the data in time that will have to fulfil this criterion. In the interduction/abduction research approach, methods as participative observation, knowledge confrontation, content analysis and feedback questionnaires are used. The set of research fields that are explored with the deployment of these methods are briefly introduced in the next section.

2.6.3. *Research on sustainability: a few considerations*

Concepts such as sustainability embody a type of abstraction that is synonymous with another world. Literally for those who deny the need for a transition towards more equity; seriously challenging for those who consider that a structural, multi-level, 2nd order change is needed to make a better world. Between these notions a range of possible approaches – such as giving lip-service to the concept, wrestling with criteria, inability, goodwill or unwillingness – illustrates the operationalisation of the concept. One issue is whether evolutionary development or a shock-wave change or a mixture of the two will mark the pathway to sustainability. Goodin (1982) states that incremental steps are not always sufficient. Learning processes are often based on a one-loop approach and neglect tacit knowledge. The complex and numerous organisational variables at the micro, meso and macro level constitute the existing routines in the market that new concepts are confronted with. Accommodative learning (Kolb, 1984) and internalisation through learning by doing (Nonaka and Takeuchi, 1995) seem to provide the basis for Lam's (2000) coherent conceptual framework integrating micro-level learning activities with organisational forms and macro-level societal institutions. This type of inter-linking is needed for the development of the sustainability concept. Because the dissemination of new concepts is a fragile process including many uncertainties, researching such processes is even more heuristic than learning to find the methodological route to the assessment of the concept.

The results of diverse cleaner production dissemination projects are interpreted by methods of hermeneutics and within a framework of *verstehen*[23] (Glaser and Strauss, 1967, Van Strien, 1986). This is possible when the researcher is part of the research field. The researcher can describe and interpret what happened in many demonstration projects. Interviews designed to understand elements of the dissemination processes are also used. Here the data of respondents consist of retrospective accounts. It is difficult to distinguish between neutral and normative talks about successes and failures. Also the exact recall of events and processes is difficult. Different types of bias, such as the confirmation trap and hindsight bias (Lammerts van Bueren, 1999) occur very quickly. The confrontation of what is said and what is done tries to get around this difficulty.

The understanding of environmental research results is often based on single indicators: the physical results of the projects in terms of pollution reduction, toxics substitution and the organisational results in terms of the number of employees involved and organisational change. In this thesis a qualitative interpretation of the internalisation of the cleaner production and industrial ecology concepts is used.

It is not easy to test new concepts in practice. In relation to the start of cleaner production research, organisations were often reluctant because the research projects indicated uncertainty about future project results, while the companies saw emissions and waste as secondary issues that were no part of their core business. This is why the conditions for optimal research are peculiar. Bringing *not asked for* concepts, managing the research and analysing the developments at the same time, requires critical reflection, to do justice to the quotation of Popper (1976): `..seeing lust white swans doesn't help you to prove that there are

23 The understanding of the interpretation

no black swans..’. The description of some case studies and illustrations provides the material for this reflection.

2.7. **Considerations about the research model and practice**

To summarize the theoretical considerations and the research approach discussed above, it can be said that the multi-level research model (Figure 2.2) defines various variables as a set of theory notions about learning and innovation to understand the impacts of the introduction of new concepts. The research models and related theoretical considerations have been explicitly formulated in this chapter, while the analysis of case studies in practice often contains implicit indications instead of hard evidence.

When an intervention is performed in a certain situation, various effects can occur. A lot of activity may be generated, and result in some incremental translation or modification , but often the main structure does not change. In the metaphor of a football match, during two periods of forty-five minutes each team can perform many actions, but the final result can still be zero-zero. In spite of the result, the score of the match influences the overall ranking in the football league.

The new concepts of cleaner production and industrial ecology were introduced in a similar institutional context. The research is focused on what happened and why certain developments happened. In order to answer these questions, dimensions such as information, perception, power and decision-making have been qualitatively analysed in the case studies the funders, researchers, and the results in the organisations at the micro, meso and macro levels. It has been found that in the case of the dissemination processes of new concepts, comparative methods (Ragin, 1994) and the inductive approach in the Grounded Theory (Glaser & Strauss, 1967) are adequate tools to analyse the complexity of variables at different levels.

3 The Context of the New Concepts and the Research on their Dissemination

This chapter begins with a description of how the emergence of environmental awareness led to the institutionalised context (conform to the market structure metaphor in Figure 2.1) in which cleaner production and industrial ecology emerged as new concepts. Section 3.1 starts with a brief overview of the development of the environmental public policy, the emergence of environmental management systems (Section 3.2), and the relationship between technology and the environment (Section 3.3). Then the dissemination of the cleaner production concept throughout the world is described (Section 3.4). In the following section, the terms of *chain management* and *industrial ecology* are explored and clarified, because they cover a variety of views (Section 3.5). In section 3.6, The *research field multi-level concept innovation model* (Figure 2.2) is briefly discussed in its development phases: concept description, dissemination, and testing. Finally, the development of environmental policy as the context for the analysis of new concepts dissemination is summarized in Section 3.7.

3.1. Environmental awareness and public policy development

The increasing human threat against the functions of nature, the environment and the human health system has generated the need for environmental public policies. In response to this growing public awareness (Boender, 1985), many governments developed single medium pollution control laws in the 1970s. The institutionalisation of those environmental regulations in the 1970s forced polluting firms to control their pollution in compliance with regulations promulgated by new Environmental Protection Agencies (EPAs).[24]

At first, the response from industry was reactive, consisting of the installation of pollution control equipment. Because of this, environmental requirements were experienced as the cause of additional costs. Later, pressure on firms formed the context for environmental management development within organisations.

An opinion survey about the top 20 issues in Dutch society in 1975 (SMO, 1975) showed that 96% of respondents wished to live in cleaner surroundings and 93% of them wanted better perspectives concerning the future availability of energy and resources. The issues were number two and three after crime reduction[25] (SMO, 1975). The SMO survey found that citizens' perception of who is responsible for solving environmental problems was (in order of importance) as follows: 1) governments, 2) industry, 3) action groups.

The emergence of a problem, in general, follows the following sequence: a. recognition, b. awareness, c. acknowledgement, d. understanding, e. solution and f. control. The problem has to be recognised and acknowledged before one can act and prevent it at a later phase. The same mechanism applied as regards the development of *environmental public policy* towards

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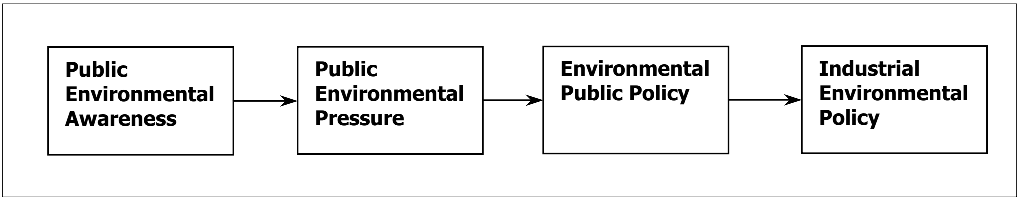
[24] The US Environmental Protection Agency (US EPA) was launched on December 2, 1970 (US EPA, 1992) as the first environmental agency in the world.

[25] Opinions about crime reduction have not changed very much in thirty years: together with security, criminality still receives the highest priority in 2005. In contrast, the environmental issue dropped to the eighth position at the end of the 1990s (CBS, 1999).

industry. The term `environment' became part of the name of ministries in many industrialised countries at the beginning of the 1970s. The first UN Conference on the Human Environment in Stockholm (1972) underscored a growing global recognition of environmental problems. In the Netherlands the term *environment* became part of the name of a Dutch ministry in 1972: it was connected to the health issue in the name Ministry of Health and Environmental Hygiene. Environmental awareness and pressure forced the development of environmental public policy in which single medium environmental laws constituted the basis for the institutionalisation of a regulatory approach in industrial environmental policy, as is illustrated in the simplified relationship depicted in Figure 3.1:

Figure 3.1 **Transformation of environmental awareness into industrial environmental policy**



In the 1970s, environmental laws and regulations were based on pollution control approaches, on a medium-by-medium basis (such as the Laws on Surface Water, on Air Pollution, on Soil Pollution and on Noise).

The Urgentienota Milieuhygiëne (1972)[26] can be characterised as an in-depth analysis of the causes of industrial pollution as a result of *laissez faire* waste dumping and emissions practices and their serious threats to the Dutch environment (Dieleman, 1987). However, the consequences of environmental public policy development were limited in the beginning, both through compromise – going for less radical approaches of environmental regulation in the policy-making process – and through the *historical right to pollute*[27] of industry at the moment of the adoption of new environmental laws.

Furthermore, implementing such legislation had its own logic, which resulted in the typical problem that, according to Bruijn and Lulofs (1996, 40), permits were discussed with firms only when their strategic decisions on which activities to perform had already been made. Permits therefore necessarily dealt with repairing the ecological consequences of such activities, rather than preventing such activities. Also, it was noticed that implementation organisations timed their visits irrespective of the financial cycle of firms. Thus it happened that demands were issued just when a large investment had been made; thereby making prevention impossible.

In the period 1970 – 1980, Dutch environmental policy developed a medium-specific regulatory framework that had to deal with the existing industrial infrastructure. Environmental policy and permitting could mainly restrict the spreading of pollution, not prevent it at its source.

26 Policy Report on the Urgency of Environmental Hygiene, Dutch Ministry of Health & Environmental Hygiene.
27 Companies do not have to meet the requirements of the new law as long as their production processes do not change.

The Law on Surface Water Pollution (1970) was the first law to be formulated as a specific environmental law. Both companies and environmental protection agencies (EPA) developed a regulatory perspective (*meeting the requirements*) concerning their environmental responsibilities. The government saw the permitting system – designed to tackle ecological problems – as their responsibility, legitimised by the growing environmental awareness of citizens. The companies stressed their function in the field of economic development and handled the environment as an issue in which the government had to prove that companies' activities were harmful. The government was placed in a position where it had to demarcate the limits of industrial pollution (Bressers and Hanf, 1995).

Around 1980, it became clear (through evaluation studies) that the regulatory system had reached an optimal level that on the whole was not effective. On 1 November 1979, the Dutch parliament voted in favour of the formulation of a preventive environmental policy to reduce waste production and encourage the re-use of resources and the utilisation of energy from waste (Motie Lansink).[28] As a consequence, the Dutch national government restructured the waste collection system at the local level, enabling the introduction of new waste treatment facilities such as waste incinerators. Furthermore, more support was given to environmental public policy planning and the integration of environmental regulations during the period 1980 – 1989. At the central government level, environmental affairs were transferred from the Ministry of Public Health and Environmental Hygiene to the Ministry of Housing, Physical Planning and Environmental Management in 1982. A new minister with a background in management consulting introduced the concept of internalisation of environmental policy, bringing ecological values into business management and symbolising the ministry's own responsibility for the integration of environmental issues in all policy areas.

In the second half of the 1980s, the ministry began to incorporate multi-medium approaches within their public policy planning and discussions with their target groups. In addition to laws and regulations, the Dutch government wanted firms to acknowledge their own responsibility for the environmental effects of industrial production. This approach was also based on a deregulation programme, in which each policy domain was assessed on the transparency and effectiveness of its regulations (Actieprogramma DROM, 1983). Although Keijzers (2000) described the focus of environmental government policies in the period 1984 – 1989 as *pollution prevention to preserve national resource stocks of water, soil and bio-di*versity, industrial practice still revolved around the necessity to comply with environmental regulatory requirements of pollution controls. This illustrates the time lag between environmental public policy-making – which was still top-down (Elferink, Meijer & Sol, 2001) on paper – whilst in practice the dissemination for the shift of environmental topics from hygiene to physical planning and environmental management in the new Ministry of Housing, Physical Planning and Environmental Management policies was in another phase. Nevertheless, the integrated control approach of the 1980s created the basis for new policy developments (Keijzers, 2000) such as:

- *Planning Programmes*: Indicative Environmental Multi-year Plans (IMP), National Environmental Public Policy Plans (NMP);

[28] The vote of the Members of Parliament was for a preventive environmental policy as a *waste ladder* approach, starting at the lowest rung of the ladder: landfill, and climbing up the ladder until the highest rung of the ladder should be reached: pollution prevention, Lansink c.s.

- *New instruments*: Environmental impact assessments, economic, social and communication instruments;
- *Integration*: The co-ordination with other ministries such as the Ministry of Economic Affairs, the Ministry of Transport and Water Management, the Ministry of Agriculture, Fisheries and Nature Management;
- *Involvement of stakeholders*: There was growing acknowledgement of societal stakeholders in the process of development of public environmental policy.

The process of integration of the other media-specific laws was finalised in the Wet Milieubeheer (Integrated Environmental Law), which came into force on January 1, 1995. The environmental protection agencies were organised at provincial, regional and municipal levels. Besides the regulatory framework, economic approaches (such as levies on water emissions and waste treatment, subsidies for clean technologies and energy eco-taxes) and voluntary instruments (such as awareness raising programmes and covenants) were developed and utilised.

Stimulated by the high environmental awareness of Dutch citizens in the period 1985 - 1991, Dutch public environmental policy emerged as a major political issue. Halfway through the 1980s, 4-year Indicative Environmental Management Plans (IMPs) were dominant as strategic public policy plans. They adopted an impact-related regulatory approach and paid little attention to technological developments. Within industry, meeting environmental requirements via end-of-pipe and abatement technologies followed a similar pollution control approach. Being confronted with the toxic sediments of polluted water streams of the three large rivers (Meuse, Rhine and Scheldt), the necessity of national and international action – both operationally in the short term and strategically in the long term – became clear to political and opinion leaders in the Netherlands.

In the 1990s, the preventive approach was explored during normal practice via pilot projects and expert workshops. During that decade both industry and government became more familiar with the cleaner production concept, although it was still mainly limited to the operational levels, rather than adopted as a mainstream concept. Despite the fact that the definition of cleaner production[29] reflected the whole lifecycle of a product, in those days, the perception of the concept was often restricted to the production processes. Later the definition of the term evolved (see Section 3.4), among other things through the attention to product policy that grew in the mid-1990s. At the end of the 1980s, the report *Concerns for Tomorrow* (RIVM, 1988) provided an analytical overview of the development of the state of the environment until 2010 at the local, regional, fluvial and global levels. The report became the basis for the political translation of the radical recommendations in the National Environmental Policy Plan (NEPP, 1989): a strategic plan for government action. Together with the (second) National Environmental Policy Plan Plus (NEPP+, 1990), it created the basis for the Ministry of Housing, Physical Planning and Environmental Management to develop a target group policy for the industrial and other economic sectors. The aim of the target

[29] `..Cleaner production means the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment..' (Baas *et al.*, 1990)

group policy was to make voluntary agreements or covenants[30] with the target (and sub-target) groups about the implementation of environmental targets defined in the NEPPs. The policy promotes the integration of all relevant environmental aspects (`compartments') and the development of chain management in industry.

It was significant for the Netherlands (and other EU countries) that new legislation and regulations were mainly developed at the European Union level in the 1990s. Dutch environmental public policy evolved from a legislative approach, via a normative approach, to a cognitive approach in the period 1970 – 2000. Table 3.1, which is similar to Hoffman's classification of the approach used by the US chemical industry (1999), provides a crude classification of the emerging concepts and policy approaches in the decades since 1960:

Table 3.1 Development of the focal points of environmental concepts and policy approaches by decade in the Netherlands

Decade	Focus of the emerging concept	Classification of the emerging policy approach
1960s	Pollution awareness (and awareness of the limits of dilution as the solution to pollution)	Recognition: Policy development
1970s	Pollution control	Legislation
1980s	Integrated pollution control	Normative
1990s	Cleaner production	Cognition
> 2000	Sustainable development	

Against this background, during the 1990s the new Dutch national environmental policy plans (NMP 1989 and NMP+ 1990), began to incorporate preventive concepts such as cleaner production (STER 1989, PRISMA 1991), industrial ecology (INES project 1994 -1997) and sustainable development (WCED 1987).

In relation to *industrial environmental policy*, a move towards self-regulation can be observed. Industry associations expressed their own responsibility for sound environmental performances within the governmental framework of requirements. Environmental management systems and their EMAS or ISO 14001 certifications became the basis for annual reports of the environmental performance of bigger corporations. Voluntary agreements between government and industrial sectors provided a basis for longer-term solutions. Furthermore, environmental organisations grew to a mature phase; joint industry – environmental NGO projects were even performed within the industrial sector in the Netherlands (Cramer, 1999).

Two organisations played a specific role in the development of self-regulation and the internalisation of industrial environmental policy. The Dutch employers organisation VNO/ NCW initiated and supported the concept of environmental management systems. The Dutch

[30] Environmental covenants are agreements - on the basis of private law - between the government and companies and/or sectoral industrial organisations for the reduction of pollution within a certain time frame.

National Water Authority supported the integration of the concept of cleaner production in their activities and the internalisation of cleaner production in industry. Furthermore they funded a special professorship on `Industrial Environmental Management' at the Erasmus University.

3.2. The rise of environmental management systems

The concept of environmental management systems within companies was strongly stimulated by the Dutch government as a dominant trend in the early 1990s. The development of Dutch environmental public policy in the late 1980s had involved the integration of regulatory, voluntary and economic instruments. In this integrated approach, self-regulation with a tool such as an environmental management system became a major issue.

Environmental care systems[31] were promoted by an association of large corporate organisations (VNO/NCW, 1986) as a proof that industry could take its own responsibilities seriously. The VNO/NCW came to the conclusion that they needed more freedom and self-regulation. This point of view was made public through two publications: one in 1985 on environmental accountancy and environmental policy, and another in 1986 on Milieuzorg in bedrijven (Environmental management within companies). The second publication contained guidelines for the development and implementation of environmental management within companies. After the issuing of this publication, a number of pilot projects under the name Co-operation for Environmental Care were carried out (Commissie Bedrijfsinterne Milieuzorgsystemen, 1988).

The results of the pilot projects led to a policy document, Notitie bedrijfsinterne milieuzorg (Notice on industrial environmental management systems), issued by the Dutch government in 1989. In this policy paper, the concept and composition of an environmental management system were explained. From then on, environmental management systems became the dominant way of managing the environmental effects of industrial production in the Netherlands. This standard environmental management system consists of eight elements: an environmental policy statement, an environmental programme, the integration of environmental management into business activities, the measurement and registration of environmental data, education and training, an internal check, internal and external reporting, and the auditing of the environmental management system (KPMG, 1992).

De Groene and Hafkamp (1994) consider that soil pollution is one of three important drivers for these developments. Soil sanitation entailed high costs for companies located on polluted soil (responsible entrepreneurs even had to use up their retirement pension savings). To avoid new soil pollution and the resulting financial risks, better environmental management within the firms would be the answer. The Brundlandt report (1987) reinforced the entrepreneurs' feeling that they have a responsibility to prevent environmental degradation. In addition, the complexity of environmental laws and regulations led to the opinion (in government and industry organisations) that modifications in structures and environmental management systems should be developed to reduce environmental pollution. The industry and government actors faced both the limits of the system and the dependency on other actors for new developments. In a context of high public environmental awareness the government was open to new arrangements. The threat of the costs of soil sanitation and

[31] First the term Environmental Care System was used; later the international label Environmental Management System replaced it in the Netherlands.

the growing environmental awareness of industry managers *as citizens* forced a change from defensive to more long-term receptive approaches. Along the line of developing economic and voluntary instruments, self-regulation emerged beside strict regulation.

3.3. The relationships between technology and the environment

This thesis focuses on several actors' perception of the role and meaning of the different definitions of three concepts: cleaner technology, cleaner production and industrial ecology. In recent decades, the application of the word `technology' in environmental sciences, has been situated between the following two approaches:

a) The use of technology to control pollution (pollution was seen as an unwanted, but inevitable product of the production process);
b) The improvement of production technology to avoid the generation of pollution at source.

This section briefly introduces the basic types of environmental technology. Technology is perceived both as the cause of, and solution to, environmental problems. In general, the Northern culture places a high value on technology (Piasecki and Asmus, 1990). To some people, the word technology refers to tools: physical goods or hardware (a technocratic approach). In this perspective, technology can be defined as complex techniques based on natural science (Hogenhuis and Koelega, 1996) or as the manipulation by humans to transform natural resources into compounds to satisfy their needs (Quakernaat and Don, 1988). To others, the technology assessment instruments and their social embedding are of importance; briefly: the cleaner technology concepts or software (a socio-technocratic approach).

Several conceptual developments characterise the relation between technology and the environment. Those developments reflect the move from control of an external issue – *the environment* – to the efforts towards integration of the issue inside organisations. In the period 1970 – 1989, organisations such as polluting companies themselves, traditional metal working companies, new environmental technology companies and research institutes developed technologies for controlling environmental pollution (LMO, 1988). The technological approach developed from pure treatment of waste to a treatment and reduction technological approach. The technological approach prevailed over a managerial approach in that period. A new branch of industry and a branch organisation[32] for environmental technology emerged in 1983. The branch organisation can be analysed as new actors with much power because of their provision of traditional solutions for environmental requirements. Others, mainly experts in government and academia, questioned why they continued to foster pollution control approaches instead of the new and innovative pollution prevention approaches.

The following discussion about the interpretation of clean(er) technology in the United Kingdom is illustrative. At the governmental environmental policy level in the United Kingdom, clean technology was seen as: `..technology, which focuses for reducing demand of raw materials and energy and on prevention as distinct from the treatment or disposal, of pollution and other wastes..' (ACOST, 1992). Clift's definition (1995): `..a means of providing a human benefit which overall, uses less resources and causes less environmental

[32] Verenigde Leveranciers van Milieuapparaten- en technieken (VLM) (United Providers of Environmental Apparatus and Technology), a industry sector organisation of 45 companies in the Netherlands.

damage than alternative means with which it is economically competitive..' ranks clean technology at a higher level than cleaner production and evaluates the human need for any product or service against the environmental impacts created in their provision. Besides this broad approach, Irwin (1995) expressed his thoughts about what cleaner technology really is: `..Is there such a thing as clean technology or is it simply a contradiction in terms?..'. Van der Vorst (1998) attempted to discover a range of individual, organisational or social philosophies underlying the development and application of technology that might together be termed clean technology. In this way clean technology was seen as a philosophy within a broader sustainable development scenario that was an end in itself.

The Dutch government supported the development of environmental technology from the beginning of the 1980s (Environmental Technology Subsidy Programme, 1982). From the end of the 1980s, the Dutch government stressed the environmental management approach as the mainstream instrument for industrial environmental performance; besides that it should be noted that the Department of International Development Co-operation (of the Dutch Ministry of Foreign Affairs) preferred the term `Environmentally Sound Technologies' (ESTs). They were defined as: "..all techniques, processes and products which satisfy human needs while avoiding or preventing unacceptable negative impacts on the environment and human health.." (1996). ESTs refer to both production and production processes, including clean technologies that are intrinsically clean; clean-up technologies that control the diffusion of waste and emissions; and products that are environmentally sound throughout their lifetimes and after disposal.

The different technologies are defined in the following way:

- *End-of-pipe technology*: the application of added-on technology to treat or manage emissions and waste streams at the facility level or at the communal level,
- *Clean-up technology*: technology that can be used to recover polluted soil, water, and air,
- *Environmental technology*: all those technologies, processes and products that reduce or prevent environmental pollution (Quakernaat & Don, 1988),
- *Cleaner production*: the concept can be divided in:
  - *Good housekeeping*: a different use of techniques or a change of behavioural patterns in the organisation to prevent or reduce pollution,
  - *Clean or cleaner technology*: the development or application of new technology that uses resources more optimally while at the same time producing less pollution and using less energy.

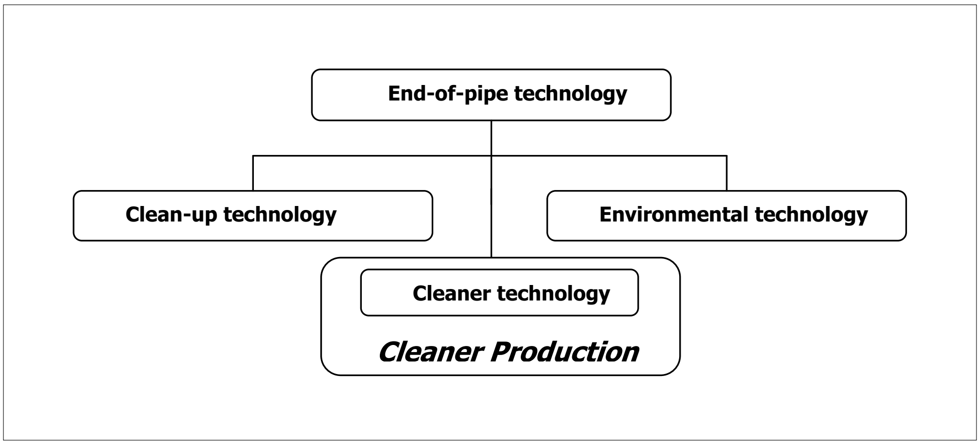
During the second half of the 1980s, a growing number of companies applied clean(er) technology for closing the loops and the reduction of emissions in the production processes. Cleaner technology experts – who were mainly found in environmental technology departments of the ministries of environment and industry in countries such as Austria, Denmark, Germany, the Netherlands and the United Kingdom – promoted the approach, which they considered to be better than end-of-pipe effluent treatment for two main reasons.

Firstly, end-of-pipe treatment often shifts the waste from one medium (liquid discharges) into another (solid wastes that are buried in landfills that have to be continuously controlled to avoid contamination from the landfill site to the air and water). Secondly, cleaner technology involves closing loops and using less energy, more efficient use of resources - including energy and water - as well as waste minimisation. It is therefore likely not only to be good for the environment, but also financially advantageous for the firm.

However, behind this simple conceptualisation of cleaner technology is a range of possible usages and interpretations. In particular, there is the distinction between radical changes within industrial processes and incremental programmes of waste minimisation applied to existing processes. More broadly, there is the key question: Whether cleaner technology should be viewed as applicable within a particular industrial process only?

The development of the different technological approaches has been sequential. Figure 3.2 provides a simplified overview of environmental technology classification.

Figure 3.2 **A simplified overview of environmental technology classification**



Cleaner technologies have not substituted for end-of-pipe technology in all applications. In some cases, the various technologies are actually complementary. The next overview reflects this development, in which end-of-pipe technologies symbolise control and clean-up technologies stand for cleaning processes. In contrast, cleaner technology is the technical development dimension of the integration of environmental management into company management, and cleaner production is its conceptual dimension. Cleaner production is seen as the final stage in these developments at the micro level of single organisations (See Figure 3.2).

This sequential development is also understandable when looking at the research time necessary to develop clean technologies. Quakernaat and Don (1988) have constructed, for the different technology categories, short term, medium to long term, and long term research time horizons. For good housekeeping activities, the research time horizon is less than one year, for add-on technologies three to five years and for process integrated technologies up to fifteen to twenty years.

3.4. The international context of emerging cleaner production dissemination policy

In this section developments around the prevention concepts in the USA, Europe and other parts of the world are described in chronological order. The first concept of pollution prevention was introduced by the corporate leader of the 3M company with the slogan: Pollution Prevention Pays (Royston, 1979, Ling, 1984) in their P3 programme in 1975. Several US states translated the concept into a technical approach in their Technical Assistance (TA) programmes. The US national government elaborated their environmental policy using concepts such as pollution prevention, waste reduction and waste minimization. Waste reduction was defined as: `..Waste reduction refers to in-plant practices that reduce, avoid, or eliminate the generation of hazardous waste so as to reduce risks to health and environment..' (US OTA, 1986); the definition of waste minimization was: `..The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either the reduction of the total volume or quantity of hazardous waste, or the reduction of toxicity of hazardous waste, or both, so long as reduction is consistent with the goal of minimizing present and future threats to human health and the environment..' (US EPA, 1986).

The United States Environmental Protection Agency (U.S. EPA) has been very active in research on pollution prevention techniques, manuals[33] and methods. The U.S. EPA output was often a guiding principle for many developments in other countries, such as in Austria, Denmark, Finland, Ireland, the Netherlands, Norway, Poland, Sweden, and the United Kingdom. Several countries translated and modified the U.S. EPA's Waste Minimization Opportunity Assessment Manual (1988).

The transfer of the concept to Europe took place in the second half of the 1980s. Waste prevention pilot projects were started in Sweden (Lanskrona project) and the Netherlands (student projects) in 1987. The transfer of knowledge to the Industry & Environment department of UNEP[34] was accomplished rather quickly afterwards via personal links. Indeed, the Industry and Environment Centre of UNEP has been very active in promoting cleaner production since 1988. A UNEP expert meeting in 1989 introduced the first definition of cleaner production as `..The conceptual and procedural approach to production that demands that all phases of the life-cycle of a product or of a process should be addressed with the objective of prevention or minimization of short and long-term risks to humans and the environment. A total societal commitment is required for effecting this comprehensive approach to achieving the goal of sustainable societies..' (Baas *et al*., 1990).

This normative approach perceives society as a context for industry to supply a business-fit method to move to sustainable activities: the pollution prevention and waste minimization approach provides many opportunities to address issues of economic feasibility, because many of the waste minimization measures are not only environmentally sound but are economically profitable for the firms too (Huisingh *et al*., 1986).

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[33] For instance even in a later phase, the Office of International Activities of the U.S. EPA developed a facilitator's manual for an international training course on the Principles of Pollution Prevention and Cleaner Production (September 1999).

[34] The United Nations Environment Programme's Industry & Environment Centre was established by UNEP in 1975 to bring industry and government together to promote environmentally sound industrial development.

Based on this philosophy, the concepts of cleaner production have evolved. In 1992, UNEP IE/PAC Newsletter of Cleaner Production contained four statements designed to answer the question, `What is cleaner production?':

a) Cleaner production means the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment;
b) Cleaner production techniques include conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes;
c) A cleaner production strategy for products focuses on reducing environmental impacts throughout the entire life cycle of the product - from raw material extraction to the product's ultimate disposal;
d) Cleaner production is achieved by applying expertise, improving technology and changing attitudes.

The UNEP and UNIDO organisations spread the cleaner production concept across the world. The small staff of UNEP IE together with a UNIDO representative started to perform cleaner production pilot projects in China and India in the early 1990s. Because of separation of responsibility of the different United Nations organisations, UNIDO representatives elaborated a structural programme of National Cleaner Production Centres. The programme was started in 1993 with allocated funds from UNEP, Austria and the Netherlands. The target of the National Cleaner Production Centres was to promote cleaner production at the national level through: conducting in-plant demonstrations and various training programmes for governments and industry to show cleaner production at work, analysing policy initiatives in the country and making recommendations to improve the policy framework for cleaner production, and acting as a focal point of cleaner production through information collection, analysis, and dissemination activities.

Other European initiatives came from The Norwegian Society of Engineers that organised cleaner production capacity-building especially in Central and Eastern Europe. The Norwegian Society of Engineers was funded by the Norwegian government. The Danish government funded bilateral programmes in India, South Africa, Thailand and Zimbabwe.

In 1993 the US AID programme sponsored a five-year programme – Environmental Pollution Prevention Project (EP3) – addressing urban and industrial pollution and environmental quality in developing countries. The U.S. National Pollution Prevention Roundtable helped spread the concept to the Asia-Pacific region in the second half of the 1990s. Furthermore, the U.S. EPA International Cooperative for Cleaner Production (ICCP), an initiative of the U.S. Environmental Protection Agency in 1997, was designed to provide co-operative resources for sharing on-line data of the global network of cleaner production/ pollution prevention centres and roundtables, and documenting information and technology exchange from industry, as well as national, regional, provincial and local governments around the world (see Section 4.4.2). The Asian Productivity Organisation (1999) developed similar Green Productivity strategies. Finally, the World Business Council for Sustainable Development developed their Eco-efficiency approach as: `The production of ever-more useful goods and services - in other words the adding of value while continuously reducing the consumption of resources and the creation of pollution' (WBCSD, 1997).

During the performance of demonstration projects, it was frequently experienced that the dissemination and implementation process was not so easy. UNEP IE took initiatives to renew the attention to cleaner production at an international policy level. As reinforcement of their 10-year-old Cleaner Production Programme, the Industry & Environment department of UNEP launched the International Declaration on Cleaner Production in the Republic of Korea on 29 September 1998. The reasons for this were both to stress that cleaner production and other preventive strategies (such as eco-efficiency, green productivity and pollution prevention) are preferred options and to encourage the adoption of sustainable production and consumption practices through partnerships with stakeholders.

These stakeholders are specific actors coming from government, industry, environmental advocacy organisations, citizens and academia. They are instrumental in the acceptance and breakthrough of new concepts. Their focus is on the role (either their own or other actors' perception of it), the definitions and the transfer of knowledge of clean(er) technology (i.e. not technology as physical goods or hardware), clean(er) production and industrial ecology with respect to the solution of environmental problems.

An integral part of the international context of the emergence of a new concept is the central role of academia. Some academics took initiatives in developing educational and training materials, as well as in testing and disseminating the concepts of cleaner production in an interactive applied science format. Although not directly in relation to pollution prevention, other academics took initiatives for developing new, multi-disciplinary theories to better understand the societal conditions for the promotion and implementation of sustainable development. Their approach stressed the importance of organisational and technological changes as two sides of the same coin that links the several human dimensions in global change: this was described by the Consortium for International Earth Science Information Network (CIERN, 1992) in the following terms:

- The Fund of knowledge and experience: the formal and informal understanding people have of their natural and social environments, and the technology that their culture defines as relevant;
- Preferences and expectations: people define their preferences and expectations, which reflect culturally defined constraints and opportunities that confront individual actions;
- Factors of production and technology: resources and technology that people use to produce goods and services constitute this category. This category helps us trace the elements that enter a system, how they are modified and what emerges at the end of the process.

CIERN (1992) strongly states that sciences must develop new theories and methodologies dealing with new conceptions of innovative forms of social organisation and types of action designed to make sustainable development possible. In environmental issues in general, different actors have direct or indirect influence on the position of companies. For example in the case of Shell's Brent Spar problem – the dumping of a crude oil reservoir used for storage in the oil drilling process in the North Sea – many scientific reports described the dumping to the sea bottom as the best environmental solution: it was on the basis of this knowledge that the U.K. government provided permission for dumping. Despite this, the latent influence of environmentalists and consumers became quickly activated under conditions of `perceiving dumping of oil-platforms as not being ethical and threatening the environment' (Grolin, 1998). Together with publications about the negative environmental and social effects of oil-drilling in Nigeria, the Shell CEO was forced to develop a transparent corporate policy. Just as a number of other multinational corporations, Shell also had to acquire understanding of sustainability through engaging or intending to engage in practices that were negatively valued by society at large.

3.5. **The emergence of industrial ecology**

Beyond individual companies, both chain management and industrial ecology emerged as new concepts in the Netherlands in the 1990s. The phrase *integrative chain management* was introduced in Dutch environmental public policy in the late 1980s (NEPP, 1989). It was defined as a management practice in which for every link of the chain (from extraction to processing, manufacture, distribution, consumption and discarding/recycling) environmental consequences are assessed and controlled in order to minimise the environmental impact of the whole chain. It was part of the interpretation by the Dutch government of the notion of sustainable development as introduced by the Brundtland report (WCED, 1987). It was presumed that within industrial sectors key organisations can specify environmental conditions to other organisations in their product chain.

The concept of industrial ecology has a diffuse background. In several parts of the world and at different times, people have been fascinated by the example set by natural ecosystems for human constructions. For instance in the development process of cleaner technology, UN/ECE (1984) describes the aim of low polluting energy within a bigger framework as: `..the aim is to obtain a complete technological cycle for the use of natural resources, compatible with or similar to natural eco-systems..', while for instance, Ausubel and Dale Langford (1997), use the concept of industrial ecology without defining it.

The concept of industrial ecology was (re-)introduced by Frosch and Gallopoulos (1989) with this definition: `..In an industrial ecosystem the traditional model of industrial activity, in which individual manufacturing take in raw materials and generate products to be sold plus waste to be disposed of, is transformed into a more integrated system, in which the consumption of energy and materials is optimised and the effluents of one process serve as the raw material for another process..'. This simple description was seen by many industrial ecology authors as the metaphor for natural ecosystems: these are very efficient processes in relation to energy use and the ability to re-use all of the wastes generated thanks to the ability of different organisms to work together. Industrial ecology is perceived as the discipline learning from, and applying, these natural systems concepts to industrial and other human activities; material flows studies provide a systematic inventory of inputs and outputs of a defined system. Frosch and Gallopoulos' approach was followed by several other definitions that placed industrial ecology at higher organisational levels, as is further discussed in subsequent sections of this thesis. All definitions imply that industrial ecology, in one way or another, mimics biological systems. The different authors used terms such as *symbiosis* (living together of two heterogeneous organisms for mutual advantage), *metabolism* (all processes in a living organism, by which energy and materials are taken in and utilised) and *synergy* (co-operation of different factors or organisms for a joint goal or performance).

3.5.1. *Cleaner production, integrative chain management and industrial ecology*

The Northern industrial economy can be characterised by an intensive use of raw materials, space and energy. This justifies a pro-active environmental public policy by which (industrial) firms are encouraged to reduce their emissions, waste, energy use and use of raw materials. Many firms have made progress in their environmental performance through a pro-active, preventive environmental management approach. Within the Agenda 21 agreement, the desire to establish a sustainable society and the pressure on companies to achieve this, was emphasised by all stakeholders.

At the level of individual companies, cleaner production is understood as the continuous application of an integrated, preventive strategy to processes, products and services in pursuit of economic, social, health safety and environmental benefits.

At the sectoral level, the concepts of integrative chain management and industrial ecology can be explored. As regards integrative chain management, four (necessary and sufficient) conditions were formulated:

- Knowledge of substance flows between society and the environment;
- Knowledge of maximum acceptable discharges into the environment;
- Knowledge of alternative options for reducing these discharges;
- Measures to obtain reductions of discharges.

But this says nothing about reduction at source through redesign or reduction in consumption. Also, it does not explicitly state anything about the flow of energy; it mainly focuses upon flows of other elements such as Aluminium, Iron, Zinc and so on. Furthermore, the issue of the institutional context of integrative chain management was not addressed, although the responsibility of industry in this respect was emphasised. Without further specification, it was implied that corporate environmental management systems and eco-design were part of the context for Integrative chain management (Baas, Bouma & Hafkamp, 1997). Within the Dutch government and in the civil service, the key assumption was that companies - individually or jointly - were not instituting integrative chain management. On the basis of this assumption, there are two possible competing approaches to implementing integrative chain management. In the most extreme approach of the two, government and regulators assume the role of *chain directors*; they propose new legislation, draft new regulations based on LCA, analyses of flows of substances, and so on. In the other, more restricted approach, they reconsider existing legislation and regulations, while adopting the concept of integrative chain management as a new policy principle (Baas, Bouma & Hafkamp, 1997).

While few authors address the issue of co-ordination within chains, i.e. within and between the involved companies, Cramer (1994) addresses these issues. She postulates the willingness, even eagerness, of companies – otherwise engaged in fierce competition for market dominance - to co-operate in order to improve their joint, overall environmental impact.

Six (1994), although analysing the matter in terms of environmental management (systems) within and between companies, focuses on the conditions and procedures for the successful implementation of integrative chain management between companies within one chain.

Industrial ecology – as defined and analysed by various authors in the next sections – provides a somewhat different perspective by broadening the scope from co-operation strictly within chains to co-operation between chains (cascading, facility sharing, and so on). The focus is often largely on physical flows of substances and the physical transformation processes. They do not address issues of co-ordination (mechanisms) within and between organisations, they ignore the institutional structures within which organisations operate. The co-ordination of activities conducted by various economic actors can be influenced by the choice for the other optimisation domain such as: product life cycles, material's life cycles, sectors of industry, geographical areas, markets (for raw materials, commodities, products, services, labour, capital and insurance) or a mixture of these domains (Boons & Baas, 1997).

Furthermore, the co-ordination can be established by intermediary organisations that function as *neutral* pushers in the development process (Côté, 1995, Christensen, 1995, Baas, 1998b). Co-ordination may also be legislative, addressing issues of competition, right to know, fiscal incentives, environmental regulations and liability. Finally, it may be cultural, social, historical or ethical. Industrial ecology should include the neurology of organisms, competition between species and population dynamics without getting trapped in oversimplifications of socio-biology (Baas, Bouma & Hafkamp, 1997).

De Kruijff (1992) argues that `..industrial ecology means in essence the development of industrial infrastructures as if these are an array of interlocking man-made systems..'. He distinguishes three types of loops or streams: industrial production of materials, industrial manufacturing of products, and the consumer-product cycle. This should lead to the `integral industrial ecological cycle'.

Industrial ecology and integral chain management are similar in that they both seek:

- To save energy and materials through de-materialisation;
- To prevent waste and storage of rest products by just-in-time management;
- To develop insight into environmental costs through work designed to internalise them;
- To promote the leasing of sustainable goods that provide producers incentives for innovation on the basis of life cycle costing;
- To integrate an infrastructure for take-back provisions, re-use of materials, equipment sharing and service centres in the industrial ecosystem.

Industrial ecology differs from integrative chain management in its focus on going beyond the industrial sector and product chain boundaries via:

- The design of by-products and waste exchange facilities to recycle and re-use wastes (EPA, 1995);
- The development of industrial ecosystems - Eco-Industrial Parks (Lowe et al., 1996) - to promote an optimal exchange of energy and materials between as many companies as possible.

The concepts of industrial ecology are set down in a wide range of interpretations such as: a conceptual model, an analytical method, a management strategy, a branch of system science and system thinking, and a regional approach. The different interpretations are briefly discussed in the next paragraphs.

3.5.2. *Industrial ecology as a conceptual model*

Frosch and Gallopoulos (1989) started from the position that the analogy with biological systems, in which waste products of one organism can be the food of other organisms, should also be applicable to industrial systems, hence the phrase industrial ecology.

The concept did not meet with an enthusiastic reception from cleaner production experts and environmental NGOs. It was feared that this approach could block or slow down cleaner production developments in companies, because it is easier to sell your wastes than working in internal company processes to prevent the generation of waste at the source. Others, such as Ayres (1989) argues in his definition of metabolism that industrial ecology provides a new vision of reality: `..The metabolism of industry is the whole integrated collection of physical processes that convert raw materials and energy, plus labour, into finished products and wastes in a more or less steady-state condition..'. However, both as regards the products and the wastes one must ask whether they are sustainable and equitable in an environmentally sound ethical vision.

Environmental issues can also be defined in another way and stimulate new approaches. Socolow (1994) describes six new perspectives at the conceptual level:

1) Liveability in the long term: the time perspective (with respect to environmental problems and environmental management systems) shifts from sanitation of pollution in the short term to thinking about liveability in the coming century and after that;
2) The global context: the perspective shifts from local problems to global impacts;
3) The conquest of natural systems: the perspective of interaction between humans and their natural surroundings;
4) The vulnerability of humans: vulnerability with respect to natural processes;
5) The analysis of material and energy streams: looking at the streams of materials and energy from the perspective of the Law of Thermodynamics;
6) The central place of industry and agriculture: the difference between consumer and producer becomes diffuse.

The model of natural ecology is the conceptual model for industrial ecology. The relationship of industry with both the natural and the constructed surroundings becomes clear from the viewpoint of the prevention of pollution and resource exhaustion.

Besides the application of cleaner production and industrial ecology at the operational level, the industrial ecology concept provides industry with a model at the strategic level for talks and exchange of materials with surrounding companies designed to improve environmental performance. The cyclical nature of material flows also affects the surrounding community, either as regards identifying the relationship between natural and industrial ecosystems (de Walle, 1996), or developing mediation to influence such systems towards sustainable development.

3.5.3. *Industrial ecology as an analytical method*

Under this heading, industrial ecology is the study of materials and energy flows in industrial and consumer activities and the impacts of these activities on the environment, as well as the influences of economic, political, regulatory and social factors on the flows, the use and transformation of resources (White, 1994).

Ehrenfeld (1994) defines the analytical approach in the following way: `..Industrial ecology is a large analytical framework that serves mostly to identify and enumerate the myriad flows of materials and technological artefacts within a web of producers and consumers..'.

At this level, industrial ecology considers total production and consumption as a web of food-supply in which nothing is lost as the ideal type of operating societies. The exchange of materials, the design of energy and water cascades, and modernisation of technologies are part of the analysis.

3.5.4. *Industrial ecology as a management strategy*

Industrial ecology as a management strategy can focus on several aspects. Firstly, according to Allenby and Richards' (1994) formulation: `..To manage the earth's resources in such a way as to approach and maintain a global carrying capacity for our species, which is both desirable and sustainable over time, given continued evolution of technology and quality of life. The study of what this entails, especially in terms of existing (objective) and desirable (normative) patterns, is industrial ecology..'. Secondly, industrial ecology as a management strategy can focus on the design and management of eco-industrial parks (Lowe et al., 1996)[35] and similar ways of exchange of materials and energy between companies. The industrial infrastructure can be designed as a series of assembled, man-made ecosystems in interaction with the surrounding natural ecosystem (Tibbs,[36] 1992, Kirschner,[37] 1995).

Industrial ecology as a management strategy also involves new actors such as physical planners and community land-use developers. The addition of environmental considerations in the physical use of space means a further step towards sustainable development at the community level.

3.5.5. *Industrial ecology as a branch of system's science and system's thinking*

Indigo Development (1998) identified the following as crucial parts of the systems approach:[38]

- A system is a set of elements interrelating in a structured way;
- The elements are seen as a whole with a purpose;
- A system's behaviour cannot be predicted by analysis of its individual elements;
- The properties of a system emerge from the interaction of its elements and are distinct from their properties as separate species;
- The behaviour of the system results from the interaction of the elements and between the system and its environment (System + Environment = a larger system);
- The definition of the elements and the setting of system boundaries are subjective actions.

A system's perspective on industrial ecology can be applied at different levels, depending on the time frame, the scope, and the order of innovation and change:

1) Short term enhancements concern the optimisation of energy use and pollution reduction in production processes and the use of a product. Incremental innovations through such tools as design for environment (DfE) are illustrative for this level;
2) New design beyond the actual optimisation level of energy use and pollution in production processes and the use of a product. A radical change such as the hybrid electric bus is an example (Van Vliet, 1999);

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35 Lowe, E.A., S.R. Moran & D.B. Holmes (eds.), Fieldbook for the development of Eco-Industrial Parks, Indigo Development, Oakland, USA, 1996.

36 `..Industrial ecology involves designing industrial infrastructures as if they were a series of interlocking man-made ecosystems interfacing with the natural global ecosystem. Industrial ecology takes the pattern of the natural environment as a model for solving environmental problems, creating a new paradigm for the industrial system as a process..' (Tibbs, 1992).

37 `..Industrial ecology applies the principles of natural systems - such as carrying capacity, material flows, resilience, and connectivity - to man-made systems..' (Kirschner, 1995).

38 Indigo Development, Critique website page, Hwww.indigodev.com/Critique.htmlH, accessed in 1998.

3) New design with highest resource efficiency and the potential substitution of products with services.

The first level involves short-term incremental approaches. At the second level, radical changes within the same functional framework of a process or a product are needed, while at the third level, fundamental changes involve the structure of production and function of products. However, the connection between the levels is not clear; are they evolutionary developments? Is one level necessary for the development of the other?

Until recently, the most advanced environmental measures taken by companies were specific to a local production plant or a local production process. However, in a more holistic view, different stages in the development of industrial and regional environmental approaches can be distinguished (Brattebø, 1996).[39] In Figure 3.3, the scope of environmental concerns (placed on the vertical axis) is faced with the scope of temporal concern (placed on the horizontal axis).

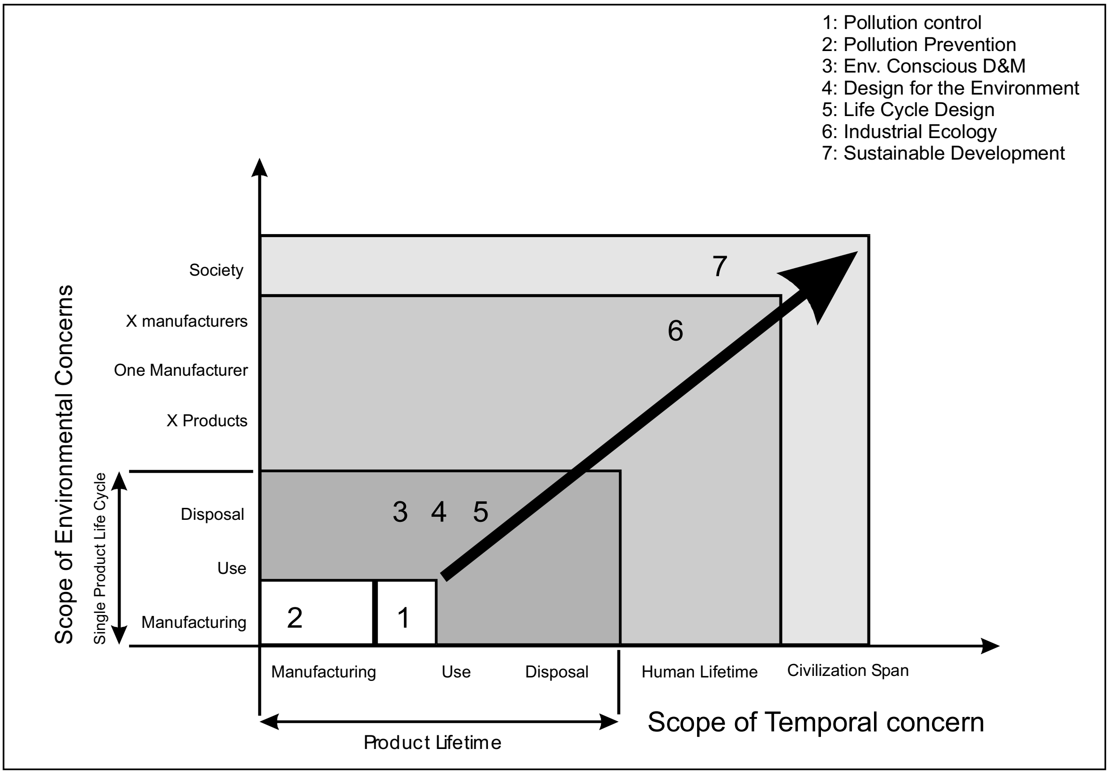
Brattebø placed pollution control (1) and pollution prevention/ cleaner production (2) still within the traditions of industry, while the arrow towards sustainability dynamically crosses the fields of Environmentally conscious development & manufacturing (3), Design for the Environment (4), Life Cycle Design (5), Industrial Ecology (6) and Sustainable Development (7). The concepts, in earlier stages, were more or less prerequisites for the later stages. In real life, the development was not so strictly linear, but had cyclic or feedback loops and/or met fall back situations (Hafkamp, 1996).

The first four stages are approaches that are typically applied within single companies. It is worth noting that Brattebø (1996) placed pollution control (1) as an additional tool to pollution prevention/cleaner production (2). The scope of dissemination of pollution prevention/cleaner production however is still at a lower level than the state-of-the-art level of pollution control.

Pollution control is mainstream in both highly and less industrialised countries. Most often the environmental regulatory system was based originally on pollution control. An illustration for the common situation in less industrialised countries is the cleaner production public policy analysis in Mexico: only the import of end-of-pipe technology is subsidised (Baas, 1998a). This finding is connected to the common situation in the Northern industrialised countries, where both the development of end-of-pipe environmental technology is dominant in environmental management and the export of end-of-pipe environmental technology is financially supported.

[39] Brattebø, Helge, From Pollution Prevention to Industrial Ecology, The Difference, Presentation at the 3rd European Roundtable on Cleaner Production, Kalundborg, Denmark, 31 October 1996.

Figure 3.3 **The dominant environmental management concepts from pollution control to industrial ecology as interlinkages between environmental and temporal concerns**



Life cycle design (5) is the first stage in which intense co-operation between the different organisations involved during the product life cycle is necessary. Life cycle design seeks to reduce the total environmental burden associated with product systems by balancing environmental needs with other design objectives such as performance, costs and legal criteria (van Berkel, 1995).

3.5.6. *Criticism of the industrial ecology concept*

Another feature of Figure 3.3 is that industrial ecology (6) is positioned in the phase before sustainable development (7). This has been criticised by practitioners, who see industrial ecology as a barrier to cleaner production. Referring to the definition from a cleaner production perspective, they see the industrial ecology approach as a step back (to level 1), because the physical activity supports and institutionalises waste exchanges, and the stimulus for creativity and innovation – that are at the basis of a preventive approach within companies – is blocked or at least delayed by the easier solution of external waste exchanges.

However, industrial ecology can be analysed at different levels in a continuum stretching from waste-exchanges to the holistic approach involving sustainable regions. Industrial ecology offers an important set of goals and organising principles that can be used to reform industrial activities in order to reduce their adverse environmental impacts. Though they recognise this potential, O'Rourke *et al*. (1996) consider that industrial ecology is currently mired in its own ambiguity and weaknesses. They formulate five main criticisms: it is poorly defined, the tools have methodological weaknesses, the strategies do not often support goals, the implementation, to date, does not reflect ideas expressed in the literature, and technical analyses of energy issues and socio-political analyses of means to transform industry are extremely limited.

With respect to the biosphere-technosphere analogy, Boons and Baas (1997) consider the implicit assumption (in the concept) about reaching an optimal state. A biological ecosystem evolves towards a - local - equilibrium via the evolutionary mechanism that operates through the processes of variation, selection and reproduction at the level of organisms. Arriving at an equilibrium state is not necessary, but the evolutionary mechanism often results in biological systems because the process of variation, selection and reproduction (in short, adaptation) runs faster than the environment is changing. It should be noted that an equilibrium state is not necessarily an optimal state. Boons and Baas (1997) take two points into account in relation to the mimicry implicit in the industry -ecology analogy:

a) The use of this metaphor rightly emphasises the fact that industrial processes are interrelated;
b) The adjustment of different processes towards each other and towards their (natural) environment does not result from autonomous processes, but can only be achieved by intentional action.

As the industrial ecology concept involves a complexity of actors, organisations and activities, intended targets can be reached but unforeseen effects can also occur. Thus, the process of influencing developments will be dynamic.

Oldenburg and Geiser (1997) state that industrial ecology can be efficient but does not solve the problem of toxic substances. Comparing the concepts of pollution prevention and industrial ecology, Oldenburg and Geiser (1997, 105) designed the following overview:

Table 3.2 Comparison of aspects of pollution prevention and industrial ecology concepts

Aspect \ Concept	Pollution prevention	Industrial ecology
Primary goals	* Prevent pollution * Reduce risk	* Optimize resource flows * Promote sustainability
Primary focus	* Individual firm	* Networks of firms
Core concept	* Planning process	* Integrated system
Primary techniques	* Life cycle assessment * Process characterization * Materials accounting * Waste audits * Full cost accounting	* Life cycle assessment * Materials accounting * Design for environment
Role of recycling	* Only in-process	* In-process, off-site and between firms
Role of government	* Technical assistance	* Barriers removal
Economic domain	* Multiple sectors	* Industrial sector
Mode of evaluation	* Materials tracking	* Materials tracking

Oldenburg and Geiser (*ibid.*) state that industrial ecology's *natural systems* model has been applied almost exclusively to industrial activities. Pollution prevention, though limited at the beginning to industry, later spread to agriculture, fisheries, forestry, transport, tourism, hospitals and other services. It has proven practicability, whereas industrial ecology remains mostly theoretical.

Their observations call for a question and some observations:

- Is not industrial ecology now in the same limited phase as pollution prevention was in the beginning? On the one hand, cleaner production can be classified as isolated projects long duration, on the other hand, there are many Eco-Industrial Park initiatives all over the world at the end of the 20th and the beginning of the 21st century (Industrial Ecology Conference, Troyes, 1999, IE Asia Conference, Manila, 2001, International Society for Industrial Ecology: Noordwijkerhout, 2001, Ann Arbor, 2003, Stockholm, 2005);
- The mature industrial ecology concept in Kalundborg involves links to fish farms and traditional farmers.

Also Côté and Cohen-Rosenthal (1998) emphasise that the evolution of eco-industrial parks towards an ecosystem is still at a very early stage of development. They stress that `..Eco-Industrial Park's analysis occurs in at least three domains facing the problem that these domains stretch across three different disciplinary sets that rarely interact..' (p.185):

1) The technical-analytical domain: industrial ecology describes a set of interactions within a physical realm of chemical and energy transactions and the technologies associated with those transactions;
2) The economic domain: industrial ecology exists within an economic or business framework where exchanges and relationships of a different sort occur;
3) The societal domain: there is a connection between the businesses and the surrounding community, in both its social and ecological dimensions, that shapes the character of industrial ecology applications such as eco-industrial parks.

In contrast to the perception that industrial ecology provides a new perspective at various stages towards sustainability, many critics fear it is a misleading perspective and a barrier to creativity in further steps towards sustainability. Also, the lack of attention to labour conditions and logistics is often criticised (Ashford, 1997). It seems that the scope of industrial ecology is an important variable. If the scope only includes the separation, recycling and mixing of waste (in other semantics),[40] then industrial ecology is not a new sustainability driver. If the scope embraces the *science of sustainability*, new pathways to sustainability can be explored.

3.5.7. *Industrial ecology as a regional approach*

Industrial ecology can be understood or applied as a regional approach instead of as a product approach. Industrial ecology is a concept that is receiving much attention from industry, government, research institutes, universities and NGOs. Industrial ecology is based upon the understanding of the flow of materials and energy through industrial systems, their impacts on the environment and how technological capability, policy instruments and other socio-economic factors affect these flows and impacts. The proposition that industrial system design might benefit from understanding natural system dynamics has suggested the concept of industrial ecosystem.

Gertler (1995) gives a more specific definition of an industrial ecosystem: `..An industrial ecosystem is a community or network of companies and other organisations in a region which chose to interact by exchanging and making use of by-products and/or energy in a way that provides one or more of the following benefits over traditional non-linked operations..':

- Reduction in the use of virgin materials as resource inputs;
- Reduction of pollution;
- Increased systemic energy efficiency leading to reduced systemic energy use;
- Reduction in the volume of waste products requiring disposal (with the added benefit of preventing disposal-related pollution);
- Increase in the amount and types of process outputs that have market value.

Wallner & Narodoslawsky (1994) wrote about *islands of sustainability*. The basic assumption of the industrial ecology approach is that development towards sustainability can be introduced starting from small industrial ecosystems or sustainable regions. The search for and the launch of new partnerships with other organisations is of eminent importance to explore the potentials of the concept of industrial ecology. Communication activities such as exchange of matter, energy, information, culture, capital and persons within the industrial ecosystem and with the environment is an important precondition for the success of a regional approach.

A further look at the definitions shows that although the cleaner production/pollution prevention techniques exclude off-site recycling, the first Waste Minimization Opportunity Assessment Manual does included such handling (1988).

Moreover, Ayres (1992) developed the concept of industrial metabolism in a broader context. Other definitions cover similar approaches at the industrial level. Sometimes in a global context of natural resources management (Allenby, 1994), sometimes in an industrial infrastructure (Tibbs, 1992) and consumer-producer relationships (Ehrenfeld, 1994).

[40] Such as the Closing the Loop workshop in Technical Program II in the The Science and Culture of Industrial Ecology conference of the International Society for Industrial Ecology in Noordwijkerhout, 12 - 14 November, 2001.

Finally, industrial ecology is used at a level beyond a company's internal cleaner production optimum (including product eco-design, extended producer stewardship, Kruszewska & Thorpe, 1995). Brattebø (1996) identifies cleaner production and environmental management as process oriented. According to him industrial ecology is system-oriented and covers a longer time frame and the whole manufacturing sector.

3.5.8. *Expected trends in industrial ecology*

Together with many US industrial ecology promoters, Allenby (1999) sees a strong role for technology as a basis for global development. He names eight basic trends affecting industrial ecology and globalisation:

1) A globalised economy and society is evolving, not necessarily homogeneously: there will be more communities, units, systems, interests, political and social entities and technology clusters at different levels, and concomitantly more relationships between them;
2) The earth is increasingly an engineered world. But this does not imply that we have the appropriate technical, scientific and policy tools to manage, or engineer such a world;
3) Western concepts of reductionist science (smaller units, greater depth, linear, short-term) will have to be augmented by more system-based, comprehensive approaches. Many familiar institutions (academic, private firms, political structures) are strongly resistant to integrative initiatives;
4) Policy generally deals with the short term and covers limited areas;
5) The degree to which virtually every modern institution is changing is both unparalleled and little recognised;
6) The terms sustainability and sustainable development are not just ambiguous because of current lack of knowledge, but because they involve social choice;
7) Evolution toward an economical and environmentally efficient economy will differentially favour certain industrial sectors and technology systems and disfavour others;
8) Environmental issues are occasionally framed in apocalyptic terms.

With this summing-up the question also arises whether the advocates of industrial ecology are focusing too much on technology and are both neglecting the need for transparency and fairness of trade, and making insufficient use of the social science knowledge of processes of (organisational) change. The globalised economy as an existing market for industrialised countries and a new products market in developing countries is already there or is emerging for many multinational corporations. But before that, the extraction of resources and food ingredients had already been part of a globalised economy for centuries. Portugal, Spain and the Netherlands already had world-wide fleets for the transport of those resources in the 17th century. The power-based inequity of trade during colonial times created the current dependency of many poor countries on their mono-culture resource that is often traded within the framework of rigid agreements with multi-national corporations from rich countries.

Furthermore, we deal with environmental issues that are difficult to solve in an international politics forum such as the climate change issue.[41] But we also face public opinion based changes in different regions of the world, such as the industrial zero-waste

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[41] However, at the World Economic Forum's Annual Meeting at 28 January 2000 in Davos (Switzerland), business leaders said that climate change is the greatest challenge for to mankind.

change in the Republic of Korea and Japan and the developed mistrust in cattle-breeding on factory farms because of many cattle diseases in Europe at the end of the 20th and the beginning of the 21st century.

3.6. From concept description to dissemination and testing

This section introduces the description and analysis of the launch and dissemination of cleaner production in the Netherlands and world-wide, and of industrial ecology in the INES project in the next chapters.

The discussion about the transition from pollution control towards pollution prevention focuses on how it is influenced by industry, government and stakeholders (such as consumers, environmental advocacy organisations, labour organisations and citizens). Critics have expressed the opinion that the transition, on a partly voluntary basis, is an illusion or goes temporarily out of control, giving polluters extra time to continue their old polluting activities, which are out of balance with the environment. On the other hand, those mental and organisational processes of change towards sustainability do take time, so it is difficult to analyse such processes within a limited time frame. Furthermore, it has been observed how management fads came and went in the second half of the 20th century, which suggests that there is a life cycle to management fashions (Whitney, Gibson & Tesone, 2001). This observation is also relevant for the concepts of cleaner production and industrial ecology; and is analysed in Chapter 9.

As a thread running through the growing attention to environmental problems is the mimicked development of environmental management systems that in essence started in the 1990s as top-down, administrative systems that were separated from general management. Later some firms developed more pro-active environmental management approaches. The firms felt responsible for their environmental performance and involved new actors at different management levels. A type of self-regulatory system embedded in voluntary agreements with government meant that regulatory agencies also had to re-think their strategies. Although a regulatory framework keeps providing the foundation for general environmental public policy, facilitating roles for stimulating industrial self-regulation will increase both through economic and social instruments, and interactive dialogues with industry.

As written in Chapter 2, the dissemination processes of the concepts of cleaner production, industrial ecology and sustainability are analysed in this thesis at the micro, meso and macro levels. These three levels must be interpreted in two ways. Firstly, the levels are dealt with in relation to system boundaries as single organisations (micro level), as organisations located in regions or as members of an industrial sector (meso level), and as a society (macro level). Secondly, the dissemination of the concepts that are examined at one level, is influenced by dimensions from other levels. Thus the dissemination of cleaner production within organisations (micro level), is also affected by developments in the surroundings of organisations at the meso and macro level.

The unit of analysis for the introduction of cleaner production is the individual organisation. In relation to it, outside actors can introduce the concept and the translation in the organisation might affect their routines. The introduction of industrial ecology is going beyond single organisations, which means that actors outside the companies can manage the overall industrial ecology projects between the different companies, but the dissemination within a company is dependent from the single company management. Sustainability looks like an umbrella concept, with a three-level sustainability model covering many dimensions in the structure and change processes columns that together reflect the Research field multi-level of concept innovation model in this thesis (Figure 2.2).

The model takes into account the dynamics of dissemination that affects all levels of the concepts and their main interface. The conditions and capabilities for breaking through existing routines are part of an eventual organisational change. In relation to this change, individual and organisational actors and their mindsets are examined within the existing institutional framework. The main variables are the history and culture of the existing institutional framework, the actors that are involved in decision-making processes within and between organisations, each other's perspectives, the perceived balance between the economy and ecology, and the willingness to change and the capacity for innovation of the organisations and their stakeholders.

- *Micro level*: the concept of cleaner production, leading to sustainable companies.

The cleaner production dissemination process was started in an `economy dominant context with a pollution control perspective'. In this context, a gap between stakeholder perspectives existed and only marginal changes of the institutional framework of environmental regulation took place. The cleaner production demonstration projects with a *learning by doing* approach were widely appreciated by the organisations involved, but the concepts had to be developed to reflect the (often minor) changes with respect to their traditional industrial practices. Learning processes for the new cleaner production concept have to cope with a technostructure based on an engineering perspective at the micro level that dominated the translation of the concept. Each of the four principles of cleaner production (Gee, 1994) - precautionary, preventative, integrative (put *eco* back in *eco*-nomy) and democratic - were marginally known or applied in industrial organisations.

Information, awareness-raising, education and research via demonstration projects are all instruments that can influence the main variables such as perception, power and decision-making processes in the societal structure in which the process of concept development takes place. They are the basis for involving new actors at higher levels within organisations in change processes.

- *Meso level*: the concept of industrial ecology, leading to cluster management and sustainable regions

The dissemination of industrial ecology also began in an economy dominant context with a pollution control perspective, although the environment as an issue was acknowledged and accepted as belonging to the sphere of responsibility of business management. More frequently environmental covenants provided the context for longer term change processes. The dialogue among regional stakeholders about the institutional framework was a dimension of the process of searching for new ways to integrate environmental management into new routines and procedures. New actors from the highest (plant) management levels became involved.

- *Macro level*: sustainable development; relation with levels of change on 2nd order learning.

At the macro level, strategic policy developments, both at the private and public organisational levels, influenced the translation processes of stakeholders. Developments in society – such as public pressure expressed in reaction to the economic globalisation processes – influenced the integration of sustainability at the micro, meso and macro levels. At the macro level, attention was paid to steering processes and conditions.

In relation to sustainable regions, the categorisation of modes of sustainability by Selman (2000) has been used in this thesis. It typifies the characteristic features of *modes of sustainability* and the integration of economic, social, environmental dimensions in a continuum from very strong to very weak.

Table 3.3 Modes, characteristic features and canons of sustainability

Mode of sustainability	➢ Characteristic features of modes of sustainability	➢ Canons of sustainability: integration of economic, social, environmental dimensions
Very strong	➢ New community structures ➢ Community-led initiatives become the norm	➢ Isolated pointers to industrial complexes based on ecological flows
Strong	➢ Local initiatives as part of community growth ➢ Community involvement	➢ Genuinely holistic thinking starting to emerge in some quarters of local government
Weak	➢ Wider public education for future visions ➢ Round tables, stakeholder groups	➢ Policies for industry generally reflect the `weaker' end of the sustainability spectrum
Very weak	➢ Lip service to policy integration ➢ Minor tinkering with economic instruments ➢ Faint social awareness and little media coverage	➢ Problems of including business in dialogues ➢ Departmental silos still strong ➢ Implications that LA21 fosters business as usual despite rhetoric

The dissemination processes are theoretically reflected in a framework of organisational change and learning processes. The concepts of paradigm shift, perception, information processing, decision-making, power, awareness raising, translation and their institutional context are the basis for descriptions and analysis of the cleaner production and industrial ecology concept dissemination processes and their application. With respect to this dissemination processes, the different uses of the approaches will be explained in Chapter 5.

3.7. Recapitulation of the development of environmental policy as the context for the dissemination of the cleaner production concepts

From the 1960s, the recognition and acknowledgement of environmental problems led to the development of public environmental policies. To meet environmental requirements, industry started to use technical, pollution control solutions in the 1970s; in the 1980s, they used closing the loop and environmental technologies as their environmental management practices to deal with waste and emissions. Environmental issues became important aspects of company management in the 1990s: the implementation of *environmental management systems* became a dominant way of dealing with these issues in a systematic manner (de Groene, 2000), and the emerging cleaner production concepts were mainly of a technical nature. However, the developments have also suffered setbacks and backlashes from several stakeholders, whilst no clear vision of the path towards a sustainable infrastructure has emerged. This mixture of progress and setbacks has been labelled turbulence (Hafkamp, 1996). Besides that, change within companies has often taken place at a low level – meeting the regulatory requirements and participation for the show (Van de Peppel, 1995).

In general, government and industry are in favour of the prevention approach. Although environmental technology should involve all those technologies, processes and products that reduce or prevent environmental pollution (Quakernaat & Don, 1988), a new industrial sector has emerged, at first focusing upon the development of waste treatment technologies, now referred to as end-of-pipe technologies. Environmental technology has provided the basis for a new sector of industry and for new environmental consulting organisations. It has also contributed to the traditional GNP accounting, in which environmental damage was not internalised in the equation. This industry-dominated environmental approach in the 1980s formed the background for the emergence of the new concepts of cleaner production and industrial ecology.

As a general rule, it can be concluded that for a long time the environment was regarded as the last item that polluting organisations took into consideration, both in their economic (externalised costs) and technological approaches (end-of-pipe applications such as pollution control). These approaches have generated many obstacles about the necessity for environmental measures, because of their costs. In line with the preventive method, another perspective gained attention, namely regarding a clean environment as a resource and not as a sink. A clean environment that is viewed as a resource can be either renewable or non-renewable. The characteristics of a renewable resource can differ because of the scope and time frame for recovery. The renewal of an entire eco-system is more difficult (or impossible) than the recovery of a polluted river. This is why we face the need for an environmental policy paradigm shift towards sustainability with a body of knowledge based on prevention.

Within this context, the analysis of the concept dissemination processes and the activities at the different levels of organisations will be described and analysed in Chapters 4 – 9 of this thesis. The general guidelines for the development and implementation of a generic method of concept innovation will be discussed in Chapter 10.

4 The Period 1985 - 2000: Cleaner Technology and Cleaner Production Developments in the Netherlands and Internationally

This chapter describes and analyses the dissemination of the cleaner production concept in the Netherlands and internationally in the period 1985 – 2000.[42] The analysis of cleaner production projects is based on observations and documents, background information provided by participants in cleaner production events and secondary analysis of research documents in the perspective of a longer timeframe. Attention is given to the origins of the separate concepts related to pollution prevention and the differences between them since their introduction, the research question being: `What were the origins and characteristics of the cleaner production and industrial ecology concepts and the intervention processes leading to the application of these concepts and accommodation with their implementation'?

The emergence of environmental technologies designed to help solving environmental problems is described first. The starting phase in the 1970s (besides the development of environmental laws and regulatory institutes) can be characterised as a pure technological engineering approach to control pollution. End-of-pipe technologies were not conceived as cleaner technologies.

In the 1980s, discussions conducted in international organisations and the documents these produced broadened the scope of technological approaches, by adding environmental and/or cleaner technologies that waste less or close the loops in production processes. Section 4.1 starts with the determination of five phases of preventive developments and the dominant actors in that process. Section 4.2 briefly reflects on the context of the emergence of the cleaner production concept. In Section 4.3, the development of cleaner production projects is described and analysed: their position is found to be specific to the distinct development phases of cleaner production implementation. This interpretation is based on the life-cycle of cleaner production dissemination from the phase of emergence until early maturity. Section 4.4 discusses the international dissemination of cleaner production, illustrated by the UNIDO/UNEP National Cleaner Production Centres Programme that is being promoted worldwide (UNIDO/UNEP, 1997). Section 4.5 describes and analyses the process of professionalisation of cleaner production, which involved launching new journals, expert associations, National Cleaner Production Centres and regional Cleaner Production Roundtables on all continents. Section 4.6 analyses the characteristics of this international dissemination process, followed by a recapitulation of the major conclusions of this chapter in Section 4.7. All projects are described according to the first round of Ragin's interduction research model (1994) at the micro level within organisations and at the meso and macro levels of the interaction patterns between organisations in relation to the dissemination of the concept, the existing institutional framework, the dominant variables in the process and the results of change.

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[42] The chapter's focus is on this period; however, a historical observation concerning earlier developments is also made. The emerging industrial ecology concept (in the shape of an Eco-Industrial Park application in the same period) is described and analysed in Chapters 7 and 8.

4.1. **From pollution control technology to cleaner production**

At the beginning of the 1980s, the Dutch government started to support the development of environmental technology (Environmental Technology Subsidy Programme, 1982). The dissemination of control technology in small and medium-sized companies received special attention in environmental public policy. The lack of environmental management in small and medium-sized enterprises often led to crisis decisions to meet regulatory requirements.

When small and medium-sized enterprises looked for external advice, they found advice from pollution control consultants with a biased knowledge of environmental control equipment and/or interests in selling such technology (Frank & Swarte, 1986).

The government's control technology approach was further elaborated into clean technology stimulation. Relatively small programmes for the promotion of environmental technologies subsidised clean technology pilot projects. In fact it was the result in the margin of the overall environmental public policy due to of the efforts of one official at the Ministry of Environment. However, the clean technology projects were not so easy to develop in practice. The dominance of cleaning and pollution control technology advice (Frank & Swarte, 1986) and the small turnover perspective for the emerging environmental technology branch (Driel & Krozer, 1987) did not promote new technological developments. As a result of this the programme mostly subsidised the application of cleaning and abatement techniques in the period 1981 - 1989. An evaluation of the national programme `The dissemination of Cleaner Technology' (Ministry of Environment, 1984) shows two deviations from the target (Betting, 1988):

- Only 21.5% of the programme subsidy was used in the industrial sectors that had priority in environmental public policy management;
- Only 28% of the programme subsidy was used for cleaner technology (47% of the subsidy was used for add-on technology, 15% for cleaning technology and 6% for clearing technology).

Besides pollution control, environmental technology formed the basis of a new sector of industry and new environmental consultancies. Another initiative to promote cleaner technology was the Moor-Vermeend Act (Tweede Kamer,[43] 1989), named after the two members of the Dutch parliament who had initiated that law. It provides subsidies[44] to companies that install environmental technologies mentioned in the law. Such a subsidy has both positive and negative effects. On the one hand companies can be stimulated to invest in these technologies and can improve their environmental performance, on the other hand they can focus too narrowly on the described technologies (some of them are purely end-of-pipe technologies) and lack sensitivity to preventive solutions. A side effect at the macro level was that this growth of environmental technology also contributed to traditional GNP accounting, in which environmental damage is not internalised into the equation.

The industrial sector's approach to the environment in the 1980s was characterised by end-of-pipe technology as central concept, lagging behind the legalistic approach of permits, in an antagonistic/negotiating relationship with government (Boons, 2000).

The following typology can be established: at a macro level, industry was following the authorities by meeting the environmental requirements that were formulated on the basis of

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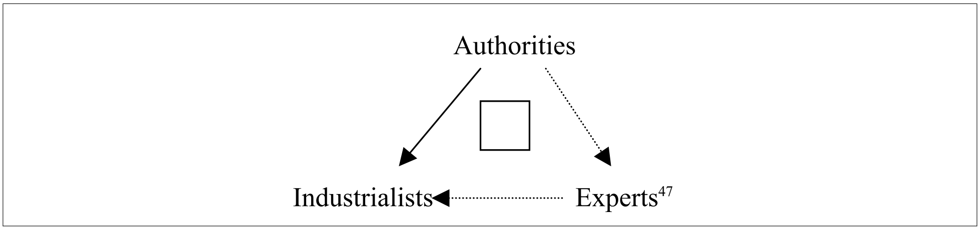
[43] Dutch Parliament, 1989.

[44] The effectiveness of subsidies themselves is not discussed in this document.

the environmental laws formulated in the period 1970 - 1985. At the meso level, the development of a new industrial sector – environmental technologies, and in the footsteps of that, consulting and engineering firms specialised in environmental technology – played a influential role. At the micro level, when small and medium-sized enterprises were forced to meet requirements, they were confronted with external advice based on biased knowledge of the environmental technology field. Biased knowledge was found both in consulting firms and government environmental agencies (Frank & Swarte, 1986). This led to a top-down regulatory environment, in which the power of environmental regulation to enforce its requirements and the power of information about environmental technology reinforced decision-making at the micro level in an `environmental costs adding perception mode'. As a result the institutionalised relationship of the actors in society strengthened traditional mutual perceptions.

Figure 4.1 **Phase I (1970[45] – 1985): Industry follows[46] the authorities and e-o-p technology experts**



In the second part of the 1980s, the technology-based paradigm still dominated the discussion; furthermore economic aspects – such as setting a boundary to the application of environmental technology – emerged as variables that were perceived as barriers in the discussion. As part of the first environmental management responses to the environmental requirements, the terms *best practical technology* and *best available technology* were established and used in policy documents and permits to indicate the provisions required to protect the environment (Baas *et al*, 1990). The definition of best practical technology also illustrated the economic limitations to the perception. Best practical technology refers to the function of technical measures to treat waste streams, using proven methods for meeting environmental quality standards at an acceptable cost, i.e., waste water treatment equipment, burning of organic vapours, and controlled disposal of chemical wastes. Standards were established, based upon the performance of the technical measures that were economically feasible.

Further efforts to eliminate emissions were met by applying best available technologies. Within this concept, more priority is given to the emission reduction capacity than to the economic feasibility. In principle, best available technology does not take into account the economic aspects. Somer (1988) introduced another variation by using the term *best technical means* that can be regarded as an equivalent to best available technology. In this term `means' may cover more than strictly technical measures.

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45 The year 1970 is used as the start of the application of end-of-pipe technology for environmental problems.
46 The arrow provides the direction of the influence of dominant actor(s) on other actor (s).
47 The term *experts* is used for professionals and researchers in expert institutes, academia and consulting firms.

The period 1985 – 1989 showed elements of the emergence of preventive approaches and new environmental public policy arrangements. It was a period of unease about the existing situation characterised by discussions about the institutionalised, strict regulatory framework and the technological paradigm for meeting environmental requirements. Besides the dialogue about economic and voluntary instruments at the Dutch national level, technology-based solutions were discussed, using a definition that was broader than end-of-pipe technology. This was very much an international attempt on the part of environmental technology experts from UNIDO and national governments. Because of the increasingly widely acknowledged shortcomings of the sole reliance upon end-of-pipe approaches to pollution control, technology experts from the Ministries of Environment of several countries (Austria, Denmark, Germany, the Netherlands, United Kingdom) and international organisations (Organisation for Economic Co-operation and Development, UN-Economic Commission for Europe, International Association on Cleaner Technology) introduced and promoted the concepts of *Clean(er) Technologies* and *Low and Non Waste Technology*.

The concept of clean(er) technology has been applied at several different levels. It has addressed the entire design of a production process or a product. It has focused on process-integrated modifications of a particular process or sub-process. It has addressed a single waste stream in order to make internal or external re-use of useful compounds. Choices between clean(er) technologies and more traditional end-of-pipe approaches may hinge upon the economic evaluations performed by the organisation involved.

A clear definition of clean technology developed by the Organisation for Economic Co-operation and Development (OECD, 1987)[48] includes three levels of technical change:

- The more or less fundamental change within the production process (i.e., the change of process conditions, equipment or raw materials);
- The process-integrated addition of technology in order to recycle useful process streams within the process (i.e., the recovery and re-use of metal catalysts or hydrocarbon vapours);
- Technology to treat waste streams in order to re-use them in other processes (i.e., the use of metal wastes in the foundry industry).

Koppert *et al* (1988) defined only the first two levels as clean technology. Christiansen and Kryger (1989) stated that cleaner technology is a production philosophy working at all levels of production, including choice of raw materials and processes and internal waste management through closed loop systems and recycling. They argued that the concept has to be extended to include the entire flow of materials through society and should therefore also focus attention upon the choices at the product design and raw material selection phases of all products and processes.

The UN's Economic Commission for Europe (ECE) developed the concept of `low and non waste technology'. In their definition (ECE, 1984),[49] two important elements appear,

[48] "Clean technologies, are any technical measures in the various industries designed and implemented to reduce, or even to eliminate at source, the production of any nuisance, pollution or waste, and to help save raw materials, natural resources and energy. They can be introduced either at the design stage with radical changes in the manufacturing process or into an existing process with separation and utilisation of secondary products that would otherwise be lost."

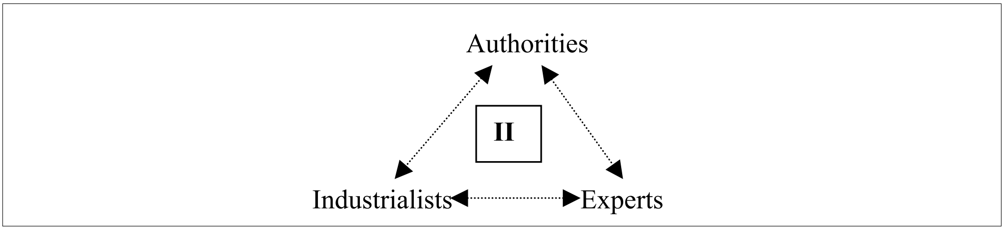
[49] "The low polluting technology is a manufacturing method (process, plant, territorial-industrial complex) where the totality of raw material and energy is used in the most rational and integrated way in the production cycle: raw material resources - production - consumption - secondary material resources, in order to prevent any negative impact on the environment likely to affect its normal functioning. In the broad sense, the low polluting and non-waste technology concerns, not only production processes but also the fate of products characterised by a longer lifetime and easier repair

namely that the `low and non waste technology' concept also explicitly takes the environmental aspects of the product into account, and that those impacts that probably will have negative environmental effects must be prevented. This definition goes further than a strict technological approach and is focused on prevention of waste and pollution that only become visible at a later period.

Prevention at the source – through modification either of the process or the product – emerged in the concepts of clean(er) technologies and low and non waste technology. Studies from the U.S. Office of Technology Assessment (OTA, 1986) and the U.S. EPA's *Waste Minimization Opportunity Assessment Manual* (1988) made the pollution prevention approach more explicit. In these studies, waste prevention techniques are defined as source reduction through product changes, input material changes, technology changes and good operating practices. Also, on-site and off-site recycling through direct re-use after reclamation are considered to be waste minimisation techniques, although recycling has a distinctly lower priority.

All together, it can be argued that industry and government were in discussion about new types of regulation, that the pollution control technology was challenged through government environmental technology experts promoting more integrated cleaner technology approaches, and that the pollution prevention approach was emerging in Europe through testing by university researchers in the period 1985 – 1989. The basis of the more or less static relationship between actors in the societal market model was shifting. Dialogue between government and industry provided the launch pad for stakeholder models; and university environmental researchers entered the industry field with business-fit concepts.

Figure 4.2 **Phase II (1985 – 1989): New types of regulation are discussed by industry and government; experts are testing the concept of pollution prevention**



The development of cleaner production concepts is described and analysed, in a first research loop, in the following sections.

4.2. The dissemination context of the first cleaner production projects in The Netherlands

Intermediary organisations have played an important role in cleaner production dissemination in the Netherlands. In the Netherlands, cleaner production pilot projects started in the period when the Ministry of Environment was strongly promoting the dissemination of

and that could be recycled and transformed after use, in order to prevent ecological damage. The aim is to obtain a complete technological cycle for the use of natural resources, compatible with or similar to natural ecosystems".

clean(er) technology. Nevertheless, in 1986 the Dutch Ministry of Environment took the initiative to invite an American academic to transfer knowledge about pollution prevention concepts to the Netherlands for the first time (Huisingh, 1986). In that context, good-housekeeping measures and substitution of toxic materials were presented as promoting both a better environmental performance and better business economics (Ling, 1984). But this initiative of the Ministry of Environment was not followed up.

Nevertheless, public environmental awareness and the changing Dutch national environmental policy created space for new orientations. The introduction of the pollution prevention concept at the Ministry of Environment in 1986 inspired a RMNO[50] member to promote the concept further outside the Ministry of Environment. A four-week stay of US professor Huisingh at the environmental departments of the University of Amsterdam and the Erasmus University in the summer of 1987 provided the inspiration and the materials for further exploration by academics in the Netherlands. A pollution prevention mini-symposium for representatives from both industry and national, provincial and local government brought to light a sharp divergence of opinions that was independent of organisational background. On the one side it was heard that those concepts could be successful in the U.S.A. because the use of energy and resources there was often more wasteful than in the North Western part of Europe. The different management systems, such as organisational development, logistics and quality management in North Western Europe, could already include the results of pollution prevention, or create at least the conditions for the concept. On the other side it was heard that the preventative approach could be the solution to our environmental problems, for which the legislative approach was perceived by industry as a government responsibility with clearly set limits (Bressers & Hanf 1995).

The divergence of opinions about the prospects of the pollution prevention concept in the Netherlands was independent of the type of organisation to which actors belonged and their position. The information about pollution prevention was sometimes misconcepted by persons feeling attacked; the incident described below illustrates a difference in perception at the individual level.

Box 4.1 *1987 Pollution prevention mini-symposium*

One day before the pollution prevention mini-symposium on 13 August 1987, some members of the RMNO and the Environmental Science Department of Erasmus University made a boat trip around the Rotterdam harbour area. During that excursion, the participants observed that a crane driver was already turning the crane before the crane apparatus was fully closed, thus, he lost materials into the harbour, that he was seeking to transfer from the barge to the on-land storage facility. A simulation of that situation during the mini-symposium made one participant angry: `..We've known about that problem for a long time..', he said. Maybe the expectation about the contents of the pollution prevention concept was at another level, maybe the message was not appreciated because the problem had not been solved until now. Anyhow, this prevented the participant from gaining an overall new understanding from a prevention perspective at that time.

[50] RMNO: Raad voor Milieu en Natuur Onderzoek (Council for Environment and Nature Research, an advisory institute of the Dutch Ministry of Environment).

Cleaner production project initiatives from the environmental departments of the Erasmus University Rotterdam and the University of Amsterdam were funded by other government organisations than the Ministry of Environment. In the case of the STER (Cleaner Technologies and the river Rhine) project (Baas, 1989) the funds for the Erasmus University research team came from the Rotterdam Port Authority, the Ministry of Transport, Public Works, and Water Management, and the Province of Zuid-Holland. However, the funding organisations all had different targets in relation to the concept.

The Rotterdam Port Authority had to store toxic harbour sludge in new landfills; they ran a project to make polluting companies abroad aware that their liability to pay the costs could be enforced by private law (POR project, 1986). Although pollution prevention was not perceived as an option for the POR project, the university research team received funds for the prevention project. Also the Province of Zuid-Holland had a secundary interest in the concept. During two decades a special government public policy managing body had been responsible for the Rijnmond area; that responsibility was returned to the Province of Zuid-Holland. The province's management was in need of regaining knowledge about the area. The STER project, which covered a major environmental problem in the region, was suitable for this purpose. RIZA, a research institute of the Ministry of Transport, Public Works, and Water Management was the only funding organisation that was primarily interested in the concepts as such. A personal introduction to pollution prevention at Erasmus University provided the basis for exploring pollution prevention thinking further in the RIZA organisation.

The Netherlands Office of Technology Assessment (NOTA) initially funded the PRISMA project (Project of Industrial Successes with Pollution Prevention, 1988-1991).[51] NOTA was originally a department of the Dutch Ministry of Education that was privatised – in imitation to the U.S. Office of Technology Assessment. Here, personal links between representatives of the NOTA, in need of a suitable project at the start of their privatised organisation, and of the RMNO, where a representative was an initiator of cleaner production research in the Netherlands, created the basis for funding. In the dissemination phase of the PRISMA project – to the Dutch parliament and internationally – funds from the Dutch Ministry of Economic Affairs and the European Union were also involved. Specialised institutes took the initiative for demonstration projects in industry. The Dutch Ministry of Transport, Public Works, and Water Management funded a special professorship in `Industrial environmental management on the basis of cleaner production' at Erasmus University Rotterdam in 1989.

Within the framework of the thesis, the stand-alone demonstration and research project described above raise the question of generalisation. The projects can reflect `good incidents for the whole firm' or `leading firms for the whole sector'. Their contexts can be a clean or a dirty industrial sector, an organised or a less organised industrial sector. This chapter describes the shift towards cleaner production as a concept-driven approach within companies in different types of sectors. As in the period 1988 – 1992 cleaner production demonstration projects were mainly carried out by a selected group of researchers related to the University of Amsterdam, Erasmus University, NOTA and RMNO, the demonstration projects are representative of general trends in the Netherlands in that period. The projects are described in relation to the original assessment procedures, using the variables of perception, power, and the typology of Oliver (1990) in dissemination processes at micro, meso and

[51] The Netherlands Office of Technology Assessment (NOTA) is currently named the Rathenau Institute.

macro levels. In Chapter 5 the cases will be analysed in a second loop synthesis (Ragin, 1994) concerning the following variables: learning processes, issue management, and horizontal and/or vertical dissemination of new concepts.

4.3. Developments in cleaner production

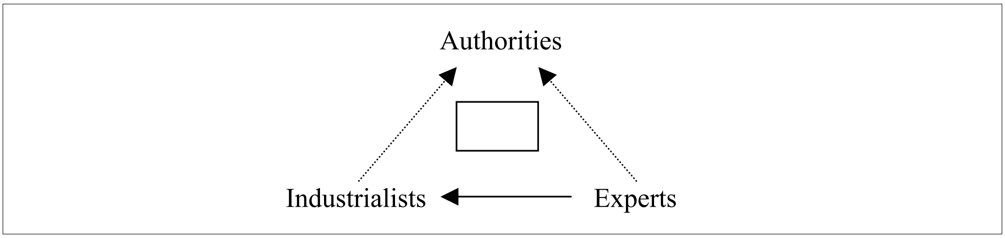
In the Netherlands, after the introduction of the preventive approach (Huisingh, 1986), students began to do pilot research to test these concepts. The first phase of the dissemination process in the Netherlands was categorised as the fact-finding phase of the cleaner production approach (see Section 4.3.1). The *Cleaner Technologies and the river Rhine* (STER) project (Baas, 1989) involved research on the state-of-the-art of environmental management within companies in a community of 30 000 inhabitants and tested the potential for pollution prevention. The research was based on interactive case studies in medium-sized companies, as well as on surveys and interviews in smaller companies.

The *Project of Industrial Successes with Pollution Prevention* (PRISMA) project (Dieleman *et al*., 1991) is illustrative of a second phase of cleaner production research (see Section 4.3.2): the design of a structured cleaner production approach.

University research teams supervised projects in ten companies in the Amsterdam and Rotterdam industrial areas on the basis of a modified U.S. EPA assessment approach (U.S. EPA, 1988, Brezet *et al*., 1989). The results of these intensive cleaner production assessments in the period 1989 – 1990 were reported to the Dutch Parliament.

The PRISMA project and the acceptance of the project results in Dutch policy-making became a driver in the dissemination of cleaner production in different ways. In this process of exploring new preventive concepts, experts from universities played a role in the dissemination of these demonstration projects:

Figure 4.3 **Phase III (1989-1995): Industry follows experts in cleaner production demonstration projects**



During the third phase of development, knowledge about cleaner production projects (see Section 4.3.3) was disseminated in different directions, such as:

- New case studies at regional levels;
- The integration of prevention in innovation projects of the Innovation Centres;[52]
- The integration of prevention in policy-making processes in the provinces (either within the existing departments or by setting up new provincial and municipal *Prevention Teams*), in the expert centre RIZA of the Ministry of Transport, Public

[52] Innovation Centres were set up and subsidised for a period of five years by the Dutch Ministry of Economic Affairs to carry out consultancy work on industrial innovation.

Works and Water Management, and in environmental public policy development in general;

- The commercialisation of cleaner production projects by consulting firms;
- The interest of several industrial sector organisations, starting in the metal working sector;
- The organisation of cleaner production expert meetings and workshops; international developments on the basis of the PRISMA project (PROSA, UNEP, EUREKA).

All these activities contributed to form a fourth phase of stronger internationalisation (Section 4.3.4) and institutionalisation (Section 4.3.5). As the initial phases of cleaner production projects were time-consuming, the institutionalisation process involved the introduction of quick-scan research. The Innovation Centres provided two-day innovation research in a company for free and some NOVEM stimulation programmes could be applied, using a two-step approach: a partly subsidised quick scan research in a company that gave insights into the potential for more in-depth cleaner production research. The Central Innovation Centre greatly stimulated the completion of cleaner production programmes from halfway the 1990s.

In the following sections the various cleaner production phases described above are illustrated by demonstration projects. The first project is a fact-finding case in the Netherlands. Although the U.S.A. pollution prevention data were available, national and local demonstration projects were needed in another country or region for reasons of culture and professional recognition. As regards the fact-finding and structured design phases, we will describe and analyse the position, perception and power of actors, the type of learning processes involved and the spreading of the concepts.

4.3.1. *Fact-finding phase of the cleaner production approach in the Netherlands*

We begin our overview of projects in different phases with the *Cleaner Technologies and the river Rhine* (STER) project (Baas, 1989). The river Rhine is of major importance for the Netherlands: approximately 65% of all inland waters originally come from this river. This is why the pollution of the river Rhine had so many undesirable consequences throughout the country at the end of the 1980s.

One such consequence was the severe pollution of sediments in the river. Because ship navigation requires a sufficient depth, the Rotterdam harbours have to be dredged regularly. However, the sludge was so contaminated with heavy metals and organic substances that it could not be used as an agricultural or horticultural soil amendment (with economic value) as in former times. The toxic sludge could not even be dumped in the North Sea anymore. Instead, it is currently stored in special dumpsites.

One of those new dumpsites for toxic disposal (called *Slufter*) was developed by the city of Rotterdam in the sea. The Slufter was meant to accommodate the sediment until the year 2002 (the end of the life-cycle of this special dumpsite has been extended because of the environmental improvement of the river Rhine during the 1990s). The Slufter was not a desirable site both for ecological reasons (the dumpsite needs to be controlled continuously and does not clean the river Rhine) and economic reasons (the costs of the site were € 91 million).[53] *De facto*, this solution at the end of the river was a peculiar end-of-pipe facility that ought to be prevented in the future.

[53] Index 1985.

The project Cleaner Technologies and the river Rhine (Baas, 1989) was presented as a possible solution to this problem: a test research of pollution prevention at the source. Three governmental organisations showed interest by funding the project for the following reasons:

- *The Research and Clean Water Policy Office – RIZA*:[54] besides emissions from industrial point sources (to be controlled by e-o-p technology), they also faced emissions from non-point sources such as municipal sewers, small companies and agriculture. They showed a real interest in the pollution prevention approach;
- *The Province of Zuid-Holland*: after the closing of the *Openbaar Lichaam Rijnmond* (a temporary special public policy managing body in the Rotterdam harbour region), they wanted to be directly involved in harbour issues, just as used to be the case in the past;
- *The Rotterdam Port Authority*: they faced the environmental, spatial and financial consequences of the polluted sediments. They felt obliged to partially fund the project because of the target and the participation of the two other funding organisations.

In this way each organisation facilitated the STER project for their own specific reasons or interest in the same issue. Besides being members in a supervision committee of the project, they also facilitated a technical commission by providing experts of expected technical solutions.

The STER report described the results of the research on the possibilities of pollution prevention at the source in medium and small-sized companies located in a test area in the surroundings of Rotterdam. The concepts of pollution prevention and waste reduction which had been applied in companies in the United States, were tested in this research. Several American case studies and the essence of the concept - the prevention of industrial pollution can generate company profits and improve the environment at the same time – were provided as *product test* in Dutch companies.

In first instance, the research was focused on prevention at the source in industries with direct emissions into water. A test area was selected by analysing several databases. Due to the specific policies on emissions into water through the installation of wastewater treatment facilities in the 1980s there were only a small number of industrial plants with direct emissions into water. For this reason the research was focused on testing the concepts by visiting 56 companies and by telephoning another 36 companies with direct and possible indirect emissions into water. Not all the contacts were equally intensive. Three categories, each with their own research method, were defined:

A. Bigger companies (more than 50 employees) were contacted several times; after the introduction of the pollution prevention concepts, the process of concept development was tried out and supervised;

[54] The Research and Clean Water Policy Office, RIZA, is a specialised institute of the Ministry of Transport, Public Works and Water Management. This institute, which provides support to nine regional Water Management Directorates, gives advice on environmental licencing in large companies, water emissions monitoring and policy development.

B. All garages, chemical laundries, printing businesses,[55] photographic suppliers, plumbers and dentists were sent checklists to analyse the state-of-the-art and the possibilities of pollution prevention and waste reduction;
C. Small companies were contacted once with a questionnaire about their knowledge of environmental issues and their attitudes.

Findings

A general conclusion, based upon this empirical research, was that managers in the companies showed great interest for environmental aspects. This did not mean, however, that there was sufficient knowledge about environmental aspects in their own company in general, or about pollution prevention in particular. Information about pollution prevention, given by the research team in their role of information specialists, seemed to raise environmental awareness, so that companies were willing to participate in the research. This, in addition to possible cost savings related to the reduction of environmental risks, was new for many managers. Two aspects were striking:
1) Most company participants were willing to provide information about their environmental situation, e.g., 14 out of the 15 garage entrepreneurs joined the research project, and so did all nine dentists. This contradicted the expectation of project-funding government organisations that most companies would keep their doors closed;
2) More than 50% of the interviewed managers declared spontaneously after the interview that the university research team did a good job in the performance of this project. They said that environmental pollution worried them with respect to the future of their children and grand-children (intergenerational concern: Vickers, 1999: 87); some managers were also faced with questions from their children, based on discussions at secondary school, about the environmental performance of their company.

The first step in the project was the introduction of the pollution prevention and waste reduction concepts. The second step was the description of emissions and waste as starting-points for developments at several levels, including: good housekeeping, research on the possibilities of re-use, alternatives to toxic compounds, substitution of materials and products, new technologies and the integration of the pollution prevention and waste reduction concepts into new investments. In the timeframe of the project (one-and-a-half year) the activities in most of the cases were limited to awareness-raising and stocktaking. Another finding was that environmental data were not available in most companies. And when some data were available, there was no connection between the administration and the responsible manager for production and waste.

Two kinds of benefits were found in several cases:
1) Direct benefits were achievable in companies with environmental costs such as levies for emissions and the treatment of chemical waste;
2) The saving of resources through more efficient use led to four to ten times as much profit than saving on environmental treatment costs.

The case of a lute producing company was remarkable as regards both kinds of benefits:

[55] All printing businesses used the off-set production method.

Box 4.2 *A cleaner production experimental assessment in a Lute company*

"Lute" is a type of plastic cement that is used in the building industry for closing open spaces between two materials. An assessment showed that the content of the lute was composed according to the wishes of every customer. The lute was produced in batch production (sometimes inefficiently small). The stock of compounds was huge. The quality of the stock of compounds decreased when it was not used within a certain time frame. This meant the loss (i.e.waste) of an important part of this stock every year. It was found that many compounds could be substituted, while the company could still produce lutes of the same quality. The director discussed this information with the company's salesmen. They would need to convince their clients that a slightly different composition of the lute offered the same quality. The salesmen's resistance was overcome with premiums as incentive and within one year the stock loss was reduced by 50%. The waste treatment costs were reduced by € 10,000 annually; the reduction of product loss was € 79,000 per year.

The research showed that, in a longer time period, benefits were achieved through changing to more environment-friendly products at an early stage and through a better adaptation to new regulations. The research revealed that it is possible to reduce emissions and save money at the same time.

Many managers of medium-sized companies were open to the promotion of preventive approaches, but overall a partial one-loop learning path was the most that could be done. The managers had difficulties in accommodating the concept in the existing infrastructure. For instance, in case of the lute company, because it was a subsidiary of a large national paint manufacturer. The process of learning by doing, that was just starting, was overruled by the strict regulatory requirements of the environmental department at the company's headquarters.

Managers of the companies in the B and C category showed differences according to the average industrial sector approach in relation to the typology of Oliver (1991):

- *Garages*: these already faced environmental requirements and had taken various measures. They showed an attitude of openness to the student researchers and were eager for information that was new to them. Information from the research team about preventive measures was complied with (Hofman and Pleijte, 1988, Hofman *et al*., 1990).
- *Chemical laundries*: they were very reluctant to face the toxic cleaning solvents issue, and displayed an avoidance attitude (Vroegop and Wijdeveld, 1989).
- *Printing businesses*: they were one of the priority target groups of Dutch environmental policy. The companies in the area were all off-set printers. Although they were willing to co-operate at first, it was not the case later on following an intervention by their trade organisation. They complied with their trade organisation

and were waiting for the results of a sectoral piece of research on environmental management.

- *Photographic suppliers*: They collected photo developer and fixer from their customers but they did not know what happened in the next phase of collection by the public waste management organisation.
- *Plumbers*: they managed their activities in an environmentally adequate manner, based on their traditional re-use of materials. However, they did not know about the amounts of re-used materials and waste.
- *Dentists*: they did not know about the ratio between the purchased amalgam and the waste amalgam that was mostly emitted in the sewer system. They challenged the risk posed by wasted amalgam (which contains bounded mercury). They said that they would comply with amalgam separators when these would become compulsory (Brezet, 1989).

The general thinking was that assistance with the pollution prevention approaches should come from independent experts. Government organisations were not perceived as capable of playing an independent dissemination role. Company officials were still being confronted with different, sometimes contradictory demands from different regulatory officials. Besides, the government regulatory officials were not knowledgeable about the pollution prevention and waste reduction concepts themselves at that time; also a facilitating role as regards knowledge transfer of pollution prevention and waste reduction concepts to companies had yet to be developed. Another finding of the research was the fact that (environmental) technology was often supplied even when it was not requested. Most of the company leaders said that they had no environmental problems because they did not need to have a permit, or that their emissions complied with their permit requirements (or that they were performing even better than the requirements). Also hardly any monitoring of emissions was performed.

Conclusions from the STER project

Looking at the research experiments in the period 1987-1988, it can be observed that the company management perception of environmental problems was made up of various layers:

- Most commonly, there was a view that the environmental problems were mainly caused by large industries;
- Small and medium-sized companies were not aware of, or knowledgeable about, environmental problems caused by their own activities;
- Another idea was also common: `we have a license for our production processes, so we are not involved in environmentally damaging activities'.

We learned from this that company management looked at environmental issues from a *regulatory* perspective and not from a *business innovation* perspective. This general perception was based on a rather static situation in relation to the following variables: power, institutions, information and decision-making. The companies were not under ecological pressure from stakeholders and regulatory enforcement concerning small and medium-sized companies was weak. Environmental management activities such as a waste registration were almost nowhere to be found.

However, the environmental awareness of the small entrepreneurs was strong, but it seemed that it was based on their environmental concerns as well-informed citizens. They did not have any insights into their own company's environmental situation. After being given practical information by university researchers about the pollution prevention concept, their knowledge improved. They understood their own responsibilities, although they were not able to monitor emissions and to elaborate on changes. Adequate information was hardly available; pollution prevention concepts were not well-known in their surroundings, which consisted of regulatory agencies and other governmental organisations, purchasers, and consulting firms.

Evaluation by the funding organisations

The funding organisations' opinion on the results of the project was different: on the whole the interest in pollution prevention grew, except at the Rotterdam Port Authority.

The Rotterdam Port Authority was mainly interested in short-term solutions to the toxic harbour sludge problem for financial and spatial (the need for new, specially-designed landfills) reasons. They were not open to longer time-consuming pollution prevention solutions.

The Province of Zuid-Holland was both satisfied with the improved understanding and relationship in the Rotterdam harbour region and with getting acquainted with the pollution prevention concepts. They wanted to foster a follow-up project in collaboration with industry (STER II). However, the trade organisation was reluctant to develop such a partnership, saying that they were in the position to acquire any environmental knowledge that was available across the world. A further spin-off was the internalisation of the concept by the Provincial Deputy of Environment who rigorously applied the approach in a preventive greenhouse horticulture policy programme in the period 1992 - 1995.

The RIZA organisation became further interested in the pollution prevention concept: they funded a special professorship and a Ph.D. studentship, organised cleaner production workshops for representatives of all Dutch water agencies at the operational level, and set up further cleaner production projects.

4.3.2. *The design of a structured cleaner production approach*

The strong potential of the cleaner production pilot projects was the basis of an in-depth *Waste prevention and emission reduction research approach*, the *Industrial Successes with Waste Prevention Project* (PRISMA, 1988 - 1991) (Dieleman *et al*., 1991).

The PRISMA project was developed in co-operation between Erasmus University and the

University of Amsterdam at the request of, and at the initiative and the guidance of a representative of the Netherlands Organisation for Technology Assessment (NOTA), assisted by a representative of the Dutch Council for Environment and Nature Research (RMNO). The PRISMA project was a demonstration project based on the results of a structured cleaner production assessment method, including the following phases: `acknowledged need for pollution prevention, top management's commitment, planning and organisation of the assessment, the performance of the assessment, feasibility analysis, implementation, evaluation and eventually new assessment targets' (de Hoo *et al*., 1990). The project's aim was to present and incorporate the waste prevention and minimization approach into ten companies in five industrial sectors in the regions of Amsterdam and Rotterdam. These sectors[56] were selected on the basis of their significant environmental impacts in the Netherlands. The companies were participating on a voluntary basis, in six cases at the intercession of a plant manager, in three

[56] The sectors involved were the chemical industry, food processing, galvanising works, metalworking and municipal public transport.

cases of an environmental co-ordinator and in one case of a manager at the operational level. They had in common that they were worried about environmental issues in general and/or could anticipate on new environmental policies. Besides, the possibility of gaining a high profile and finding new opportunities in a `no costs' consulting situation was also a (hidden) objective for several organisations.

Although the participating organisations evaluated the project positively, their raised expectations were not always met (Dieleman, 1999). Also the researchers sometimes encountered surprising research conditions. For instance, in the case of a public transport organisation, the researchers found themselves confronted with a new top-down environmental management approach. At the same time that the PRISMA project was working with project teams involving employee participation at all hierarchical levels, a new (municipal) environmental management system was being introduced in a top-down administrative way that prevented following up the PRISMA project after the cleaner production assessments and concluding report.

Evaluation by the funding organisations

The Ministry of Environment did not fund the PRISMA project. Three other governmental organisations showed interest in PRISMA by funding phases of the project.

The Netherlands Office of Technology Assessment (NOTA) initially funded the execution of the PRISMA project itself. In 1988, the U.S. Office of Technology Assessment (OTA) had made a *Waste minimization* report for the U.S.A. Congress. A meeting of representatives of the Dutch Council on Environment and Nature Research (RMNO) and NOTA led to a dual interest: the RMNO considered that a first large national project on pollution prevention should be launched; the NOTA, as a new and co-ordinating organisation, needed an appealing and high-profile project. The PRISMA project met both requirements.

The Dutch Ministry of Economic Affairs and the European Union funded the second phase (dissemination to the Dutch parliament and internationally). The Ministry of Economic Affairs recognised both the innovative aspects of the concepts for Dutch industry and their export value by translating the research findings into an English-language PRISMA manual. The EUREKA R&D programme of the European Union rewarded the value of the concepts by funding a dissemination programme for Europe. The EUREKA platform has been functioning since 1992 and was extended to include representatives from (and carry out activities in) 18 European countries ten years later.

Conclusions of the PRISMA project

On the whole, the PRISMA project researchers found that with an *innovation-oriented*, waste prevention policy, remarkable results could be achieved; companies could save extensively on the costs of energy and raw materials while at the same time they could significantly decrease their environmental impacts.

The PRISMA project provided detailed, company-specific waste prevention and reduction plans and policy recommendations. The results of the project were presented to the Dutch parliament. It was acknowledged that these constituted promising government environmental policy recommendations, and they served as the basis for the promotion of cleaner production throughout the Netherlands. The cleaner production assessment and good-housekeeping measures, in particular, became widespread at the sectoral and society levels: the PRISMA project was used as a label instead of a pollution prevention instrument (just as the label *aspirin* for the medicine).

At the same time, this meant that the label involved an encoded knowledge approach. Only the cleaner production assessment method provided a basis for preventive developments. In that way it created a beacon that was not open to further dialogue. Although a cleaner production assessment is normally designed with several feedback loops, in practice the assessments developed as one-loop learning processes, ending with a cleaner production plan (after the feasibility studies of the prevention options). Companies, especially those whose attitude was just to `allow the project', displayed *back-to-normal* behaviour after the one-hit intervention.

The impact of the PRISMA project has been enormous. It has laid the groundwork for further dissemination in the Netherlands, Europe (EUREKA programme, 1992) and via the UNEP/UNIDO Cleaner production programmes to numerous other regions of the world. Government organisations saw the dissemination of cleaner production as their new responsibility, especially after the parliamentary procedure in the Netherlands. They set up dissemination groups at the levels of provinces and large municipalities, either through cleaner production prevention teams within new departments, or through specific tasks within their existing departments.

The Dutch Ministry of Economic Affairs saw the project as an opportunity to export expertise. For instance, UNIDO showed that it valued the expertise by inviting the environmental institutes of the University of Amsterdam and Erasmus University to design a training programme for the staff of the new UNIDO/UNEP National Cleaner Production Centres and, in the starting phase of the centres, to function as their counterpart institutes.

The close link between the PRISMA research team and the funding organisation meant that the primary target of the project was kept in focus; the results were satisfying. In a second round of financing the dissemination of the results, sub-targets such as expertise export were also included.

4.3.3. *The dissemination phase of cleaner production projects*

After the STER project and during the PRISMA project in the period up till 1994, cleaner production concepts were spread to various organisations. The dissemination involved policy documents, the organisation of dissemination and demonstration projects at a regional level, the working-out in specific sectors and the start of internalisation (see Sub-section 4.3.4). The following projects and their time span are specific to these different categories of dissemination:

* *The preparation of a policy document*

The working document *Protection of the North Sea: Time for Clean Production* was prepared for the Foundation of Greenpeace International in the period 1989 – 1990 (Baas *et al*., 1990). This document provided insights into the (clean) technology-driven policies in the 1st and 2nd North Sea Declarations on pollution reduction in the North Sea. A policy analysis and procedures for the development of a regulatory framework that can facilitate the implementation of cleaner production were the central themes of this document. The Foundation of Greenpeace International used the report to influence the 3rd North Sea Ministers conference. Furthermore the cleaner production concept became a major pillar in their environmental advocacy lobby activities.

** The set-up of a regional cleaner production intermediary institution*

The *Stimulation of Pollution Prevention & Waste Minimization in branches of industry in the Rotterdam region* including the construction of a network of specialised organisations for the transfer of knowledge of cleaner production (STIMULAR project, Koppert *et al*., 1992) is an illustration of this approach. STIMULAR started as a co-operative project of the Innovation department of the municipality of Rotterdam and the Rijnpoort Industrial Innovation Centre. The Innovation department of the municipality of Rotterdam and the Rijnpoort Industrial Innovation Centre were both new organisations that were exploring paths to reach their targets. Both organisations were impressed both by the interactive PRISMA method and the contacts with companies and sectoral organisations. The organisations joined together in the STIMULAR project that was mainly funded by the Innovation department of the municipality of Rotterdam. Under the leadership of the Innovation department project team, the STIMULAR project focused upon the development of a collective method providing data for cleaner production approaches in medium and small-sized companies, and stimulating business innovations – innovations related to improvements within the organisation, its products or processes. Five to six companies per industrial sector were selected for pilot studies involving the development and implementation of cleaner production plans (see Box 4.3). The results of these demonstration projects were disseminated to other companies in the region through articles in professional publications of the industrial sector, training programmes and brochures.

Box 4.3 *STIMULAR metal project*

The STIMULAR project in the Rotterdam region started with cleaner production research within five small metal working companies. The smallest company had 6 employees, the largest one 40. The director was the contact person in all companies. The directors' workshop leaders assisted them in the collection of operational data. The companies were selected via their regional industrial sectoral organisation, which knew about the director's interests in environmental issues. This interest was based on either personal concern, or on the anticipation of more severe legislation, or on the potential of learning new approaches. The advisers could spend 10 days in each company; the workload for the company varied from 7 to 16 days for 2 – 5 employees in 4 months. Nowhere were the employees structurally involved in the assessments. The project resulted in cleaner production plans involving possible options and their implementation.

The first STIMULAR project in five small companies is well documented (Koppert *et al*., 1992). Most of the companies in the project were already sensitive to environmental issues. They expected cleaner production research to solve their problems (*traditional advisory* approach). However, the offer made by the STIMULAR research team was characterised by another approach: on the basis of knowledge and research experience, the emphasis lay on the learning process of cleaner production to be able to mobilise and expand the problem-solving and innovation capability of the company itself (*change process, agogy action*). Despite the small size of the companies and the divergent expectations, several lessons leading to improvement were learned. For instance, one involved company leader met with various surprises whilst performing a cleaner production assessment himself, experiencing what a prevention-based perception worked out in his very small company (See Box 4.4).

Box 4.4 *The case of a sea container maintenance company*

A small company, with twelve employees, active in the maintenance of sea containers, was eager to join a pilot cleaner production sub-project of the STIMULAR project. The company leader, who was responsible for data collection during the stocktaking, was surprised by the unavailability of adequate input-output data, the high cost of the paint used by the firm, and the extensive wastage of paint by the firm, both through excessive spraying of the sea containers and residual paint left behind.

By doing the stocktaking himself, he began to look at environmental aspects from a new perspective. In the inventory process two facts were especially revealing:

a) Each week, eighty pairs of gloves were thrown away, but only the right hand gloves were dirty. This finding made the company leader decide to only purchase right-hand gloves. After some time a company was found that could supply only right-hand gloves. This resulted in a 50% waste reduction and a cost saving of approximately € 4500 each year!
b) Spraying with an organic solvent-based paint was not effective. The paint consisted of 50% organic solvents, which were emitted directly into the air; about 20% of the paint was wasted due to excessive spraying, and 5% remained as a residue in the paint container and had to be managed as chemical waste. Therefore, only approximately 25% of the paint was effectively applied to the surfaces being treated.

The primary emissions from the coating procedure were approximately 200 tons of volatile organic solvents (VOCs) per year and an inaccurately quantified amount of hazardous waste paint residues. After obtaining these data, the researchers discussed the possibility of using water-based paints with the paint manufacturer, but the technical and economic development of water-based systems was perceived by them to be inadequate and premature. However, half a year later, the paint supplier offered a water-based paint with the same quality and price as the organicsolvent-based paint. After a period of experimentation, all painting done by this sea container maintenance company is now with water-based paints. The result, less pollution of the air (VOCs), soil and water, has been achieved by this product modification.

Another important aspect is the business relationship between the companies. Through the demand for water-based paints, market dynamics has been stimulated. Further advantages include:

* the improvement of the workers' environment; they are no longer exposed to the health risks of the organic solvent vapours;
* a high material usage efficiency results in less paint waste and increased efficiency also decreases energy usage;
* the substitution to water-based paints means that the `left over' paint containers are not hazardous waste anymore, but ready for recycling;
* financial benefits; since substantial savings[57] have been obtained.

[57] The financial total benefits have been kept confidential.

Both private and public organisations were involved in a STIMULAR network for the transfer of knowledge about cleaner production. The STIMULAR project became the STIMULAR association in 1993.[58] The Municipality of Rotterdam, the Rijnpoort Innovation Centre, the Province of South Holland, the Chamber of Commerce and the European Union provided funds for this association at the start. During its further development to a financially self-sustaining association, funds provided by companies for cleaner production projects were also generated. The financial structure became a mixture of basic funding from several departments of the regional municipalities, government subsidies for specific projects and commercial activities based on the generated cleaner production expertise.

The Innovation Centre of the Overijssel province performed a cleaner production project in eleven small and medium-sized companies in different industrial sectors in the period 1990 - 1991. Consultants from the innovation centre supervised the assessment teams in the companies. Joint evaluation meetings of the participants, industry sectoral specialists and cleaner production consultants worked well for the purpose of information exchange and cross-fertilising (Suijkerbuijk *et al*., 1992).

* *Evaluating cleaner production dissemination arrangements in the Dutch provinces*

The Dutch provinces are responsible for many operational tasks falling under national environmental public policy. The PRISMA project was received very well at the provincial level. Some provinces such as Noord-Holland and Zuid-Holland set up *Prevention teams* within their environmental policy departments that are responsible for cleaner production activities in their province. This construction was decided to avoid a `two-hat' situation (the carrot and stick) for environmental regulators. Not only in the outside world - the prevention teams faced a lack of acceptance by companies - but also within the provinces the discussion centred on whether environmental protection agencies should have any other task than regulation. The institutionalised environmental protection framework was based on pollution control and dominated the activities of provincial environmental departments. Although prevention received attention, no structural organisational learning and change process in the most relevant provincial departments was initiated.

Initially, the provinces that decided to start prevention teams, such as the province of Zuid-Holland, involved intermediary organisations (such as consulting firms and the STIMULAR project) to perform demonstration projects in companies. Other provinces preferred the integration of cleaner production activities within their existing organisational structure.

The province of Gelderland facilitated a cleaner production project (PROGRES) performed by environmental scientists from the University of Amsterdam supervising cleaner production assessments in six small and medium-sized companies in the period 1991 –1992 (Berkel *et al*., 1992). Although the supervisors worked with a process-oriented approach, technical advisory assistance was also needed sometimes (Berkel *et al*., 1993).

The cleaner production team in Zeeland constituted another variation in regional developments. The *Zeepret*[59] research project, performed in the period 1992 – 1993, focused

[58] A similar development occurred in Graz, Austria. In addition to an EU project in 1995, the community of Graz and the Österreichische Kommunalkredit AG jointly realised the Cleaner Production Centre Austria. CPC Austria started in November 1996, with the aim of functioning as a platform and intermediary for the dissemination of cleaner production.

[59] The acronym *Zeepret* can be translated as `Sea fun': it stands for *Zeeland prevention project: choosing for less waste.*

upon involving a broad range of stakeholders in the development of a `Centre for the transfer of cleaner production concepts in the province of Zeeland'. Representatives of the Chamber of Commerce, the Industrial Councils, the Environmental Protection Agencies, provincial authorities and environmental NGOs were involved in this process (Lutz, 1993). Also, the province of Zeeland decided against setting up a pollution prevention team.

* *Dissemination in different categories of organisations*

This section deals with cleaner production dissemination projects in four different settings.

1) Preventive Environmental Care in Schools (PREMIS)

The PREMIS project (1990 - 1992) focused upon teaching pollution prevention and cleaner production concepts in Dutch vocational education establishments. The goal was to train people who will work as technicians in industry in this preventive environmental protection approach.

The PREMIS project resulted in both the development and testing of an educational programme for the students, and the implementation of preventive environmental care in the school organisation itself (Korver and Hupkes, 1993). An association that funds relevant, new societal activities that are not dealt with by government facilitated the project. Using such cutting-edge projects as demonstration, the association hopes to trigger further stimulation by other public or private organisations. In the case of the PREMIS project this did not occur however.

2) Environmental Care in the Royal Air Force

In the period 1990 - 1994, a preventive environmental care system for the Royal Dutch Air Force was developed. The design of training programmes for environmental officers at all Air Force locations, an Air Force-specific waste reduction manual and even a Ph.D. thesis were part of the project (Bouma, 1995). The project was facilitated to raise environmental awareness in the air force and to start environmental management programmes at all locations. That target was met: the nomination of fourteen environmental co-ordinators on location was part of the further dissemination plan.

3) Waste Prevention and Workers Councils in Industry (APRIORI)

Cleaner production concepts in industry were usually focused on the role of corporate management (top management as regards commitment, and operational management as regards waste reduction audit assessments). The APRIORI project (1991 - 1993) aimed to develop and test educational materials for workers councils (Buys and Hofman, 1993). This project was facilitated by a labour union for their workers council training programme. Furthermore the final report was handed over to the Minister of Social Affairs and Employment in order to influence the decision about the need for workers council advice in the case of environmental issues and measures in the restructuring process of the Law on Workers Councils.

4) PREvention CAses RIza (PRECARI project)

The Research and Clean Water Policy Office – RIZA of the Ministry of Transport and Public Works, funded the PRECARI project (1992 - 1993). That research and advice institute for nine regional Water Management Directorates gives advice about the process of granting permits to large companies in the fields of monitoring and water policy development. During the project the institute initiated a cleaner production assessment in the facilities of a chemical and a pharmaceutical multinational, and a tapestry manufacturer. The objectives of this project were twofold:

- firstly, to introduce the pollution prevention concept into large companies that believed that only small and medium-sized companies were involved in the PRISMA project. The contacts that water management regulatory agencies had with these companies were used for this purpose;
- secondly, the representatives of RIZA participated in the project both as environmental experts and as students of cleaner production assessments that could be worked out in the development of expertise within RIZA and the Water Boards as learning organisations.

The development and results differed very much per case study (Boons, 1993). The project is further explored in Chapter 5.

Finally, in this overview of cleaner production dissemination in different settings, the performance of eco-design projects needs to be mentioned. The projects started in the period 1992-1993: a product-oriented demonstration project about the opportunities for environmental product improvement was one of the first outputs of this development (Riele and Zweers, 1994). After the development of an eco-design teaching module, the Faculty of Industrial Design of the Delft University of Technology started eco-design programmes that also included study periods in several countries worldwide such as Costa Rica[60] India and Thailand.

4.3.4. *International phase in cleaner production approach*

The internationalisation of the cleaner production approach on the basis of the PRISMA project can be illustrated by three developments:

1a) *Mimicked bi-national projects*, such as the PROSA project, a joint research project of the universities of Gent and Rotterdam in the provinces of Oost-Vlaanderen (Belgium) and Zeeland (the Netherlands), both in border regions;

1b) *Mimicked by projects in other countries*, such as the *Project Catalyst* (WS Atkins, 1994) in the United Kingdom;

2) *A European dissemination programme*, the EUREKA project, involving academics leading regional projects with the participation of local industry and government in more than ten countries;

3) *The UNEP/UNIDO National Cleaner Production Centres programme* with a growing number of cleaner production centres in almost all countries in the world.

The starting phase of nearly all projects mimicked the cleaner production assessment procedure. Following the PRISMA approach, in many countries the U.S. EPA Waste Minimization Opportunity Manual (1988) was modified and translated into the national language. Despite the existence of a Dutch PRISMA manual, the Flemish partners in the PROSA project expressed the wish to develop a Flemish manual (Jacobs *et al*., 1993).

In general, the new researchers in new projects took advantage of the possibility to mimic and learn from the completed cleaner production projects by using existing knowledge about found options of cleaner production applications. The number of preventive options for improvement in metal working companies in the PROSA project increased a factor 10 thanks

60 See for instance the M.Sc. Graduation report, *Development of an appropriate ecodesign approach for Panel-ex, Costa Rica*, Lonneke Baas, 1998.

to this knowledge about different fields of attention as the following figures in Table 4.1. show:

Table 4.1 Dutch metal working company in the PROSA project

Field of attention	Resource	Good housekeeping	Technology	Internal re-use	In total
Metal-working	9	15	21	6	51
Valve revision	7	9	14	-	30
Welding	6	9	12	-	27
In total	22	33	47	6	108

The PROSA team in the province of Oost-Vlaanderen in Belgium found a similar number of cleaner production options. The options in the technology field were more than 50% of the options in total:

Table 4.2 Flemish metal working company in the PROSA project

Field of attention	Resource	Good housekeeping	Technology	Internal re-use	In total
Degreasing of plunger and sprinkle machines	2	3	4	1	10
Degreasing high-pressure machine	1	-	1	-	2
Degreasing by hand	5	2	-	-	7
Manganese phosphatisation	6	5	28	3	42
Test cells	3	1	4	1	9
In total	17	11	37	5	70

This does not mean that the implementation or future development of all options was seen as feasible. Many cleaner production projects stopped here and did not pay the required attention to organisational implementation processes. The results of the feasibility studies have to be fine-tuned for the implementation phase. This fine-tuning has to be performed *after* the project intervention. In most organisations, weak internalisation of the project meant that the urgency of cleaner production options was denied in relation to traditional priorities. Other reasons were the lack of capability and/or capacity for further fine-tuning and the lack of the *outsiders push*.

With respect to the performance of the project and how actors perceived the approach, the following observations were made. The PROSA project was an initiative of the provinces of Oost-Vlaanderen (Belgium) and Zeeland (the Netherlands) for the performance of PRISMA-like cleaner production activities (Dieleman *et al*., 1991) within the scope of the *Euregio Scheldemond*, a European Union framework for better co-operation between national border regions. Ten companies, five in Oost-Vlaanderen and five in Zeeland, joined the project under the management of research teams from the University of Gent and the Erasmus

University Rotterdam (Jacobs *et al*., 1992). Furthermore, the province of Oost-Vlaanderen was very active in the dissemination of the cleaner production concept, involving many Flemish government and intermediary organisations. Various workshops made those organisations familiar with the cleaner production concept and the role that those organisations could play in the dissemination process. One of the funding partners in the Netherlands was the Directorate of Zeeland of the Dutch Ministry of Transport, Public Works and Water Management. Its primary goal in this project was to establish connections with the Flemish water management officials. Because Belgium was in the process of re-allocating responsibilities between the federal and regional levels of the country, the trans-national water management issues could be handled at the federal Belgian level instead of the national level.

Inside the companies, the PROSA project mimicked the PRISMA project as regards the phases `getting commitment of the management, starting a project team, performing a detailed stocktaking on the basis of an input-output model, selection of research fields, broadening the project team with representatives of different departments for strengthening the brainstorm capacity and the acceptance of the brainstorm session results, performing limited feasibility studies for all options from the brainstorm session, designing a pollution prevention plan, starting prevention working groups on feasibility studies of the prevention options, and implementing options'.

In five companies, only the management joined the project team, in five other companies other employees were also selected. In seven companies the project team was limited to one or two persons. In the brainstorm sessions the project teams were expanded.

Table 4.3 Number of project team members in the brainstorm sessions per company[61]

Company	Total number of employees	Number of project team members
Transit company	80 – 90	6
Printing business	22	2
Hospital	750	3
Painting firm	90	4
Roof material producer	183	8
Electr icity works	80	4
Shipyard	17	5
Metalworking company I	185	6
Metal working company II	150	3

A structured implementation of prevention options took place in companies that were not used to such an approach. Most of the companies relied upon informal internal communication. This made the steering of knowledge about prevention difficult, especially in the case of a lack of motivation inside the company. Financial barriers were made up of both the underestimation of environmental costs, especially the tangible costs, and economically unsound environmental investments (one company saw a return on investment of two years

[61] One company did not allow the publication of the research results.

as the limit). Finally, reducing pollution did not constitute an incentive either because of the small scale of the pollution or the lack of compulsory requirements placed on the companies.

4.3.5. *Institutionalisation phase of cleaner production*

The dissemination of cleaner production by university departments temporarily influenced the institutional field of the concept's suppliers. Although the university departments were acting as intermediary organisations in an experimenting research role, in the period 1991 – 1993 they met growing criticism from traditional consulting firms for being a competitor in their field of work. When the cleaner production concepts received growing recognition, at first government initiatives and later consulting firms (especially after being financially stimulated by the government) took the lead in the dissemination process of cleaner production.

These government initiatives were taken in order to facilitate the work of external dissemination organisations as well as the development of cleaner production approaches within government bodies:

- Either within environmental public policy development, directly through legislation, and indirectly through the facilitation of projects and the training of government officials such as in the PRECARI project (Boons, 1993), the municipality of Breda (Kousemaeker, 1993), the municipalities in the province of Noord-Holland (Reijenga, 1994) and through the introduction of waste prevention in local government as a new policy area (Reijenga, 1995);
- Or in setting up prevention teams in provinces and large municipalities.

Information brochures on *Prevention in Industry* (Afvalpreventieteam Zuid-Holland, 1995) and prevention fact sheets, such as `Cleaning and degreasing of metals', and `Waste reduction in meat processing' were other products of governmental involvement in this approach.

Van Berkel (1996, 71) qualifies the period 1993 – 1996 as a specification process containing the following categories: `industry specific demonstration projects, municipal projects and abridged technical assistance'. In general it can be argued that in the second half of the 1990s a cleaner production institutionalisation process took place in the Netherlands. The provincial and municipal prevention teams continued their work. In October 1996 the Ministry of VROM, the Inter-Provincial Deliberation body (IPO)[62] and the United Dutch Municipalities (VNG) jointly published the *Performance strategy for prevention 1996 – 2000: There is much to be won through prevention* (Ministry VROM/IPO/VNG, 1996). The provincial prevention teams were the driving force behind 70% of more than 400 waste and emissions prevention[63] projects, performed by several intermediary organisations and consulting firms in many sectors of industry and service organisations (InfoMil, 1999). These projects were developed within a framework of cleaner production dissemination because they were focused on organisational activities with the involvement of at least one non-profit dissemination organisation. The InfoMil organisation, a national *Information centre on environmental permits*, started a help-desk to inform organisations about cleaner production.

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62 In Dutch: Inter Provinciaal Overleg (IPO).

63 In 1988, the term *waste and emissions prevention* (AEP) was introduced in the PRISMA project as an equivalent to pollution prevention. In the rest of the thesis, the term cleaner production will also cover this term.

The Dutch Innovation Centres[64] developed an *environmental innovation scan*. This scan is an elaboration of eco-design applied to the total LCA trajectory of products and services. The work of the advisers in eighteen regional innovation centres led to many successful cases of cleaner production, and the application of alternatives to CFC and Carbon Hydrogen solvents (Innovatie Centra Nederland Netwerk, 1996). A *Schoner Produceren* (cleaner production) project of the Dutch Innovation Centres developed into a continuous programme on the initiative of the Ministries of Economic Affairs and Environment in co-operation with the Inter-Provincial Deliberation body in 1996. The programme was focused on small and medium-sized companies (less than one hundred employees), and provided information via a weekly television programme for small and medium-sized enterprises, quarterly newsletters, bulletins and subsidy arrangements. These cleaner production subsidy arrangements provided:

- An *Information and a quick scan*:[65] the aim was to get companies interested in environmental and energy-saving measures on a profit basis. Intermediary organisations performed an environmental quick scan and developed courses and databases. The projects must involve at least two of the following environmental themes: `environmental management, environmental technology, environment-induced product design, prevention of emissions or energy efficiency';
- *Energy efficiency and cleaner production advice* for in-depth advice about environmental and energy improvement of small and medium-sized enterprises.

The Ministries of Economic Affairs and Environment have been jointly funding this arrangement since July 1998. The 2001 funds totalled € 2 million. The conditions for funding include the following: the company must have less than 250 employees, and must be viable and positive in general, while the project has to be performed on their own account and at their own risk. Another important condition is that the applicant is capable to perform the project. The subsidy covers 2/3 of the project costs, which must be higher than € 22,727 and lower than € 113,636. These arrangements have provided consulting firms with a foundation for further quick scan exploration. The cleaner production consulting firms emerged during the institutionalisation process in the second half of the 1990s, when they performed hundreds of cleaner production quick scan projects in almost all sectors of industry and services, upgraded projects, organised training courses, and provided assistance to government. In quick scans the emphasis lies on quick results and on separating the wheat from the chaff.

In May 1997, a KPMG/NIPO report published a baseline measurement of cleaner production implementation that had been performed in November 1996 and should be repeated every two years.[66] The report distinguished four phases in the shift to cleaner production by companies:

- Non-interest phase: companies that are not at all or hardly interested in the environment;

[64] The Innovation Centres and the Advisory Institute for Small and Medium-sized Enterprises merged into the Syntens organisation in 1997, combining technological and management aspects (including environmental issues) in an innovation network for companies.

[65] A cleaner production quick scan in a company is a piece of research based on a cleaner production check-list, carried out by an expert, which focuses on quick results for implementation and as basis for eventual further research.

[66] However, the information dissemination by the Ministry of Environment and the consultancy responsible for the *Schoner Produceren* programme is poor: the KPMG/NIPO evaluation report of 1999 was no longer available in February 2001.

- Interest phase: companies are interested but have not implemented any environmental measures yet;
- Implementation phase: companies that are implementing environmental measures;
- `Routinising' phase: companies that have integrated environmental measures in their management.

The results of the baseline measurement in a survey of one thousand companies were as follows: non-interest phase 22%, interest phase 41%, implementation phase 22%, and `routinising' phase 15%. Despite the fact that 63% of the companies were still inactive, the general attitude on cleaner production was positive and more than half of the companies asked for information. About 60% of the companies took the following measures to reduce pollution: reduction of energy use, changes in work methods, and the use of more environment-friendly resources (KPMG/NIPO, 1997).

The subsequent measurement by the cleaner production dissemination research project in November 1998 (KPMG/NIPO, 1999) referred to the attitude, interest and behaviour of the companies (not to the effectiveness of policy strategies and instruments) and the influence of cleaner production on the reduction of environmental pollution and the improvement of environmental quality. On the one hand, it was stated that the implementation and `routinising' phases were already in place in 49% of the companies. On the other hand, it was found that companies were not taking more environmental measures than in 1997. In 2001 report, the implementation and `routinising' phases were in place in 52% of the responding companies. The 3% increase concerned the implementation phase.

These findings led to the conclusion of a stop in the shift to cleaner production (KPMG/NIPO, 2001). The conclusion is a contradiction to the 1999 report; the question is whether the interpretation of the used definition of cleaner production is correct. As definition is stated: "..Cleaner production is company management that contributes to the reduction of pollution in an economically responsible way..". The operationalisation in a survey question (45: 3) started with the description that "..cleaner production involves environmental management, ecology induced product development, the application of clean technologies, energy-saving and waste prevention..". The question about prevention of waste and emissions however, for 81% of the respondents, also involved the collection and treatment of their company waste and for 82% of the respondents it included the treatment of wastewater.

Information was asked for by 51% of the companies in the years 1997 and 1998; most questions (38%) were about wastewater, soil pollution and sanitation, chemical waste, air emissions, paint, packaging. The next largest category was information about resources (13%). It was alarming (questions 14-23) that the organisations that had not done anything in the previous two years of the report publication were responding negatively about doing something in the coming two years, for instance performing a cleaner production assessment (71% of the respondents had no plans, 12 % did not know and 11% would think about it) and participating in a sectoral demonstration project (76% of the respondents had no plans, 12 % did not know and 9% would have to think about it).

The KPMG/NIPO research project of 1999 focused on small and medium-sized companies. In this category, only 11% of the responding companies had an environmental management system. In comparison with 9% in November 1996 and 10% in 2001, not much progress had been made. The 10% of companies with an environmental management system in 2001 was in line with the response of 85% of the companies in 1999 that they would not implement such a system in the two years after 1999 (6% did not know).

As regards the issue *bringing a new product on the market*, the most important was the use of environment-friendly materials in the composition of the product and reaching agreements with suppliers and customers in the product supply and distribution chain (see the qualification of different aspects relevant to decision-making in product design in Table 4.4):

Table 4.4 The qualification of different aspects relevant to decision-making in product design in %

Aspect	Very important	Important	Unimportant	Very unimportant	Do not know/ no answer
Use of environment-friendly resources	17	43	26	5	10
Recyclability	14	31	32	11	12
Energy use*	11	42	31	7	9
Emissions*	10	29	37	14	11
Water use*	6	17	44	15	18
Waste water*	6	12	40	18	25
Environmental aspects of packaging	15	33	30	10	12
Limited use of resources	14	37	33	7	9
Energy use of the product	10	34	31	14	11
Agreements with suppliers and customers	17	44	26	6	7

* During production

The environmental aspects of the production process were hardly covered in relation to a new product design. In particular, water use (44% of the respondents thought it unimportant, 15% very unimportant and 18% did not know) and wastewater (40% of the respondents saw it as unimportant, 18% very unimportant and 25% did not know) were not seen as aspects to be covered in product design. Another remarkable classification for the water issues was that the category `do not know/no answer' was very high (respectively 18% and 25%). This meant that the water data in general was still an underestimated aspect of better water management.

Furthermore it was interesting to see in the 1999 report that in a range of attitudinal questions moral statements such as "cleaner production is a moral duty for my company" scored as highest. Furthermore it was remarkable that the statement "cleaner production provides my company cost savings" scored 5.0 (on a scale of 1 – 10), while the statement "by cleaner production my company prices itself out of the market" scored 4.4. It seemed that the economic issue, both in positive and negative sense, was not playing an important role in cleaner production. Despite the fact that cleaner production was promoted as a win-win concept, this was one of the explanations of the difficulty in dissemination. Another observation in this research report was the meagre translation of the operationalisation of the definition of cleaner production. Water treatment and waste separation before treatment were part of the definition.

As regards the pathway towards sustainability, this meant that education on what cleaner production really is was getting increasingly important. This is in line with the conclusion that the most important categories for cleaner production information were suppliers and producers (23% in 1999 and 2001) and sectoral organisations (19% in 1999), as these categories also deal with waste treatment facilitation. The above findings mean that the knowledge infrastructure had not changed very much by 1999. Earlier, Frank and Swarte (1986) had already found that both consultancies and communities were major information providers. However, the communities referred companies to the consultancies.

In the 2001 report, a remarkable shift in information gathering in sectoral organisations was noticeable. In the 1999 report, 19% of the responding firms had asked for information; the figure in the 2001 report was 31%. The percentage of companies that did not know where information could be gathered decreased from 22% to 13% in the period 1999 – 2001 (smaller companies in particular seemed to be better informed).

Finally, De Bruijn and Hofman (2000) compared the detailed *PRISMA* cleaner production assessment with the quick-scan method in their analysis of 24 national projects, involving 1500 companies that used the cleaner production method and 182 companies in the province of Noord-Holland that applied the quick scan method. They found that the PRISMA approach was more radical and resulted the companies making fundamental changes. In contrast, the quick-scan method only resulted in the implementation of good housekeeping measures.

The evaluation by the Ministry of VROM/IPO/VNG of the prevention strategy of the 1996 – 2000 programme was positive about a reduction in environmental pressure on companies. It resulted in a new programme *With prevention on the road to sustainable enterprises* (Ministry of VROM/IPO/VNG, 2001). Because it was found that the implementation of prevention is time-consuming, the new programme's strategy stresses the process of transition.

4.4. International dissemination of cleaner production projects

Because cleaner production projects in Sweden, the Netherlands, Denmark and Austria had a major influence on international developments, this section provides an overview of the main international cleaner production dissemination projects. A structured international dissemination of cleaner production projects by the U.S. Agency for International Development (AID) programme and the UNIDO/UNEP National Cleaner Production Centres (Sub-section 4.4.1) started in 1993. These programmes were designed for the dissemination of cleaner production via demonstration projects and dissemination policies. Furthermore in this section, attention will be paid to the translation and dissemination by other international organisations, such as the USAID programme (Sub-section 4.4.2). Two other important global institutions also included pollution prevention in their policies. The OECD favoured the preventive approach as a good-business practice promoting clean technology in the 1980s and cleaner production in the 1990s (Sub-section 4.4.3). The involvement of international industry and business organisations are briefly explored in Sub-section 4.4.4. The World Bank (Sub-section 4.4.5) used to test environmental projects in a traditional pollution control approach. In 1995, after a long time of discussion and much criticism, the World Bank started to include pollution prevention in new projects. The European Union was a late contributor to the preventive approach as well. Only during the 5th Research Framework Programme (1998-2002) was the term cleaner production introduced (Sub-section 4.4.6).

4.4.1. *The UNIDO-UNEP National Cleaner Production Centres Programme*

The United Nations Environment Programme's Industry & Environment Centre was established by UNEP in 1975 to bring industry and government together to promote environmentally sound industrial development. The mission of UNEP is `to encourage the development and implementation of industrial policies, strategies, technologies and management practices that contribute to sustainable development by making efficient use of natural resources as well as by reducing industrial pollution and risk' (UNEP/IE, 1998).

The goals of UNEP IE are to build consensus on preventive environmental protection through cleaner and safer industrial production and consumption, to help formulate policies and strategies to achieve cleaner and safer production and consumption patterns, and facilitate their implementation, to define and encourage the incorporation of environmental criteria in industrial production, and to stimulate the exchange of information about environmentally sound technologies and forms of industrial development.

UNEP IE has developed seven work programmes to achieve these goals, one of them on cleaner production. The dissemination of knowledge is performed via conferences, seminars, training activities, demonstration projects, journals, technical report series, handbooks and other training materials, information on diskettes and a web site.

The UNEP was restructured in 1998. The Industry & Environment Centre of UNEP was reorganised into the Division of Technology, Industry and Economics (TIE Division) in order to reflect an integrated approach (UNEP, 1998). The TIE Division consists of one International Environmental Technology Centre and four Units: Production and Consumption, Chemicals, Energy and Ozone Action, Economics and Trade. Cleaner production falls now under cleaner and safer production *technologies* in the Production and Consumption Unit.

In co-operation with the `Industrial Sectors and Environment Division' of UNIDO, UNIDO-UNEP National Cleaner Production Centres (NCPC)[67] have been established in ten countries in a first phase starting in 1994. These are located in Brazil, China, the Czech Republic, Hungary, India, Mexico, the Slovak Republic, Tanzania, Tunisia and Zimbabwe. UNIDO-UNEP started to provide assistance to other starting centres in the period 1998 – 2003. The centres of Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Morocco, Nicaragua, Russia and Vietnam joined in 1999. New Centres in Croatia, Ethiopia, Kenya and Mozambique started in 2000. Cuba, the Republic of Korea and Panama joined in 2001. In 2002 new centres were set up in Lebanon, the Republic of South Africa, Sri Lanka, Uganda Uzbekistan and Zambia.

Local professionals trained by UNIDO/UNEP manage the cleaner production centres. They are hosted in an industrial, environmental or university institution. They can receive

[67] `..The purpose of a NCPC is to promote the cleaner production strategy in enterprises and government policies, in harmony with local conditions, and to develop local capacity to create and meet cleaner production demand throughout the country. The Centres (and the personnel trained by them) do not deliver ready-made solutions, rather they train and advise their clients on how to find the best solutions for their specific problems..' (UNEP Division of TIE, in collaboration with UNIDO, 2002).

advice and assistance from experienced cleaner production institutes that function as counterpart institutes.[68] During the development of new National Cleaner Production Centres (NCPC), starting in 1998, the directors of the first phase NCPCs have also played a role in both the dissemination of cleaner production knowledge and the design of a business plan and a cleaner production policy dissemination plan (Brazil, November 1998, El Salvador, November 2000, Guatemala, July 2001).

At the beginning of 1998, cleaner production (pollution prevention) centres[69] and points of contacts were established all over the world. Table 4.5 at the next page represents the number of centres and points of contact (governmental organisations, industrial organisations and universities) in 1998.

UNIDO and UNEP started annual NCPC evaluation meetings in November 1995 in Vienna (Austria). The participants in the meeting were the NCPC staff members of UNIDO and UNEP, the directors of the NCPCs, representatives of counterpart institutes, some donors and experts. The first meeting was unstructured and lacked clarity about the goals of the evaluation and what was expected from the NCPC directors.

Table 4.5 Number of Cleaner Production Centres and other points of contact world wide[70] (UNEP IE, 1998)

Region	Number of Cleaner Production Centres	Number of other points of contact on CP promotion
Africa	4	3
North America	2	12
Central & South America	11	4
Asia & Australia	8	32
Europe	24	61
In total	49	112

The second meeting in November 1996 in Nyanga (Zimbabwe) had a better structure, although the time constraint kept being characteristical for all evaluation meetings. The second meeting covered problems such as capacity building, a stable staffing and the position of a host institute. Also, the discussion about the new ISO 14000 standard started then: should ISO 14000 certification replace, or be a vehicle for, cleaner production development? Concerns about ISO 14000 were expressed about the costs of the procedure, the lack of participation of NGOs and developing countries in the standardisation process, whether it is really a standard, and is international or not; does it make a difference in environmental performance or is it a myth; and finally, it does not secure compliance (Hobbs, 1996). Within this forum cynicism has been dominant in relation to the overkill and formalisation of

[68] The counterpart institutes are located in Austria, Denmark (2 institutes), the Netherlands (2 institutes) and the U.S.A..

[69] Only national centres have been counted; i.e. in China there are 15 centres in various provinces, cities andindustrial sectors, in India there are 5, and in Hungary 4, regional centres (UNEP/UNIDO, 2001).

[70] The number of organisations has been expanding continuously in the years after 1998.

documentation and added bureaucracy. Also, participants wondered whether a `stand alone' environmental management system would hinder integration with broader business issues. Another criticism was that ISO 14000 treats symptoms, not causes; that it focuses upon compliance and pollution control, that it imposes no substantial performance obligations and that it can enshrine mediocre performance.

Because cleaner production was generally seen as a `win - win' concept, it was assumed, in the beginning, that cleaner production demonstration projects were the only thing that was needed to ensure widespread dissemination and implementation. This assumption was, together with the engineering background of most of the NCPC directors, the reason why the development of cleaner production dissemination policies was scarcely dealt with. Only the Tunisian government favoured sustainable development as the integrated approach for industrial development via their NCPC from the start. In the Czech and Slovak Republics, attention to cleaner production policy development was also growing. In 2000, the Czech government declared cleaner production to constitute the integrating basis of their policy development (see Annex IV.1). Furthermore, cleaner production policy dissemination was formulated in workshops in Zimbabwe and Mexico. The Zimbabwe NCPC had scarce capacity for the continuous elaboration of that approach (see Annex IV.2); whilst the Mexico NCPC initiated a cleaner production stakeholder network on the basis of cleaner production policy research in 1998 (see Annex IV.3).

The observation that more stakeholders in the dissemination processes were needed was made during the 3rd UNIDO-UNEP NCPC annual evaluation meeting in Bangkok in November 1997. A further formulation of that observation was one of the key items in the 4th UNIDO/UNEP NCPC annual evaluation meeting in Prague in March 1999 (Baas, 1999).

Navratil (1999) made an overview of current and planned services and activities of the NCPCs based on information provided by their directors. The list of services and activities is a product of collective deliberations during the course of the 4th annual meeting of NCPCs in Prague in March 1999 (see Annexes IV.4 and IV.5).

One can speculate that some entries might have been influenced by *what the others do or plan to do*. In some cases (such as Zimbabwe) the plans for the future seemed to be too optimistic and ambitious while other NCPCs (such as Tunisia and India) displayed a certain amount of caution or conservatism in describing their activities and plans for the future.

It was apparent that there were justifiable differences between the *new* NCPCs (such as in Nicaragua, El Salvador and Costa Rica)[71] and the *old* ones. All NCPCs were engaged in core activities such as short-term training (up to five days) and dissemination of generic information on cleaner production. All except one (El Salvador) were engaged in conducting in-plant assessments (combined with training company staff). Most NCPCs were engaged in policy dialogue (preparation of, or comments on, policy papers, etc.); many of them also conducted training courses longer than five days and reported (to provide information) on cleaner production technology. Users of this service (information on cleaner production technology) however, seemed to be limited to just a few companies from among those in which in-plant assessments were conducted.

Ongoing involvement in non-core activities was less intense. The most significant was co-operation of the old NCPC with educational institutions in introducing cleaner production

[71] In the case of Croatia the Centre was not established then; the 'current' activities in fact represented a plan for the immediate future.

subjects in their curricula. Some of the old NCPCs claimed to have included environmental management systems, environmental benchmarking, environmental accounting, and energy efficiency (conservation) in their activities. Only a few NCPCs indicated involvement in more complex activities such as LCA and eco-design, while no NCPCs had been involved in hazardous waste management. It was worth noting that only some of the old NCPCs advised companies on financing and transfer of technology.

The planned activities were related to the time horizon `now + 3 years' which exceeded the time frame of their business plans. In a few cases, some of the core activities were to be discontinued (short-term training courses); the India NCPC expected that short-term training courses, awareness raising (general cleaner production information) as well as in-plant assessments should only be performed by their newly established regional centres.

All NCPCs planned to continue or get involved in policy dialogue, and in the following activities: co-operation with educational institutions on cleaner production curricula, environmental management systems training, implementation, dissemination of information, LCA training, eco-design, benchmarking, environmental accounting, cleaner production financing, transfer of technology and supply chains. Some of these activities were new to most of the NCPCs: LCA, eco-design, and supply chain development.

The 5th UNIDO/UNEP NCPC annual evaluation meeting in Bern, Switzerland (in May 2000) focused on exploring links with global programmes such as the climate change programme. Such programmes could also partially make some funding available as part of the self-sustainable principle that was introduced at the end of 1998.

The 6th UNIDO/UNEP NCPC annual evaluation meeting in Korea (November 2001) saw the need for both specification and integration of cleaner production concepts. It became clear that the newer centres were in need of more training in the basic cleaner production tools that they were called upon to use and promote. Along that line technical presentations and the presentation on a basic toolkit for centres were well received by the new centres in particular, which felt that such tools could greatly help them during the first couple of years.

The mature centres backed modular and sectoral approaches, such as the integration of cleaner production, energy efficiency, resource efficiency, waste management, health and safety, and environmental management systems. The growing role of social accountability and triple bottom line activities fits into this line of attack.

During the 7th UNIDO/UNEP NCPC annual evaluation meeting in Mayrhofen, Austria (May 2003), learning processes from experiences of other NCPCs were on the agenda, for instance the application of clean technologies in the performance of a Multilateral Environmental Agreement (MEA).[72]

Cleaner production policy development analysis

At the global level, UNEP played an important role in developing strategies for the dissemination of cleaner production. UNEP acted as CEO by developing a vision, mission statement and a policy dissemination manual, whilst UNIDO acted as the operating body.

As policy development was not the best output of the cleaner production projects in the 1990s (Hobbs, 1998), UNEP published the International Declaration on Cleaner Production;

[72] A Multilateral Environmental Agreement is a legal agreement, concluded between a large number of states or international organisations as partners, in written form, and governed by international law, whether embodied in a single instrument or in two or more related instruments, with the goal of environmental protection and sustainable development (webpage UNIDO Cleaner Production Programme, 2003).

the declaration stated the need for reorientation, presented a strategy towards sustainable production and consumption, stressed the importance of a win-win approach, the need for an acceleration of cleaner production implementation and for engaging new partners and the public sector. This was in line with broadening the scope of cleaner production and restructuring the UNEP organisation into the unit *Production and Consumption*.

At the national macro level, a number of initiatives mimicked the international model, i.e: starting a national cleaner production centre with the supervision of a national host institute and advisory board, involving the expertise of counterpart institutes, and launching demonstration projects in order to promote awareness-raising about cleaner production.

The directors were mainly trained engineers; their orientation was stronger on demonstration projects than on the management of dissemination policy and networks. In a later phase more attention was paid to developing business plans for the centres and policy advice networks. Helping SMEs to obtain financing for cleaner production investments and disseminating technical information also became core activities of the centres.

Prior to the start of the first round of starting National Cleaner Production Centres (NCPC), UNIDO and UNEP officials generated and joined cleaner production demonstration projects to show the excellence of the concept. The DESIRE Project (DEmonstrations in Small Industries for Reducing wastE) was completed in December 1994 and implemented between 1993 and 1995 on behalf of the Environment and Energy Branch of the United Nations Industrial Development Organisation, to promote the uptake of waste minimisation techniques in clusters of small-scale industries in India. An evaluation assessment based on data of December 1997 (Berkel and Luken, 1999) showed that all five companies that participated in the demonstration projects continued their waste minimisation activities and had doubled the total number of implemented waste minimisation options in the first three years after completion of the demonstration project.

The pioneering phase of starting national cleaner production centres can be qualified as a period of learning by *trial and error*, both for the UNIDO management and the National Cleaner Production Centres (NCPC). By using manuals and assistance from counterpart institutes the concepts were introduced on the basis of encoded knowledge. That knowledge, in the model of cleaner production assessment approaches, had a strong engineering focus on production processes. Accounting, dissemination policy, marketing, products and eco-design were out of sight for a long time. In the first NCPC annual evaluation meeting, cleaner production experts often overruled the programme management; in the second meeting, the NCPC directors discussed their experiences in cleaner production demonstration projects. They focused on their results, the time taken to receive results and how to disseminate results. Although, the programme management introduced a new subject (total cost accounting), the main concern of the NCPC directors kept being the basic operations.

During that second meeting, UNEP expressed the need for documentation in support of requests for future funding from donors, but UNEP's plea for documentation was not well understood and even misconstructed as a control instrument. Two years later it became clear that few donors would continue funding centres for more than five or even three years. The transition from donor financing to self-sustainability was in the case of the Mexican NCPC desperate: the director was informed about the end to donor financing one month before it stopped (Romano, 1999). The programme management rationalised this development by arguing that within three to five years NCPCs would have created a sufficient cleaner production market for them to survive after the end of initial funding.

The first generation of NCPCs have made the transition to sustainability, although some still face deficits. They finance their activities from domestic funds, operational incomes (training programmes, CP assessments, consulting fees) and international funding (World Bank, bilateral assistance) (UNEP/UNIDO, 2001). However, NCPCs cannot be fully self-sustainable financially because some of their core activities – such as policy dialogue and information dissemination – will not create income. The threat of being dependent on funds for other goals is not far away. The issue of whether NCPCs should become an ISO 14000 certification institute or become involved in the performance of the Basel Convention[73] led to discussions that consumed much time. On the one hand, ISO 14000 certification and the Basel Convention performance can be an entrance to include cleaner production; on the other hand, the financing is strictly structured towards their goals and is mainly based upon performance capacity. Instead of mastering too many new activities it may be preferable to network with those institutions and companies that have already established themselves in those areas.

The 6th NCPC evaluation meeting showed the differences in the needs of mature and newer centres for further learning experiences. Of course the newer centres have more basic needs that are sometimes neglected by those who have longer experience in the cleaner production field. However, the cleaner production dissemination process up to now has taught us that more than technical or economic information is needed. An UNIDO evaluation (Clarence-Smith, 2000) has concluded that the dissemination and application of the cleaner production concept by small and medium-sized companies (the core client base for the centres) does not occur so easily on the basis of its economic merits alone. The development of NCPCs is fragile. Developing local capacity to promote cleaner production is quite slow since it takes time to build up the critical mass of hands-on experience and *success stories*.

There is a definite need to evaluate more closely how much the capacity being built by the centres is actually leading to the desired environmental and economic benefits. And finally, at least in their work directly with industry, centres have so far not brought about significant transfers of cleaner technology. One major constraint faced in many countries has been companies' limited access to affordable financing for such transfers. Overall, the UNIDO/UNEP NCPCs have had undoubted successes, and when given enough time, they have managed to become financially self-sustainable. The question is whether or not these successes are sufficient, and will ever be sufficient, to bring about long-term, sustained cleaner production to the countries in which the centres are located.

In some countries in Central Europe, cleaner production has developed as part of the new legislation or of national policy, as in the Czech Republic. New laws and policies had to replace the old system's rules, and some cleaner production experts were successful in promoting cleaner production: this made it possible to leap-frog over the end-of-pipe, pollution control phase and proceed directly to the preventive approach. The national context also played a role: environmental pollution was very widespread and hardly any funds for environmental protection measures were available. Relatively small investments in cleaner production could be beneficial and could bring about sufficient financial savings so that corporate funds would become available for subsequent cycles of improvements.

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[73] The Basel Convention is an international agreement on the transportation and treatment of hazardous waste.

For example, in Poland cleaner production has been included in environmental legislation since 1998: sustainable production and consumption have to be part of a company's philosophy. In the Czech Republic, cleaner production was integrated in national policy: all ministers signed one document to link cleaner production to their activities (see Annex IV.1). Both countries have signed the International Declaration on Cleaner Production.

But `older' industrialised countries are also implementing cleaner production in their policies. The Government of Canada has taken a strong leadership role in environmental protection by making pollution prevention the cornerstone of the new Canadian Environmental Protection Act, 1999 (Canada Centre for Pollution Prevention, 2000).

4.4.2. *United States Agency for International Development*

The United States Agency for International Development (U.S. AID) funded three international programmes on a bilateral basis.

The Environmental Pollution Prevention Project (EP3) programme was run in the period September 1993 - August 1998 with the following objectives:

a) To establish sustainable pollution prevention programmes in developing countries;
b) To transfer urban and industrial pollution prevention expertise and information;
c) To support efforts to improve environmental quality.

The EP3 programme has established centres in eight countries: Bolivia, Ecuador, Egypt, Indonesia, Jamaica, Mexico, Nicaragua and Paraguay.

The US World Environment Centre's Waste Minimization Programme (WEC) has introduced the concepts of waste minimization through a series of demonstration projects in ten countries of Central and Eastern Europe: Bulgaria, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Uzbekistan.

The U.S. Asia Environmental Partnership has individual country programmes, which provide information and assistance on how to incorporate pollution prevention approaches into industrial management. There are two project offices located in the Philippines and Singapore.

4.4.3. *The Organisation for Economic Co-operation and Development (OECD)*

The OECD published a second report about the state of the environment in member countries in 1985 (OECD, 1985). They referred to the global division of resources and emissions in the following statement (p. 261): "..While the Member countries of OECD contain 17% of the world's population and cover 24% of its land area, they account for about 69% of GDP and world trade, for 81% of chemical product exports, 84% of automobile exports, and about 75% of forest product imports..".

These figures show the imbalance in the use of resources and production in the Northern industrialised region in comparison with the major part of the world. However, at that time the focus was on controlling industrial pollution, not on the environmentally sound use of resources. Therefore the OECD promoted the preventive pathway and developed a clear definition of clean technology (OECD, 1987).[74] The 1987 OECD Clean Technology definition includes three levels of technical change:

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[74] "..Clean Technologies, are any technical measures in the various industries to reduce, or even eliminate at source, the production of any nuisance, pollution or waste, and to help save raw materials, natural resources and energy. They can

a) The more or less fundamental change within the production process (i.e., the change of process conditions, equipment, or raw materials);
b) The process-integrated addition of technology in order to recycle useful process streams within the process (i.e., the recovery and re-use of metal catalysts or hydrocarbon vapours);
c) Technology to treat waste streams in order to re-use them in other processes (i.e., the use of metal wastes in the foundry industry).

The attention given by the OECD to environmental issues strengthened the status of a more holistic approach to cleaner technology. The integration of cleaner production became a frequent subject in many reports.

4.4.4. *International industry and business organisations*

It is obvious that accidents have played a crucial role in the development of environmental management in the chemical industry. The Rotterdam Port Authority, faced with the pollution of the river Rhine's sediments, was not successful in starting a dialogue with the German chemical industry until the Sandoz fire in 1986. After several other disasters (Bhopal, Soveso, Exxon Valdez), the *everything's under control* attitude of the chemical industry was in strong contrast with a very poor public image, stemming from the public's perception of the high risks with which the chemical industry is associated. A national initiative of the Canadian Chemical Producers' Association (CCPA) in 1985 resulted in the Responsible Care programme of the chemical industry worldwide in 1991 (The Gazette, Montreal, 6 August 1991). Via this programme and increased public information, the chemical industry has been trying to improve its image. This is also affecting the Netherlands. Information to the public is based on the E.U.'s Soveso guidelines. The Dutch chemical industry has developed a pro-active position via voluntary agreements on environmental management systems and covenants on their 4-year environmental action plans. However, only some parts of the environmental burden are affected. Consequently the Responsible Care programme does not constitute a radical re-orientation.

In the run up to the UNCED conference (Rio de Janeiro, 1992), more than a hundred international corporations united in a coalition, named the World Business Council on Sustainable Development (WBCSD). The companies shared commitment to the environment and to the principles of the relationship between economic growth and sustainable development. This coalition includes companies from more than twenty industrial sectors. They promote their eco-efficiency principles via publications (WBCSD, 1995, Schmidheiny and Zorraquin, 1996) and newsletters.

In Asia, the Asian Productivity Organisation (APO) has recognised that a new balance is required between environmental protection and economic activities, and established the Green Productivity programme in 1994. In the first World Conference on Green Productivity in December 1996 *The Manila Declaration on Green Productivity*[75] was formulated (Asian

be introduced either at the design stage with radical changes in the manufacturing process or into an existing process with separation and utilisation of secondary products that would otherwise be lost.."

75 "..All stakeholders [should] promote awareness and mutual cooperation in Green productivity by actively participating in networking of complementary activities, exchanging of ideas and experiences, dissemination information, and encouraging the involvement of everyone in the Green Productivity Movement as the strategy for better quality of life for all.."

productivity Organisation, 1999). As department of the Asian Productivity Organisation, Green Productivity Asia designed the *Six-step Green Productivity Methodology* (see Annex IV.5). As green productivity focuses on productivity improvement and environmental protection, the central element of the green productivity methodology is the examination and re-evaluation of both production processes and products to reduce their environmental impacts and highlight ways to improve productivity and product quality. Implementation of these options leads on to another cycle of review and so promotes continuous improvement.

4.4.5. *Other international organisations*

Many international organisations started involving preventive approaches in their projects, although in a different timeframe and some, such as the World Bank, are still in an orientation phase. For a long time the World Bank supported environmental projects in a traditional format. Under the influence of various criticisms, the preventive approach has become the current guideline for new projects. The Bank also wants to foster environmental management in poor countries in co-operation with a richer country in the region. An illustration of this is the organisation of an environmental management conference in Korea by the World Bank Environmental Forum jointly with the Korean Ministry of Environment in February 2001.

The Asian Development Bank stepped on the cleaner production bandwagon at an earlier stage. They facilitated many cleaner production research and demonstration projects, environmental policy projects and the Asia-Pacific Cleaner Production Roundtable (Evans, 1999).

The influence of the European Union as supra-international institution is increasing. However, the front-runner countries such as Austria, the Netherlands and the Scandinavian countries are often faced with slower progress in other E.U. member states than their own policy could develop independently in the 1990s.

The EUREKA research programme funded a major cleaner production programme: *Preventive Environmental Protection AppRoaches in Europe* (PREPARE), based on the design and the results of the PRISMA project (Dieleman *et al.*, 1991). The PREPARE working group was established to enhance the exchange of information, improve co-operation and stimulate the development of R&D programmes on cleaner production, cleaner products and service systems. The working group started with research institutes in (among other countries) Austria, Denmark, Ireland, Italy, the Netherlands, Portugal and Spain in 1992; by 2002 the group involved experts from industry and research in 18 European countries. One of the activities is a thematic group of the PREPARE network *European Network for Environmental Best Practices* (ENEBP), launched at the Joanneum Research Institute for Sustainable Techniques and Systems in Frohnleiten, Austria, in 1998. The main objective is providing an e-mail platform for asking and sharing information about preventive activities and techniques.

The European Environment Agency in Copenhagen was organised rather late in the life of the European Union. The agency is involved in E.U. environmental policy-making. Until now the agency has not played an explicit role in cleaner production dissemination.

4.5. **Professional organisations**

The emergence of professional organisations and cleaner production roundtables is explored in this section. What occurred is that as the professionalisation process of actors, policies and instruments in cleaner production evolved, cleaner production also spread in other professions.

Any societal process of professionalisation is characterised by specialisation and differentiation. Developments such as eco-design and total cost accounting are illustrations of specialisation. In May 2005, no less than the 8th annual international conference of the Environmental Management Accounting Network (EMAN) was organised. Other factors of professionalisation in the cleaner production field were the development of routine procedures such as quick-scan appliances, starting up associations of experts, and the launch of scientific and institutional journals. Several journals in the field of pollution prevention and cleaner production have been initiated since the second half of the 1980s. An overview is provided in Table 4.6:

Table 4.6 Major journals in the field of pollution prevention and cleaner production[76]

Type of journal	Name of journal	Year of first issue	Publisher
Scientific	Pollution Prevention Review	1991	John Wiley & Sons
	Journal of Cleaner Production	1992	Elsevier/Reed
	Journal of Industrial Ecology	1997	M.I.T. Boston / Yale University
	Progress in Industrial Ecology	2003	Inderscience Publisher, Switzerland
Institutional	Industry and Environment Review	1978	UNEP IE
	Cleaner Production Newsletter	1986	UNEP IE
	Journal of Clean Technology and Environment Sciences	1989	IACT
	Pollution Prevention News	1989	US EPA
	Journal of Sustainable Product Design	1997	Centre for Sustainable Design, U.K.
	Prevention First	1999	US National Pollution Prevention Roundtable

In addition to the launch of new journals related to cleaner production and its specialisations, the publication of articles with new subjects in mainstream journals also provides an indication (George, 2002). George uses the growing number of articles in mainstream accounting journals as illustration.

Maurice *et al*. (1986) speak about the degree of professionalism, the relative importance of formal knowledge versus mastery or practical (tacit) skills, and the formal recognition of qualifications. Their study underlines the importance of education and training as a key

[76] In the table the journals on industrial ecology are included.

institutional factor shaping the knowledge configurations and patterns of social interaction within firms. Also education is part of professionalisation: cleaner production courses are provided in several regular academic education models as well as in postgraduate education at the M.Sc. and Ph.D. levels or as separate post-academic training courses.

The creation of intermediary organisations for the discussion and dissemination of pollution prevention and cleaner production concepts constitutes another aspect of professionalisation. The organisations with crossing borders' influence are classified under pollution prevention/cleaner production roundtables in Sub-section 4.5.1 and other organisations in Sub-section 4.5.2.

4.5.1. *Pollution prevention/cleaner production Roundtables*

The first Pollution Prevention Roundtable was designed in the U.S.A. Fifteen years later, Cleaner Production Roundtables are organised in all regions in the world. The roundtables function as platforms for cleaner production information sharing and dialogue about dissemination between representatives from governments, industry, consulting firms and experts in the region.

National Pollution Prevention Roundtable, 1985 (U.S.A.)

The first meeting was organised with 15 participants from five U.S. states in North Carolina in April 1985. The National Pollution Prevention Roundtable (NPPR) has a Board with ten members: one representative of each EPA district is chosen. A staff of approximately five members provided assistance to local organisers. The NPPR meets twice a year: one roundtable has a broad agenda and is visited by approximately 500 stakeholders with different backgrounds. The other roundtable is more focused on educational subjects for EPA officials.

European Roundtable of Cleaner Production, 1994

During a visit of the U.S. NPPR in Tennessee, November 1993, a group of twenty academics from universities, environmental agencies and ministries of seven European countries decided to start a roundtable. The first European Roundtable of Cleaner Production (ERCP) was organised in Graz (Austria) in November 1994 and attracted 200 participants. With a frequency of one Roundtable per year, subsequent ERCPs were organised in Rotterdam (the Netherlands), Kalundborg (Denmark), Oslo (Norway), Lisbon (Portugal), Budapest (Hungary), Lund (Sweden), Cork (Ireland) and Bilbao (Spain). All Roundtables but Lund were attended by approximately 300 participants; 550 participants took part in the Roundtable in Lund in May 2001.

During the third ERCP a general Board with one representative per country (in total 30 countries) and a Daily Board of five members was officially chosen. The whole ERCP structure functions as a voluntary organisation; in the period 1996 - 1998, the Austrian chairman could manage a small Austrian fund for secretarial assistance. The chairman elected in 1998 had assistance from his institute in Sweden. The ERCPs are organised by local committees that are responsible for obtaining funds and for developing the programmes. Despite this weak organisational structure without an administrative office, the 10^{th} Roundtable is to be organised in Antwerp (Belgium) in October 2005 and the 11^{th} Roundtable will be organised in Basel (Switzerland) in 2006.

Asia-Pacific Roundtable on Cleaner production, 1997

The first Asia-Pacific Roundtable on Cleaner production was organised in Bangkok (TH) in November 1997. Approximately 250 participants from 25 countries attended the Roundtable. An APRCP network was established in April 1998. The APRCP is officially registered as a NGO in the Philippines; the organisation's Board counts four members and its Supervisors Board ten members.

The 2nd Roundtable was organised in Brisbane (Australia), in April 1999 and was attended by 300 participants. The third one was held in Manila (the Philippines) in February/ March 2001. The objectives of the 3rd ARRCP were**:** to enhance regional co-operation and improve knowledge about cleaner production, to facilitate information sharing about cleaner production technologies, programmes, and policies, to strengthen partnerships of international, regional, and national programmes to advance the principles of cleaner production, and to strengthen a cleaner production network across the globe**.**

The 4th Roundtable was scheduled to have been held in Yokyakarta (Indonesia) in October 2002, but was delayed and relocated, for security reasons, to Bangkok (Thailand) in January 2003. The 5th Roundtable was organised in Kuala Lumpur (Malaysia) in March 2004; the 6th Roundtable has taken place in Melbourne (Australia) in October 2005.

Conference of the Americas on Cleaner production, 1998

This Latin (Central and South) America Roundtable on Cleaner production was held, for the first time, in Sao Paolo in August 1998. The 2nd conference was organised in Bogota in October 1999. A council of governmental experts on cleaner production for the Americas was agreed at that conference. Their second meeting was in Buenos Aires in October 2000.

A national Roundtable on cleaner production was organised in Mexico in Querétaro in January 2000. Follow-up Roundtables were organised in Monterrey in September 2001, Guanajuato in September 2002, Guadalajara, Jalisco in October 2003, and the 5th one in Monterrey in November 2004.

The Central-American Cleaner production centres hold frequent joint information, education and policy conferences, such as the cleaner production policy workshops in El Salvador (November 2000) and Guatemala (July-August 2001).

Africa Roundtable on Cleaner Production and Sustainable Consumption, 2000

A first Southern Africa Roundtable on Cleaner Production was organised in Johannesburg in May 1998. The first continental Africa Roundtable was organised in Nairobi, Kenya, in August 2000. There is a growing number of national cleaner production centres in Africa.

International Pollution Prevention Summit

As an outcome of the U.S. EPA International Co-operative for Cleaner Production initiative, Environment Canada and the Canadian Centre for Pollution Prevention jointly organised the first International Pollution Prevention Summit in Montreal in October 2000. In their first flyer it was stated that: "Leading practitioners will join together to strengthen partnerships and to stimulate further action on pollution prevention. Participants will include representatives of pollution prevention roundtables and cleaner production networks". Approximately 210 participants from all over the world created an atmosphere of a *Cleaner Production Roundtable of the Roundtables*, discussing action plans for the topics `Changing behaviour, Finance, Education, and Policy' in a global environmental and economic context.

UNEP's International High-Level Expert Seminars on Cleaner Production

UNEP started to organise these seminars in 1992 with a 2-year frequency. The seminars were organised in Paris (1992), Cambridge (1993), Warsaw (1994), Oxford (1996), Pyengchang (Republic of Korea, 1998), Montreal (2000), Prague (2002) and Monterrey (Mexico, 2004). The next seminar is scheduled to be held in Dar-Es-Salam (Tanzania, 2006).

Table 4.7 presents an overview of the nationalities and the number of participants per continent who attended UNEP's 5th International High-Level Seminar on Cleaner Production in Pyengchang in the Republic of Korea (29 September - 1 October 1998), the 6th seminar, followed by the 1st Cleaner Production Earth Summit in Montreal in Canada (respectively 16-17 October 2000, and 18-20 October 2000) and the 7th seminar in Prague in the Czech republic (29-30 April 2002). This overview makes clear that there has been a switch in attention to spreading the cleaner production concept to Africa and Asia. Interest in Latin America was also growing, although the representation in the 2002 seminar looked different. Nicaragua's NCPC director further illustrated the co-operation between Central American NCPCs by representing them too. The participation of Latin-American representatives in the 8th seminar in Monterrey (15-16 November 2004) was high. Finally, it was observed that the total number of countries and participants represented in the cleaner production movement, continues to grow:

Table 4.7 Number of participants and country background per continent in UNEP's 5th, 6th and 7th International High-Level Expert Seminar on Cleaner Production

Continent	Number of countries			Number of participants		
	1998	2000	2002	1998	2000	2002
Africa	7	14	28	19	23	38
North America	2	2	2	17	72[77]	22
Latin America	7	17	9	12	27	15
Asia	16	17	28	125[78]	56	75
Europe	19	25	32	56	77	193[79]
Pacific region	2	2	2	6	6	5
In total	53	77	101	235	261	348

As with many other ecological fora, the organisation of the UNEP's International High-Level Expert Seminars on Cleaner Production tries to have a fair diversification of stakeholders (see Table 4.8). From attendance figures at the seminars in Montreal (Canada) in November 2000 and in Prague (Czech Republic) in April 2002, the following statistics have been calculated:

- The representatives of the UN and NCPCs have a share of 20% of the participants in both seminars.
- The seminar location reflects the regional culture, leading to strong attendance from certain categories.

77 47 participants from the organising country (Canada).
78 51 participants from the organising country (Republic of Korea).
79 62 participants from the organising country (Czech Republic).

- Government representatives had a higher participation rate in North America (35%) than in Europe (25%).
- The participation of representatives of university and research institutes was higher in Europe (17%) than in North America (13%).
- This is also the case for the category `consulting firms, unions, NGOs': in Europe 32%, in North America 24%.
- The participation of industry is more or less stable at 6-7%.

This type of conferences does not fit the business culture worldwide for reasons of time consumption and the abstract nature of the topics on the agenda. Regional industrial leaders who were invited to make a presentation dominated the industry participation. The relatively strong participation of Asian industry in other regions of the world reflects the fact that industry in developed Asian countries is increasingly confronted with a strong public environmental awareness. The stronger participation of North American and European universities in relation to other parts of the world is based on a longer tradition of applied scientific research and environmental sciences (see Table 4.8).

Table 4.8 Overview of the background of participants in UNEP's International High-Level Expert Seminars on Cleaner Production for continent-wide and professional organisations

Continent	Number of participants		NCPC/UN		Consulting firm, union, NGO		Government		Industry		University	
	2000	2002	2000	2002	2000	2002	2000	2002	2000	2002	2000	2002
Africa	16	38	8	11	6	6	2	15	-	-	-	6
North America	95	22	6	2	19	10	51	3	7	-	12	7
Latin America	23	15	11	3	4	7	6	2	1	1	1	2
Asia	32	75	8	15	8	26	8	18	6	5	2	11
Europe	39	193	11	37	13	63	4	48	1	14	11	31
Pacific region	5	5	1	1	-	1	2	-	-	-	1	3
In total	210	348	45	69	50	113	73	86	15	20	27	60

UNEP's Expert working groups on Cleaner Production

At the beginning of the 1990s, several international expert working groups were organised around themes such as leather, textile, and dissemination policies.

4.5.2. *Further `greening' organisations*

This sub-section deals with organisations that have the *greening of industry* as their objective. They might be structured in relation to a specific field such as clean technology and environmental accounting, or as an NGO with general *greening of industry* targets.

International Association for Clean Technology (IACT)

IACT was initiated by several Clean Technology experts from UNIDO and ministries of Environment in Denmark, Germany, the Netherlands and the United Kingdom. The first conference was organised in 1988 in Vienna.

Greening of Industry Network

The Greening of Industry Network was launched in 1991 as an international association of professionals from academia, business, NGOs and government, focusing on issues of industrial development, environment and society, and dedicated to building a sustainable future. The Network mobilises a community of researchers to stimulate the emergence of a new strategic research area on the greening of industry, creates a dialogue between this emerging research community and leaders in business, labour, government, NGOs, public interest groups, and provides an opportunity for all stakeholders with equal voice to develop research and action agendas on issues of industry, environment and society.

The mission of the Network is: "..The Greening of Industry Network develops knowledge and transforms practice to accelerate progress toward a sustainable society..". The Network is not directly linked to the cleaner production philosophy, but is based on common thinking about ecologically-induced changes in industry management, many personal interrelationships developed. The Network has co-ordinators for the Americas, Asia and Europe, engaging participants from 50 countries to respond to the challenge of sustainable development. The GIN organises annual conferences alternating in the three continents. In October 2004, the 12th GIN conference was organised in Hong Kong, China. From 2005, regional conferences are to be organised, with the first one taking place in Enschede (the Netherlands) in April 2005.

Environmental Management Accounting Network, 1997

The Environmental Management Accounting Network is a network of researchers, consultants, business people and policy advisers interested in environmental management accounting as a tool of corporate environmental management. It aims to provide a medium through which those interested can contact others with similar interests, and to organise regular events for the dissemination and exchange of news and ideas (EMAN website 2002). The professionalisation of the EMAN group is illustrated by the annual EMAN conferences in different places in Europe. For example, the 7th EMAN – Europe conference was organised in Lüneburg (Germany) in March 2004 and the 8th one in Rotterdam (the Netherlands) in May 2005. Also, the agreement on an Asia-Pacific charter of EMAN in February 2002, is an additional indicator of this process of professionalisation.

The greening of industry approach involves organisational change. Such change may result directly from new ways of thinking and acting, but may also stem from the management tools developed in order to support the company's greening process. The relationship of environmental management accounting to organisational conditions and driving forces for changes which are conducive to cleaner production processes, is an important research subject.

Universities

Three U.S. universities began their involvement in pollution prevention research in the 1980s: a. North Carolina State University in Raleigh, North Carolina (with a focus on pollution prevention), b. the University of Tennessee (with a focus on cleaner products) and

c. the University of Massachusetts, Lowell (with a focus on toxics use reduction). Many other U.S. universities are currently doing research on technology and dissemination policy on pollution prevention.

Several European universities have played an important role in the dissemination and transformation of the U.S. pollution prevention concepts in Europe. The Lund University (Sweden) and the universities of Amsterdam and Rotterdam (the Netherlands) initiated research and demonstration projects at the end of the 1980s. In a second loop, the Technical University of Lyngby (Denmark) and the Technical University of Graz (Austria) became involved with new research based on the general concepts. The Delft University of Technology (the Netherlands) created an Eco-Design education and research programme.

NGOs

The Greenpeace International Foundation has supported the cleaner production concept since 1988, when two representatives of Greenpeace participated in the first Conference of the International Association of Clean Technology in Vienna and were informed about the preventive approach. The working document *Protection of the North Sea: Time for Clean Production*, prepared for the Foundation in the period 1989 – 1990, was included in the material for debates during the 3rd North Sea conference in The Hague (the Netherlands) in February 1991 (Baas *et al*., 1990).

The Greenpeace International Foundation translated the cleaner production concept into a slogan: *Cleaner Production: No Time To Waste* and used it as a basis for lobbying in national and international policy-making; Greenpeace also commissioned the eco-design of a bicycle and a car as illustrations of cleaner products applications.

The *Global Action Plan* organisation has also been actively involved with awareness-raising in the field of prevention. In the period March 2001 – January 2004 in the Netherlands, eco-teams of approximately eight persons in a neighbourhood or a professional organisation (such as in a bank and a ministry), analysed their activities in order to improve their environmental and energy use performance.

4.6. The characteristics of the international dissemination process

On the threshold of the third millennium, the prevention concept was discussed and developed in many platforms and regions throughout the world. UNEP and UNIDO had contact with cleaner production dissemination centres in some 140 countries. The international cleaner production dissemination policy learning process was strongly mimicking the technology assessment phase of the first phase Dutch cleaner production demonstration projects. The results of the available demonstration projects can teach us, taking cultural differences into account, two important cleaner production lessons for starting cleaner production projects in developing countries:

1) The possibility of leap-frogging over the end-of-pipe, pollution control phase and proceeding directly to the preventive approaches, although the conditions in developing countries are not always clear (Hwang and Tilton, 1990);
2) The perception that there are no funds for environmental protection measures: relatively small investments in cleaner production are beneficial and can bring about sufficient financial savings so that corporate funds become available for subsequent cycles of improvements (Berkel and Luken, 1999).

However, these learning processes only enjoyed a late recognition. The fact that national and local demonstration projects are needed in cleaner production dissemination was known from earlier dissemination processes in Europe. But the plea of Gladwin (1993) to use organisational theory in analysing the greening of organisations was long neglected. The first phase National Cleaner Production Centres had, despite training programmes in Europe for their leaders, a trial-and-error engineering focus in demonstration projects. All NCPCs have grown, as regards the number of both their employees and knowledge disciplines. The institutionalisation of the centres is strongly dependent on the background of the host institute. The background situation at the start (structure and main research discipline) can still be recognised in the current situation. The centres in large countries also involve cleaner production professionals at regional levels. For instance the Indian NCPC is hosted by the National Productivity Centre and is managed by two directors. For the dissemination of cleaner production concepts in demonstration projects and policy, eighty professionals at regional levels in India are involved.

As regards the overall characteristics of the start-up and growth phases of the cleaner production centres, it can be concluded that the dissemination of the cleaner production concepts was strongly based on an engineering approach and encoded knowledge; the dissemination had a technical origin without any attention being paid to organisational change. The dissemination of the cleaner production concepts had a weak social process origin. The organisational process of change was mainly based on a `one hit' intervention, neglecting the context of weak environmental regulation, the need for continuous management commitment, the enlisting of tacit knowledge and advice for the implementation phase. Although cleaner production dissemination policy activities have increased in all centres, as regards the overall learning process it can be concluded that worldwide the `new for the country' cleaner production concepts also have had to be modified to fit into the existing culture and infrastructure of a country or region. This learning process took time to ripen in the old NCPCs but was applied at an earlier organisational phase in the new Central American NCPCs.

The annual UNIDO/UNEP NCPCs evaluation meetings can be characterised as a learning process. The meetings are a liaison between UNIDO and UNEP, and are structured by information sharing, attention to new developments, and donor issues. In the growth phase many NCPCs extended their activities as a result of the information received and learning. Until the UNIDO/UNEP NCPC evaluation meeting in November 1997, the Chinese NCPC was not convinced about the need for a cleaner production dissemination policy. Afterwards they learned about the signals for such a necessity and presented their policy experience in the UNIDO/ UNEP NCPC evaluation meeting in March 1999 as if they had never denied that there was a need for a dissemination policy. In a special session about networking,[80] there was a discussion about the fact that each NCPC will have to be aware of their specific national situation, which requires a 'roadmap' for cleaner production dissemination policy research. In particular, large countries realise that they need to start regional cleaner production centres or link activities with other regional organisations. In selecting stakeholders, one must bear in mind that cleaner production must be developed as an innovative concept and that a pollution control perspective must be avoided. The main stakeholders that could be detected were the Ministries of Industry, Trade, and Finances, universities – who are educating future company managers (both engineering and business-

[80] UNIDO/UNEP NCPC evaluation meeting, *National Networking* session, Prague, CZ, 10 March 1999.

economics) – and financial institutions (needed to raise funds for cleaner production projects and investments). The role of key persons in stakeholder organisations – who want to join a NCPC in cleaner production dissemination partnerships – was stressed. In addition to the session, all NCPCs plan to continue or get involved in policy dialogue (Natravil, 1999: Annexes IV.4: A and B).

The positive results of the cleaner production dissemination policy analysis in Mexico in 1998 were the basis for learning processes after the start-up phase in Central American countries. The longer established Costa Rican NCPC had already explored the stakeholder approach; the other Central American countries were trained during cleaner production dissemination policy workshops in El Salvador in November 2000 and in Guatemala in July/August 2001.

The issue of dissemination policy is now recognised as an important NCPC activity. The semantics of the word *policy* in some languages, such as the Spanish word *politicas*, has two different meanings: policy and politics. This is sometimes confusing and prevents getting a clear view on what an organisation can handle. When the word *politicas* is used as a principle or direction that guides the decisions and actions of an organisation, it is closer to NCPC management. Nevertheless politicians and policy-makers can also be stakeholders in cleaner production dissemination. A distinction can be made between several types of policy approach:

- *Formal approach* to cleaner production public policy: this entails approaching government and the political arena directly to publicly involve cleaner production in the policy-making processes and promote cleaner production in all its efforts;.
- *Stakeholder and network approach* to influencing cleaner production public policy: this entails approaching the government and the political arena indirectly via a process of doing research on the main stakeholders, the organisation of joint cleaner production awareness-raising meetings, and starting up a cleaner production network.
- F*ine-tuned approach* to specific sector and product policy: this entails selecting certain categories of stakeholders in order to directly influence their policy, for instance, energy companies to make them shift to renewable energy provision, and banks to make them grant investment incentives to firms that are implementing cleaner production.

An overview of the activities of the first generation of NCPCs in 2002 confirms the trend towards a greater diversity of the centres. The centres started with a director and one or two assistants. An overview of key variables of mature NCPCs shows that all these centres (between 5 and 7 years in existence) have expanded the number of their employees and their background knowledge disciplines (see Annex V.4). The institutionalisation of the centres is strongly dependent on the host institute's background. The background situation at the start can still be recognised in the current situation. Social sciences disciplines, except for the Hungarian centre (with its economic sciences background), are marginally represented (three employees with an international trade, business administration, law, economics and/or accounting background). In the large countries the centres involve cleaner production professionals at regional levels. All the centres pay attention to the policy need for cleaner production dissemination.

Although the cleaner production concepts are equally viable in different parts of the world, their dissemination has to be adapted to the culture of the country. Until now only limited experience with the translation of the concept into the country's culture and infrastructure has been available: research has been performed through an in-depth cleaner production policy analysis in Thailand (Huisingh, 1997) and a quick scan cleaner production dissemination policy analysis in Mexico (Baas, 1998). Based on the findings, a *Cleaner production dissemination policy analysis quick-scan* has been developed (see Annex X.1).

4.7. Recapitulation and conclusions concerning the cleaner production dissemination process

Several conclusions can be drawn from the shift from environmental technology towards cleaner production. Industrial environmental protection started on a pollution control basis with control technologies. The 1970s can be characterised as a pure technology engineering approach to control pollution. In the 1980s, public policy development included the emergence of integrated environmental policies and new economic and voluntary instruments. Taking more responsibility, industry in the Netherlands developed environmental management systems strongly supported by the Ministry of Environment with large subsidy programmes for the introduction of environmental management systems. Most of the sectoral organisations developed sector-specific systems and manuals.

At the end of the 1980s, the cleaner production concept emerged as the technology assessment approach. To recapitulate the highlights of the foregoing sectors of this chapter, Figure 4.4 provides an overview of the different life-cycle phases of cleaner production dissemination: emergence, growth and maturity in the margin of the development of environmental management systems. Although it is often said that cleaner production and environmental management systems could merge well, the technology focus of cleaner production assessments and the administrative focus of environmental management systems led to two separated domains, which limited the possibilitites for integration.

Figure 4.4 **The life-cycle phases of cleaner production implementation in the Netherlands**

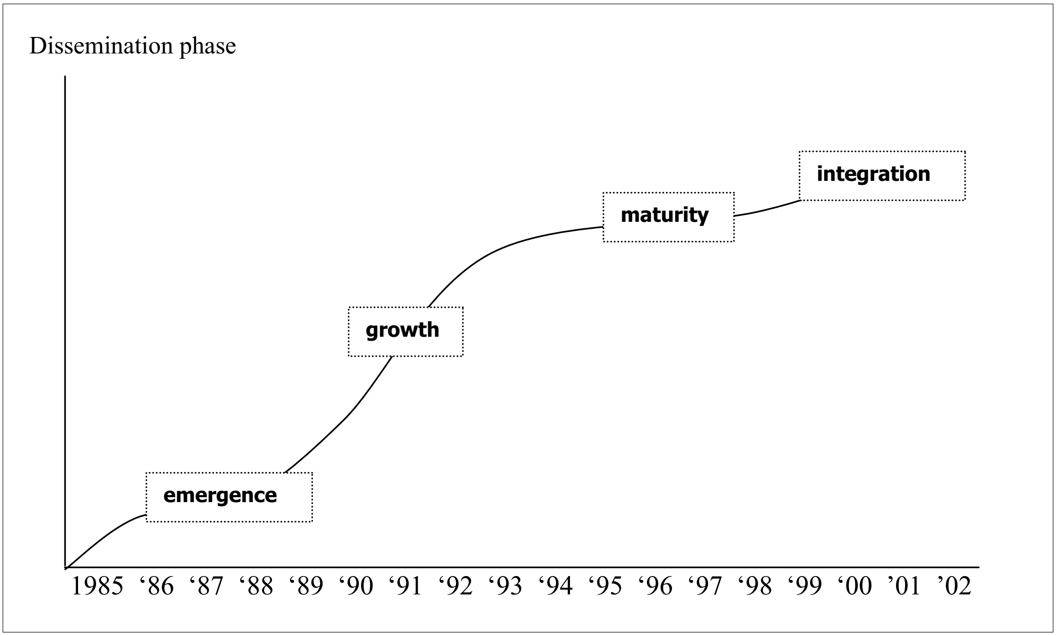


Figure 4.4 represents the qualitative interpretation of the various growth phases of the recognition of cleaner production concepts: the fact-finding phase of the cleaner production approach (Section 4.2) and the design of a structured cleaner production approach (Section 4.3) illustrate the emergence phase of cleaner production in the period 1987 – 1991 in the Netherlands; the dissemination phase of cleaner production projects (Section 4.3) illustrates the growth phase in the period 1991 – 1994. From 1995, the mature phase of institutionalisation of the concept and professionalisation can be detected (Section 4.5). The international phase in cleaner production dissemination (Section 4.4) started its life-cycle in 1993 and is going with the same technology through similar phases.

The following conclusions are based on the dissemination processes of the cleaner production concept in successively the phase of fact-finding (4.3.1), structured design (4.3.2), dissemination (4.3.3), internationalisation (4.3.4 and 4.4), institutionalisation (4.3.5), and professionalisation (4.3.6 and 4.5).

Structure:

At the end of the 1980s, the general perception of how to solve environmental problems was based on pollution control in a rather static, power, institutions, information and decision-making configuration. Companies were not facing pressure from stakeholders on ecological issues and regulatory enforcement concerning small and medium-sized companies was weak (Sub-section 4.3.1). Government and sectoral organisations were eager to promote environmental management systems. Many organisations used the mainstream approach consisting of the top-down administrative introduction of environmental management systems, which held back the introduction of cleaner production.

In the Netherlands, the cleaner production concepts were mediated by environmentally committed academics who introduced the concept at the micro level of companies towards the end of the 1980s. The PRISMA project facilitators found overall that with an innovation-oriented waste prevention policy remarkable results could be achieved. They documented that industries could save extensively on the costs of energy and raw materials and at the same time decrease their environmental impacts significantly. The results of the project were presented to the Dutch Parliament. The recommendations on government environmental policy were recognised as promising and served as the basis for the promotion of cleaner production throughout the Netherlands (Sub-section 4.3.2.). All market actors, government organisations, experts, NGOs and industry associations were involved in the dissemination processes of cleaner production (Sub-section 4.3.3). Internationally, in Europe, university experts initiated cleaner production projects involving the expertise of professor Huisingh in the final part of the 1980s and the early 1990s, leading for instance, to the completion of the PRISMA project in 1991. UNEP and UNIDO designed programmes and facilitated university expertise on cleaner production for countries in all regions of the world (Sub-section 4.3.4). Several foreign aid programmes (Denmark, the Netherlands, Norway, USA and Switzerland) together with UNEP and UNIDO facilitated the international dissemination of the concept (Section 4.4). In the second half of the 1990s a cleaner production institutionalisation process took place in the Netherlands with government organisations at national, provincial and municipal levels playing facilitating roles (policy strategy documents, dissemination funds and prevention teams). Consulting firms took the lead in the dissemination of cleaner production concepts to small and medium-sized companies (Sub-section 4.3.5). Internationally, experts playing a dissemination role, and international agencies and foreign aid departments of several countries acting as facilitators, mediated the cleaner production concept (Section 4.4).

Processes

Academics started to test the pollution prevention approach on the basis of a business-fit environment improvement method. The cleaner production concept was not well-known, but managers in small and medium-sized companies showed great interest in environmental aspects as well-informed citizens. They understood their own responsibilities, although they had no understanding of their own company's environmental situation. Information, together with project assistance, was valued but insufficient to firmly establish change processes (Sub-section 4.3.1). The Dutch Ministry of Environment did not subsidise the emerging phase of cleaner production; other ministries, a technology assessment organisation, some provinces and large municipalities marginally funded that phase.

In the PRISMA project (Dieleman *et al*., 1991) was found that with an innovation-oriented waste prevention policy remarkable results for industries to save extensively on the costs of energy and raw materials could be reached while at the same time the industries could decrease their environmental impacts significantly (Sub-section 4.3.2). The PRISMA project was mimicked in further dissemination projects, both nationally and internationally. In the Netherlands the PRISMA project became the driver for new case studies at regional levels, the integration of prevention in innovation projects of the Dutch Innovation Centres, the integration of prevention in policy-making processes in provinces and large municipalities, the commercialisation of cleaner production projects by consulting firms, the interests of several industrial sectoral organisations (starting in the metal working sector), the development of policy documents, the organisation of cleaner production expert meetings and workshops and international dissemination developments (Sub-section 4.3.3).

During the cleaner production emergence phase, university experts set up cleaner production research projects, whilst during the growth phase consulting firms mediated the dissemination of results. This process has been repeated in many countries in Europe. UNEP and UNIDO organisations also mimicked the dissemination of the concepts through demonstration projects, instruction manuals and in a later phase dissemination policies with stakeholder involvement (Sub-section 4.3.4). With respect to institutionalisation processes, prevention became a joint strategy at all governmental levels in the Netherlands. As the initial phases of cleaner production projects were time-consuming, the institutionalisation process involved the introduction of quick-scan research. The Dutch Innovation Centres provided two-day innovation research and several incentive programmes developed a two-step approach: a quick-scan as a first step, providing the basis for more in-depth cleaner production research as a second step. This approach became the basis for the Dutch cleaner production subsidy programmes starting in the second half of the 1990s. Encouraged by government funds, this quick-scan approach was used to transfer knowledge about the concept to small and medium-sized companies (Sub-section 4.3.5). Another aspect of the institutionalisation process is professionalisation, in the shape of specialised expertise, national, regional and global expertise networks and expert and scientific journals (Sub-section 4.3.6).

Outcome

The STER project showed that the cleaner production concept had a strong business economics and pollution prevention potential. The entrepreneurs proved to be more open to innovative approaches with positive environmental results than many government representatives expected (Sub-section 4.3.1). The PRISMA project provided detailed, company-specific waste prevention and reduction plans and policy recommendations (Sub-section 4.3.2). In particular, the cleaner production assessment and good-housekeeping measures became widespread at the sectoral and societal levels. The impact of the PRISMA project was enormous. The project illustrated how an emerging concept can break through and served as the basis of a growth phase of the concept. The PRISMA assessment method received the status of a *label* instead of a pollution prevention instrument.

In general, during the emergent phase of a new approach, there is space to reflect about further development. However, the status of the PRISMA method meant that the label embodied an encoded knowledge approach. Only the *cleaner production assessment method* became the basis for preventive developments. As a result, it created a trade-mark that was not open to further dialogue. Although the cleaner production assessment was designed with several feedback loops, in practice the assessment developed as a one-loop learning process, ending with a *cleaner production plan* after the feasibility phase. The engineering approach, based on encoded knowledge, largely dominated the characteristics of the cleaner production concept. Furthermore, demonstration projects had to show practical results. All these activities developed in the direction of a mature phase of institutionalisation and stronger internationalisation. Also, professionalisation and specialisation are characteristics of a mature phase. However, societal dissemination processes ask for more ingredients in continuous social change processes and this was hardly the case.

4.8. **The state-of-the-art at the beginning of the 21st century**

There are many different perceptions of the impact of cleaner production. A simple one is: `The picking of low hanging fruit in new areas and organisations' (`..although it is not as easy a process as is often suggested..', Dieleman, 1999). A more complex one is: `A time consuming process in more advanced phases like business re-engineering or re-structuring'.

In the life-cycle of dealing with environmental issues, the question arises whether environmental management is needed as an independent concept. Currently, we are beginning to understand that negative impacts on our surroundings are indicators of the inefficiency of industry, due to wastage of materials and energy. So, how can we influence other choices in production, products, services, logistics in such a way that negative impacts are reduced? In this perspective, can we imagine that the emergence of an advanced clean industry is noticeable? Some have stated that that is impossible. At the end of the 1990s two diverging trends emerged:

1) Ongoing professional research on the concept of sustainable development and the emergence of local authority and citizens' groups involved in the formulation of the Local Agenda 21 action plans (Global Action Plan Nederland, 1999, NCDO, 1999). Furthermore the concepts of *Sustainable Enterprises* (Cramer, 2002, Keijzers *et al*., 2002) and *Corporate Social Responsibility* (NIDO, 2002, Cramer, 2003) emerged. Also, the discussion about *What is a sustainable region?* grew as an important issue, high on the political agenda.
2) A decreased public interest in environmental issues in the Netherlands. This item is remarkable and seems to be partly based on the perspective that environmental problems

do not have the predicted outcomes. This reflects the theory of Downs (1972) that predicts that after the breakthrough of an issue, the phase of shifting to the margin of public interest will follow. Another possible assumption is that in the public's perception environmental policies have successfully led to an adequate management of several environmental problems.

5 Analysis of the Development of Cleaner Production Projects

This chapter presents an analysis of the initial positions, the methods used and the effects of cleaner production assessment research and dissemination within the *market of transition processes of new concepts* (Figure 2.1), theories of learning and change processes in the context of Ragin's interduction research model (Ragin, 1994).

First, the author focuses on developments within cleaner production research projects (Section 5.1) and discusses the positions of the different types of actors in the initial phase of cleaner production dissemination research (Section 5.1.1). Then he turns to the research methods that were used (Section 5.1.2), and the decisions about participation in a cleaner production demonstration project in the emergence and early growth phase (Section 5.1.3). Then he deals with the categories of employees that were involved in cleaner production projects (Section 5.1.4). Subsequently, the author addresses the emergence of competition and preference for new concepts of cleaner production and environmental management systems at a public policy level (Section 5.2). Section 5.3 reflects upon the various terms used in industrial environmental management approaches and Section 5.4 provides a taxonomy of eco-induced tools and instruments.

In Section 5.5, a first set of conclusions about the process of the dissemination of cleaner production concepts is presented. Section 5.6 is a general discussion of the cleaner production learning process. Following Ragin's research model, first the data concerning the dissemination of cleaner production are treated as evidence. Then the formulated theoretical ideas about the position, perception, and power of actors, the kind of learning processes and the dissemination of the concepts are analysed. Section 5.7 recapitulates the main lines of the analysis in this chapter.

5.1. Developments within cleaner production research: beyond projects

At the beginning of cleaner production research activities, it was generally found that corporate knowledge about emissions and wastes was incomplete and totally inadequate. Furthermore, while most company representatives were aware of their responsibility for protecting the environment, they lacked the knowledge about alternatives that was needed for making improvements. It was assumed that knowledge about pollution, the relationship between pollution and business economics, and the alternatives, and a consequent change in focus from a *problem oriented* approach to an integrated systematic approach to all production processes and products within the company would become part of the *internal* learning process within the company.

Within that learning process, it was envisioned that the organisational change plan would consist of an integrated approach including a behavioural strategy (change of attitudes and values), a structural strategy (a change of structures) and a technical strategy (change of production and methods).

The evaluations of courses designed to help company leaders to develop those integrated approaches showed that these integrated approaches generated a continuous process of change resulting in improved performance of the company more frequently (Baas and Huisingh, 1994). Another important facet of the corporate learning process was the realisation that prevention-oriented measures intended for environmental improvements did not automatically lead to increased operating costs. The improvement options in six metal working companies in the STIMULAR project showed that only one out of four options led to higher operating costs (Koppert *et al*., 1992):

Table 5.1 *STIMULAR:* overview of the number of the developed cleaner production options in six metal working companies and their economic aspects

Company	A	B	C	D	E	F	**Number of options per category**
More costs	2	3	3	3	0	1	12
No net cost changes	3	4	9	1	1	7	25
Cost savings	2	2	2	3	2	1	12
Number of options per company	7	9	14	7	3	9	49

Although the first generation of cleaner production demonstration projects showed substantial reductions in waste and emissions and thanks to these results – and because of its assumed win-win basis – was seen as an easy concept to spread, researchers faced the following critiques at the same time:

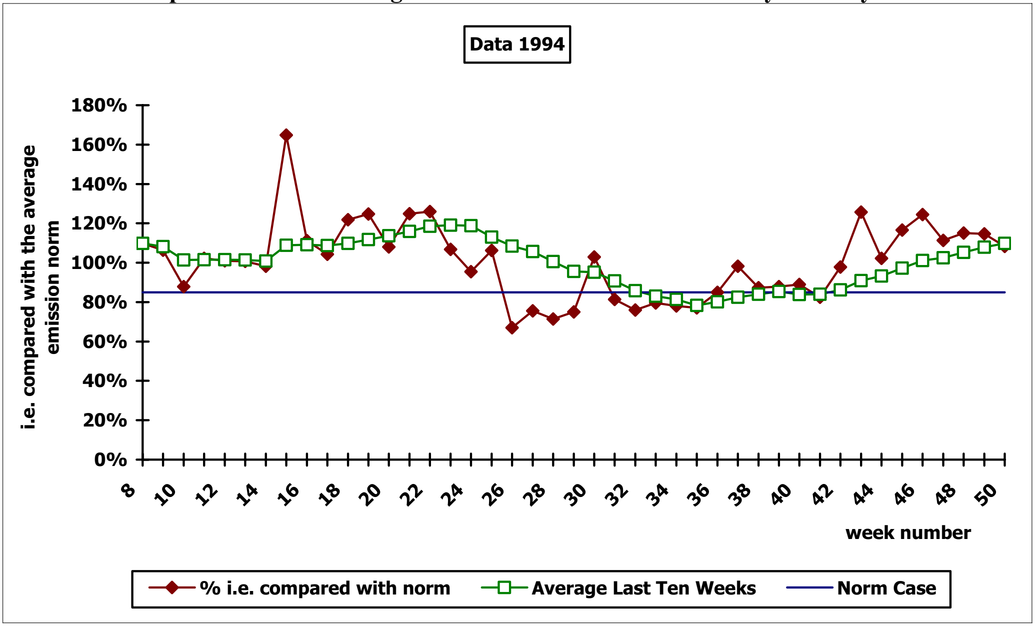
- The results are based on "picking low hanging fruits";
- The growth in production will match the waste reduction levels (30 %) within a decade;
- The dissemination of cleaner production does not happen automatically: practice shows that the concept needs more than one intervention in a company and more efforts to launch those concepts in other areas.

In essence, these critiques concluded that the valuable preventive approaches needed a structural basis within an organisation to ensure that the content (continuous improvement), change process (integration at all organisational levels) and dissemination (actors of change) would be optimised.

Both within single companies and/or multinational corporations as well as in governmental organisations, the role of key actors emerged as a very important factor for the introduction of preventive approaches (Van Vliet, 1999, Cramer & Reijenga, 1999, Vickers, 1999). The positive attitude of a key actor in an organisation can create a platform for change that can be re-enforced by other powers in the organisation. An example that illustrates this point is from the dairy industry company, where a cleaner production project was started and then mainly supported by the plant manager. In the years after the project, the plant manager was eager for further progress and started a *Continuous Improvement Team*. The team used core production data for continuous improvement research and activities. Their goal was to be at 85% of the average emission level of the Dutch dairy industry. Figure 5.1 shows a decline of pollution in the first half of 1994. After the summer holiday the figures increased.

This was due to the installation of new milk processing and packaging machinery that was needed for the extension of raw milk processing at the end of the year 1994.

Figure 5.1 **The average inhabitants equivalent (i.e.) emission spreadsheet in a Dutch dairy plant compared with the average emission norm of the Dutch dairy industry in 1994**

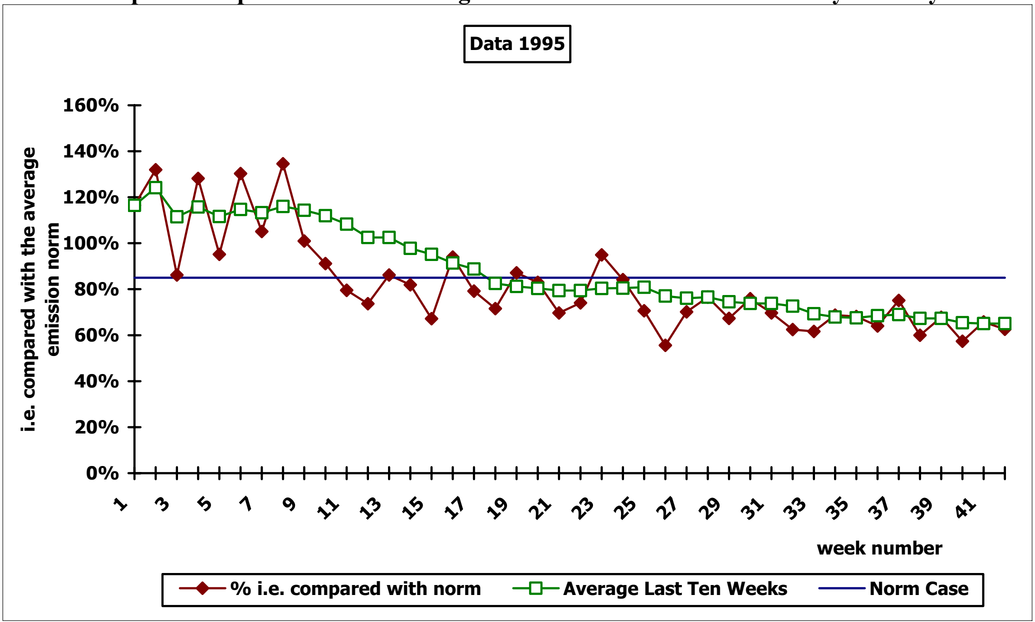


At the end of 1994 and the beginning of 1995, the extended milk processing, including several new techniques, met with many kick-off problems and this generated a lot of pollution at the beginning (see Figure 5.2).

At first, the cleaner production improvement team returned to crisis management: the biggest pollution cases had to be properly managed again. After two months, the cleaner production improvement team returned to the pathway of continuous improvement and monitored pollution reduction, as the overview of the average emissions in 1995 shows. Halfway through 1995, the cleaner production improvement team was successful in keeping the pollution level continuously below the norm for inhabitants equivalents. Figure 5.2 represents the continuing trend in increasing emissions as the result of the efforts of the crisis team to solve the problems in 1995.

The data in Figure 5.2 reveal the dynamics of the emission changes in a dairy plant that had a waste reduction team working to effect reductions in wastes and improvements in efficiency. The figures prove that implementing waste reduction measures based on monitoring data provided the basis for continuous improvement in their environmental performance and economic efficiency. The dairy plant’s waste reduction team was unique in the entire Dutch dairy industry, although their approach was propagated by the corporation’s staff environmental manager, at first within his own corporation and later as a member of the Dutch dairy sector delegation during negotiations with the Dutch Ministry of Environment about a dairy sector covenant.

Figure 5.2 **The average inhabitants equivalent (i.e.) emission spreadsheet in a Dutch dairy plant compared with the average emission norm of the Dutch dairy industry in 1995**



5.1.1. *The positions of different actors at the beginning of cleaner production dissemination research*

The 1987 pollution prevention mini-symposium (see Section 4.2) was held within a context where citizens, government and industry representatives responsible for environmental policy perceived that solving environmental problems was urgent. The limits of traditional regulatory approaches generated uncertainty about the actual possibility of solving environmental problems in the last part of the 1980s. A tentative reflection emerged in discussions that went something like this: "If the legislative approach does not provide the proper stimulus for industry to address environmental problems as their individual responsibilities, then perhaps, the preventive approach might be an alternative that would be better suited to business".

Furthermore, the international context of environmental problems such as the problem of toxic sludge in the Rotterdam harbour demanded that different approaches should be developed and implemented. Despite this, confidence in the application potential of the pollution prevention concepts was low. Only a few persons saw the potential of the concept and had enough power – in their individual position in their organisations[81] – to provide some funds for the design of a pollution prevention project in the Rotterdam harbour and industry area. These funds provided a few committed environmental science academics (who felt challenged by the potential of the preventive approach) with the opportunity to design research on the effects and implementation of pollution prevention concepts in the

81 The organisations were the Rotterdam Municipality Port Management and the North Sea Directorate of the Ministry of Transport and Water Management

Netherlands. This is an illustration of the role that key actors can play in the development of new approaches, both in facilitating as well as in exploring the new approaches.

Introducing the new concepts as well as doing research at the same time involved both normative and inter-subjective elements. Bringing the concepts forward as research experiments without any guaranteed results strongly appealed to the company managers. At the same time, the research approach was often judged by other scientists as not being sufficiently scientific because of the strong normative elements involved and due to its theoretical weaknesses. However, the experiments of academic-led research on the implementation of pollution prevention concepts made the societal appreciation at the level of entrepreneurs visible in 1988 (see Section 4.3.1). Hereby, the following experiences were observed:

- The expectation of representatives of the funding organisations[82] for the STER project that companies would not be willing to join did not prove correct; their anticipation of such a reaction was based on their experiences of a reactive position of industry in meeting environmental requirements;
- The company managers appreciated the activity of academics and were willing to co-operate without the perceived threat of government; most of them translated their personal concerns into a rational commitment to the project for environmental reasons.

From these findings it was concluded that in that period societal pressure provided a sense of urgency that made entrepreneurs receptive to a helping hand from experts (see also Kalli, 2003).

5.1.2. *Which research methods were used?*

In this section, attention will be paid to the following question: for which target group was cleaner production dissemination research designed? Subsequently, the research method will be evaluated and the section will end with closing remarks that are devoted to the dissemination of the concept.

At the start of the cleaner production action research, interested academics approached the government for research funding and industry for testing the concept. Because the concept was seen by academia as a business-fit concept, industry was seen as a primary target group by the researchers. At the same time, in case of positive research results, the government should be approached to become receptive for the development of preventive environmental public policy. The most important dissemination canal was the research itself. During the cleaner production assessments, options were developed and implemented within a company.

The cleaner production assessment approach was modified from US EPA's Waste Minimization Opportunity Manual (1988). The first phase is structured in sub-phases such as: get commitment of the director, provide some information and education on sustainability and the organisation of the project to the company, and generate a cleaner production assessment team. The second phase is the performance of cleaner production assessments. A brainstorm session with representatives from several levels in the organisation forms the basis for several cleaner production options. Economic, environmental and organisational feasibility studies on promising options complete the assessment loop with results for

[82] The Dutch Ministry of Transport and Water management, the province of Zuid-Holland, and the Rotterdam Municipality Port Management

decision-making. After the organisation of the implementation of options, an evaluation would lead to a cleaner production action plan with new assessment loops (see Annex V.1, De Hoo *et al*., 1990).

The implementation of cleaner production was applied as action research and, in a meta-level approach, used as the basis for scientific review. The action research method had elements of empirical (quasi-) experimental research with participants in the research field; the research data led to a diagnosis (the assessment) and further action for implementation (Fleurke, 1982). The used methods – such as document analysis, questionnaires, observation, participation, production process data collection, interviews, group feedback and indirect indications – fitted well in the assessment loops.

The preparation phase of cleaner production research was characterised by uncertainty on the side of the researchers: they had no experience with the assessment procedure and results and how companies would react on their proposals. The selection of the companies was also ad-hoc: it was done through existing relationships and the information held by environmental inspectors. Much information and dialogue was used beforehand to determine the targets and the expectations of the project, the wishes of the participating company, the playing field and the conditions for the project (in the case of a new concept, the structure and technology of a company provide strong limitations).

In contrast to the successful results of cleaner production projects – such as waste and emissions reduction of 30% (PRISMA, PROSA) – the dissemination of the concept to other companies did not start out automatically and proved to be very difficult. As with other new concepts, the dissemination of the cleaner production concept is not self-sustainable. Bruce *et al*. (1994) analysed the dissemination process of new ideas in a corporation with the same kind of affiliations in several American regions. One of their findings was that the critical actors became the people who discover, apply and transfer the new ideas (Bruce, 130). General managers became concerned not only with the flow of materials but also with the flow of knowledge. From that knowledge can be learned that the more the top managers are involved in the development of new concepts and the more they are willing to discover the essence of the concept and to apply it, the better the new concept is disseminated within the organisation. That line was confirmed in the cleaner production projects.

5.1.3. *Decision of a company to participate in a cleaner production demonstration project*

In the cleaner production assessment procedure (US EPA, 1988, De Hoo *et al*., 1990), it is recommended to involve key managers in order to secure their commitment at the beginning of the assessment. However, this is not always possible in practice. But even having management commitment does not guarantee an active management approach, or in a later phase, a positive decision about the implementation of prevention options.

It was found that the first contact between a company and the project representatives was important. That contact provided a first insight into the structure and culture of the company, both internally (e.g., hierarchical or flexible, closed or open) as well as externally (e.g., independent or part of a larger organisation, defensive or pro-active, strong regulatory pressure or beyond compliance). Within that context, it was found that the company's decision about voluntary participation in a cleaner production demonstration project could be predicted (negative, neutral or positive). Along the lines of Oliver's classification of organisational approaches to external requirements (1991), the following dichotomy outcomes and the rationality of their answers were expected at the beginning of the cleaner production research projects in the Netherlands:

- Negative: - shows no interest and does not join (avoidance, escape);
  - decides that it cannot say no to a project proposal (compromise, pacify);
- Neutral: - allows the project (acquiesce, habit, comply);
  - is open to project development (acquiesce, imitate);
- Positive: - is not capable of performance and willing to be advised (compromise, balance);
  - active in steering cleaner production projects (defy, manipulate).

For instance, at the start of the PROSA project in 1990, many companies were not interested, partly because of a lack of knowledge about the concept, partly because of a lack of any incentive for the development of structural environmental management. The organisations that joined the project had specific, varied motivations. Two organisations had a pro-active approach; they wanted to integrate environmental issues in their production processes and products as part of their governance profile. Two organisations were curious, having been stimulated by publications of their industrial sector association. Four organisations were anticipating on new environmental regulations. Finally, two organisations condoned the execution of the project, but were very reluctant in joining activities.

Because the participation in cleaner production projects is on a voluntary basis, Oliver's typology (1991) might not cover the same rationality as in a mandatory situation. The organisation's perception of having no problem often signals a lack of knowledge about environmental issues or about where to address demands for external advice. In addition, the fact that the concept of cleaner production was not well-known meant that the company did not have to conceal an avoidance strategy. It can be said that not joining as an answer to a demand for participation in a cleaner production project is an avoidance decision, but the rationale was in practice also based on a lack of need, recognition or acknowledgement, instead of concealing, buffering or escaping.

Furthermore, managers can adopt a fad or take a wait-and-see position, given that most managers have neither the time nor inclination to be the testing ground for untried and unproven fads (Whitney *et al.*, 2001). Also, the situation in which an organisation is neutral, but open to new developments, can be a form of acquiescing in a learning sense. This means that in the absence of any institutional pressure other variables are important in the process of receiving knowledge about new concepts. Personal commitment (as was seen in the STER project, Baas, 1989), and sensibility to new information and the translation of new concepts are such variables. Based on experience in cleaner production projects during the emergence and early growth phases of the concept, the following overview can be established in terms of strategies and tactics in decision-making for new concepts such as cleaner production:

Table 5.2 Strategies and tactics in decision-making processes to participate in cleaner production projects

Decision to participate	Strategies	Tactics	Examples of response and/or position
Negative	Deny	* No need * No interest	* No pollution in our activities * No participation
	Avoid	* Escape * Dismiss	* Setting other priorities * ”We do everything we can for the environment”
Neutral	Acquiesce	* Allow * Neutralise * Pacify	* Social control: ”We can not say no” * Priority to an environmental management system * Accommodate the project
	Co-operate	* Learning	* Open to new approaches
Positive	Compromise	* Balance * Influence	* Balancing between expectations and reluctance * Translation of concept in institutional model
	Co-operate	* Learning * Steering	* Wanting to adapt to new approaches * Wanting an interactive process for organisational learning and adaptation of the new concept

In the organisations that participated in cleaner production projects both acquiescence, especially consent and neutralisation, as well as compromise prevailed. The main cause of these attitudes were that the existing routines to meet environmental requirements provided no need for change within the institutionalised environmental regulation context; that context did not generate a *question articulation* to look for a preventive approach to solving the problems (Dieleman, 1999). Furthermore, the uncertainty about the needed cleaner production efforts and their results was another cause. In this type of situation the introduction of new concepts benefits rather more from social control (“we cannot say no”) in a neutral setting such as an university research project.

5.1.4. *What categories of employees were involved in cleaner production projects?*

In order to gain a first insight into the organisation, questionnaires were often used. The environmental manager in the larger companies and the entrepreneurs in the smaller ones were responsible for answering the questions. The dominant part in cleaner production assessments was stocktaking, to gain knowledge of the compounds and materials streams used in production processes. Manuals such as those developed in the PRISMA and PROSA projects asked also for organisational schemes - PROSA even asked for an environmental mission statement - but that information was hardly used. Even the PRISMA project, with its structural waste prevention teams, did not pay much attention to organisational aspects.

The cleaner production assessment approach stressed the need for commitment of the top management at the start of the project. Management commitment provided the legitimisation for the project, but the conditions for later implementation were not discussed at the start. Neglecting the strong power and institutionalised position of the managers and their worldview meant that the dissemination of assessment results needed new commitment. Feedback to top management about the project phases appeared necessary for continuous expertise development about what cleaner production can really mean. Based on that observation, knowledge management commitment could stimulate continuous improvements.

In practice, the environmental manager in the larger companies, or the entrepreneur in the smaller ones, were the main partners in the project. The involvement of different personnel categories was not easy for a number of reasons.

In large companies:

- Other categories could hardly be reached, because the environmental co-ordinator's network was weak to higher management representatives (PRISMA, 1991);
- In case of shift workers, the schedule provided hardly any time for operators for other activities during working time (INES, 1987).

In smaller companies:

- The direct operational work could hardly be interrupted for other activities (STIMULAR, 1992);
- The employees were not seen as competent enough to participate (in many projects).[83]

Furthermore, because the structured cleaner production assessments focused primarily on production processes, personnel categories working indirectly with the production processes were seldom involved in the projects. This type of neglect or non-involvement often resulted in a lack of crucial inputs from certain categories of employees. In the case of the lute company (see Section 4.3.1), salesmen determined the success of the project, but this type of personnel was usually absent from structured cleaner production demonstration projects that were assessed inside production plants.

The issue of providing information to all employees was part of the strategy of cleaner production assessments. The aim of the information was to make employees familiar with the project, to avoid the perception of it being a threat to their job, to commit them to the project and to generate new ideas in the project. However, the involvement of employees was often very limited. Although major projects such as PRISMA, PROSA and STIMULAR organised brainstorming sessions to discuss the generation of options, follow-up meetings were seldom organised to ascertain which options were to be implemented.

There has been much discussion about brainstorming sessions. Stroebe (1994) sees brainstorming as less effective than reflecting alone in silence, because participants have to wait whilst others speak, and because they overestimate their own contribution to the group. However according to Nijstad (2000), the fact that participants cannot exactly say which ideas they have produced does not indicate an overestimation of their contribution. He states that the efficiency of brainstorming stems from the fact that employees are less confronted with failures and moments when nothing can be invented. Groups also provide more shared satisfaction when there are results, and are less inclined to give up certain ideas. Taggar (2002) found that when involved managers provide feedback and effective conflict management, they improve the leverage of individual creative resources into group creativity. Individual creative performance will mutually be increased by group behaviour that facilitates the open sharing of information. It follows that when groups are inadequately trained in team process behaviour, or are too large, team creativity-relevant processes can stifle creativity. This means that brainstorm sessions need special preparation for an optimal facilitation of group work.

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[83] For instance in a galvanic company in the PRISMA project, employees could not speak the Dutch language and the company management could not speak their native language; information could hardly be spread.

The brainstorming in cleaner production assessments in the PRECARI, PROSA and STIMULAR projects was positive for participants. The brainstorm leaders first of all created the situation of *safe places* for the participants. In most cases it was the first time that representatives from different hierarchical levels in the companies were together to discuss the same options. Because the first phase in cleaner production projects is dominated by good housekeeping approaches, the input of the operators was new for managers. For this reason, a chemical company and a tapestry (re-)introduced the concept of brainstorming including representatives of the workshop level (Boons, 1993).

The best brainstorm session results were reached in the presence of a stimulating atmosphere, a diversity of knowledge and representation of company departments, and the reflexivity of an independent session leader. Apart from the discussion about whether the most effective results are reached in individual or group sessions, it was discovered in cleaner production projects that employees at the operational level never had the chance – or the challenge – to think about a production problem alone in silence. Remarks about deviations and disturbances in production processes were often ignored in their experience. Being represented in the brainstorm session was a good motivation for sharing their experiences with recurring signals during production process disturbances or in product deviations. A good example of this situation occurred in the Akzo case during the PRECARI project (Boons & Neumann, 1993), where in the first phase of a 48-hour production process operators could already predict that a certain batch would have a lower quality at the end of the process. Although they could not explain why a certain colour in an acidification phase in the production process should be the mark of a negative result, their tacit knowledge was valuable for specific research.

Unfortunately, this kind of knowledge was hardly ever explored in the implementation of cleaner production assessment options. This is an illustration of the fact that potential learning processes are not encouraged. The reasons for this can be manifold: for instance, the institutionalised procedures and practices do not include it, or the labour and its related responsibility patterns are divided rigidly, and so on. But the experience in the first phase of cleaner production projects is that the lack of demand by management, institutionally captured in the web of pollution control (Cramer & Schot, 1991), was the main failure at the micro level of organisations.

5.2. The emergence and competition of new concepts at the public policy level

At the macro level, we can see that an environmental management system was an emerging concept for industrial organisations during a phase (in the 1980s) when the Ministry of Environment was developing new policy instruments and changing the organisation of their policy-making processes. As has been described in Section 3.2, the Dutch employers organisation VNO/NCW developed guidelines for *Milieuzorg in bedrijven* (Environmental management within companies, 1986). Together with a number of pilot projects (Commissie Bedrijfsinterne Milieuzorg-systemen, Milieuzorg in samenspel, 1988), it provided the basis for the policy paper on environmental management systems by the Dutch government (Notitie Bedrijfsinterne Milieuzorg, 1989). The environmental management system would have to be used in approximately 12 000 companies with a large environmental burden or risk; for approximately 250 000 companies a partial system would be applied. The systems would be implemented on a voluntary basis, in 1995 at the latest. This self-regulatory approach, combined with an environmental management system, became a part of the first National Environmental Policy Plan (1989).

In this changing situation, the concept of cleaner production was introduced at the end of the 1980s, when the discussion about environmental management systems had already been translated into industry and public policy. The publication of the PRISMA project (Dieleman *et al*., 1991) was the breakthrough of the acknowledgement of the concept. It was remarkable that the Dutch National Water Authority supported the integration of the concept of cleaner production into their activities and the internalisation of cleaner production in industry. There was no tuning with the Ministry of Environment. The National Water Authority had to instruct an external researcher to collect the most important environmental policy documents for their information (Maan, 1990).

In practice, the pioneers of the concepts of environmental management systems and cleaner production could well have the same ideological background, for the persons behind both concepts were concerned with the improvement of the environmental performance of industry.[84] However, the translation of that concern for environmental management systems was administrative, top-down, and instrumental; for instance the environmental auditing system (Molenkamp and Vogel, 1987, Bins-Hoefnagels and Molenkamp, 1988) is based on incremental steps that fit in the existing inspection views and management structure at the Ministry of Environment. The translation of cleaner production was interactive, bottom–up, and exploring new pathways; it was radical in asking another management perspective (Huisingh, 1986) and ideologically naive in the expectation that project results should speak for themselves during the dissemination process.

It can be observed that the top level of the Ministry of Environment functioned as a wedge between the concepts. Although in the second part of the 1980s public opinion about the necessity of a healthy environment was very positive, the Ministry of Environment's position in the government as a whole and in society was weak. Contrary to the Ministry of Water Management, the Dutch Ministry of Environment has no operational regulatory tasks or direct dialogue with single industrial companies. The ministry officials have contact with industry associations lobbying in policy-making processes, but the control of environmental laws and the formulation of environmental policies is performed at the provincial and municipal levels.

With respect to the internal dimensions of perception and power, the Ministry of Environment was not involved in the emergence and development of the cleaner production concept. Despite the invitation to Professor Huisingh to hold pollution prevention workshops and to advise the Ministry of Environment in August 1986, the two-person cleaner technology unit at the Ministry of Environment was not sensitive to the change management characteristics of the preventive concept. Their worldview – based on technological solutions such as clean technology – blocked the acknowledgement of cleaner production as a promising concept in that ministry.

Other departments of the Ministry of Environment stimulated the route of facilitating the development of environmental management systems. In the traditional sequence of

84 Project performance according to the two concepts could be contradictory: in a municipal public transport company the PRISMA project team had good assessment results in garages, and for the use and substitution of cleaning products in subway stations. However, the results were not implemented because the organisation was given instructions by the municipality to join the development of an environmental management system.

recognition, acknowledgement and definition of an environmental problem, the policy-making process, approval in the parliamentary decision-making process and implementation of new policies, Ministry of Environment officials met with much reluctance in industrial sectors with an above average environmental burden. As another input to break the inertia of this situation, both new policy approaches such as working with the policy-making life cycle model within the Ministry of Environment and dialogue with other ministries and societal target groups were started (Winsemius, 1993). This meant that in this organisational change phase in the Ministry of Environment in the period 1982 – 1986, a new target group network had to be developed. Also industry was in favour of this development in answer to public pressure (De Jong and Lambooy, 1990). Soil pollution was another driver (De Groene and Hafkamp, 1994), as soil sanitation meant high costs, especially in the personal situation of owner-entrepreneurs.

In this context, in which deregulation and self-regulation (Actieprogramma DROM, 1983) could also be placed, officials entered structural process of dialogue and their practical consequences for the first time. When in such a situation a target group is powerful and wishes to move in the same direction (self-regulation) as the Ministry of Environment, then that powerful position will be explored to one's own advantage. Ministry of Environment officials happened to be eager to develop the policy infrastructure and subsidy programmes for the formulation and dissemination of environmental management systems. For the dissemination of the cleaner production concept (which academics were promoting at the beginning), this situation meant competing with the mainstream development of environmental management on a voluntary basis. At the macro and meso levels of policy-making there was agreement about an infrastructure for environmental management systems. And, although the value level of the cleaner production concept was appreciated, the focus was on the other new concept – environmental management systems – that could more easily gain recognition.

This thesis does not compare the success of one concept against the other one. The power position of industry in relation to the governmental wish for change towards environmental self-regulation provides the basis for the conclusion that the content of environmental management systems is nearer to the existing worldview elaborated in traditional industrial, environmental problem solving approaches and requirements. The development and dissemination of environmental management systems were more successful because they were easier to implement as incremental steps within the institutionalised market framework of transition processes of new concepts (Figure 2.1).

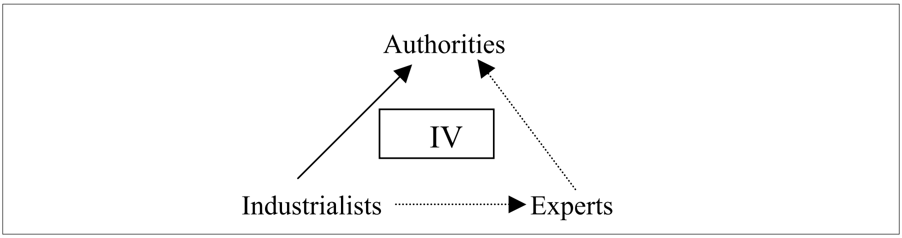
5.3. The adaptation of environmental management approaches and the terms used

Quality Management systems such as ISO 9000 worked as market incentives once they had been acknowledged. On the contrary, environmental regulatory measures were perceived as external requirements in the 1980s. Within this context, environmental aspects started to be seen as internal incentives too in the 1990s. Waste prevention techniques can also include good operating practices, which broadens the scope of possible measures: from technological only to production management. Besides waste minimisation techniques, which are ways to implement waste prevention, another very important element of the pollution prevention and waste minimization concept is attitudinal change: the focus shifts from pollution control (through technological measures) to pro-active pollution prevention (through an integrated approach to the entire production process). This implies a management structure that allows a continuing process of identifying waste prevention opportunities and developing and implementing waste prevention measures (Huisingh, 1989).

The dissemination of the good-housekeeping approach and new instruments such as Life Cycle Assessment (LCA), Design for Recycling (DfR), Design for the Environment (DfE), Total Cost/Benefit Accounting (TCBA), ISO 14001, Industrial Ecology and Sustainable Development became familiar terms within large industrial companies. The use of these instruments on a voluntary basis was characteristic of the phase when industry took the initiative of self-regulatory approaches.

Governments and experts supported this initiative, at least in giving space and time for self-regulatory developments. Cleaner production experts influenced governments to focus on the development of facilitating infrastructures.

Figure 5.3 **Phase IVPol (1995-2000): The Dutch government follows the self-regulation of industry**[85]



At the European level, larger countries such as Germany and France were not strongly involved in the clean(er) technology and clean production debate:

- Germany always had a strong technical pollution control approach and stressed the importance of stringent environmental regulations uniformly and strictly enforced (such as TA Luft, and the *Take back duty* of packaging);
- France was involved in the promotion of *Technologies Propres* (clean technologies) in the mid-1980s, especially in *Bassins de l'eau* (water catchment areas). Levies for water discharges were used to subsidise cleaner technology that could prevent water pollution (Drouet, 1987). This approach had very little application in the direction of cleaner production.[86]

In a later phase, preventive concepts with slightly different names were elaborated on. Those translations (Czarniawski & Sevon, 1996) and modifications (Oliver, 1991) conform to the micro level processes of concept innovation as presented in Figure 2.2. Analysing those translation and modification processes, the following categories can be distinguished:

[85] In Chapter 6, we shall see how the characteristics of the exploration of the industrial ecology concept are similar to this policy phase.

[86] A French publication of 1996 about the basic concepts of cleaner technologies illustrates this point well: it only has a few references to the 1980s (Roustan *et al*., 1996).

1) *Specialised translation*: the translation or modification is an in-depth preventive elaboration of the concept, for instance eco-design. This means an acknowledgement of the exploration of the concept in a professional discipline.
2) *Ideological translation*: the cleaner production concept is translated as co-operating, e.g. product stewardship, or as being circumscribed within the traditional structure of production, e.g. eco-efficiency.
3) *Confusing and subverting translation ("political use")*: the semantic discussion about the terms in the prevention approach is strongly illustrated by Hirschhorn's critical review (1997) of approximately 15 years of pollution prevention innovation in the U.S.A.. He concludes that the pollution prevention revolution failed, among other things, because of the strength of the pollution control stakeholders (in the 1990s, pollution control gave, even in the perception of regulators and environmentalists, more certainty than pollution prevention) and due to the confusion in semantics in creating new labels like clean technology and eco-efficiency. He concludes also that cleaner production and industrial ecology are weak variations of pollution prevention, that cleaner production has less pollution prevention integrity, and that industrial ecology has a high potential for subversion of pollution prevention (pollution prevention excludes off-site recycling that is a fundament of industrial ecology).

This division into categories of translation or modification of the cleaner production concepts is analysed in the following sections.

5.3.1. *Specialisation as part of an intellectual professionalisation process*

According to the life cycle of concepts' description by Karsten and Van Veen (1998) the original concept can be disseminated as a fruitful concept. It can also disappear, either as an unsuccessful concept, or become integrated into the appropriate terminology (such as culture in the description of an organisation). In the case of cleaner production, a few experts with various disciplinary backgrounds adopted the concept early on (Rogers, 1983). They perceived the value of the concept as an umbrella for further specialisation on the basis of their disciplines. If we draw on a market metaphor, we may say that these actors were developing their expertise as a new specialisation within the preventive route. Also, the demonstration projects were used to provide case study illustrations to bring about the transformation of existing industrial routines. Instruments such as eco-design and environmental accounting are examples of this type of development. The overview below explores specialisation in the fields of technology, material streams and accounting:

* **Ecological technology**: Vergragt (1992) defines ecological technology as: "..technology that provides production means and products in sustainable balance with the global ecosystem for the provision of material human needs..". Because ecological technology has not yet materialised (this technology should be the basis of a factor 20 reduction of resources and energy use), environmental management plays a dominant role in the first phase, followed by the further development of cleaner technology. Jansen and Vergragt (1993) assume that the essential radical changes that are required will take two generations according to their following construction:

1) Development and implementation of environmental management within industry (covers the first 5 years of the two generations);
2) Cleaner technology (covers the first 20 years of the time frame);

3) Ecological technology (25 years, more knowledge about this concept must be developed in the last part of the time frame) (Jansen, 1991, Moser, 1992, Vergragt, 1992, Jansen & Vergragt, 1993, Jansen, 1994).

In order to avoid developments that do not fit in the pathway to sustainability, they use a system of back-casting (taking a future sustainable system — such as chemistry, food, hydrogen energy – as illustration and as a basis to look back and consider current developments in relation to that future sustainable system). This back-casting method assumes the possibility of taking more radical steps in different time frames that cover approximately 40 years (Weaver *et al*., 2000).

In Sweden, the Ministry of Industry set up a *Delegation for* ***Sustainable Technology*** in 1996, whose responsibility is to stimulate the commercialisation, faster market introduction and increased sale of products which have fewer negative effects on the environment and offer opportunities for industrial development and job creation (Swedish Delegation for Sustainable Technology, 2000).

* **Product design**: as the design of a product has an important effect on the use of materials and on environmental pollution in the long term, this issue received increasing attention in the 1990s. It evolved from material substitution (Baas and Spoel, 1986) to the concept `from product to services' (Rocchi, 1996). Large corporations such as the Sound & Vision/Business Electronics division of Philips Corporation gained the experience that an eco-efficient product design methodology highlights the need to integrate environmental issues in the product design process as early as possible. This ensures that environmental issues become an integral part of corporate business strategy (Cramer, 1997).

In this pathway, **Dematerialisation** is also an important dimension in the design process in relation to the use of energy, physical materials and toxic compounds. Dupont-Roc (1995) approached the theme from an energy perspective: "..in dematerialisation, human needs are met through technologies and systems requiring a much lower energy input as productivity in use strongly improves..".

Geiser (2001) emphasised that the choice and use of materials defines the final environmental pressure: "..If we paid closer attention to the impacts of the materials that we produce, we could pay less attention to the impacts of those materials once they are released to the environment and people are exposed to them..". Geiser included strategies such as dematerialisation and detoxification in his mental map of sustainable applications of material streams.

* **Total Cost Accounting**: this tool was designed to assist managers with identifying and quantifying costs that are *normally* hidden in e.g. overhead costs and externalised costs (White, 1989). This tool can also focus upon liability aspects and cleaner production benefits. Including the latter, the concept can be broadened to Total Cost/Benefit Accounting, which shows that environment-induced activities can make a profit too. The total cost accounting concept evolved into **Environmental (management) accounting** (Rubinstein, 1994, Bartolomeo *et al*., 1999, Bennett *et al*., 2002). According to the Environmental Management Accounting Network (EMAN), the greening of industry is likely to require changes in the relationships between a company's accounting function and its environmental management.

* **Sustainable banking**: the greening of industry also generated the need for new routines concerning the provision of loans based on sustainable business plans. After the emergence and growth of specialised new banks in this sector (Louche, 2004), the traditional

banks also began to develop green programmes at the end of the 1990s (Jeucken & Bouma, 1999, Bouma, 2002).

5.3.2. *Practical or business-like translation process*

The introduction of a new concept, such as cleaner production, seems to follow a pattern with intrinsic dimensions for modifications by the receiving organisations. The pattern of fundamental demonstration projects can prove the value of the concept and at the same time dissipate its momentum because of the time-consuming process of performing such projects. The potency of the concept is fully recognised, but the need for quicker applications seems to be the motive behind different translations. The modification of the concept can be practical, and preserve its essence. The translation process can also simplify the concept in such a way that the original goals and objectives are lost. This can be a result of either an intended development or an unintended effect. The translation process is tied with the willingness and capability of managers to integrate the new concept. A company's translation ability can be limited because it can only cope with incremental improvements within the existing production framework, or it can only use management instruments that are linked to their encoded knowledge, or it avoids the uncertainty of what is perceived as unrealistic or impractical. The following concepts are classified for this type of translation processes:

* **Life Cycle Assessments**: These various concepts and tools were designed to assess the environmental burden of a product's whole life cycle. They helped to generate broad awareness of the potential of eco-product design (U.S. Congress, Office of Technology Assessment, 1992). This potential was further specified in a series of eco-design manuals (Keoleian and Menery, 1993, Brezet *et al*., 1994) and the concept was also placed at the core of industrial ecology (Udo de Haes, 2001).

* **Design for Recycling** and **Design for the Environment**: Because a Life Cycle Analysis is a time-consuming, complex process, less complete and less complex methods such as Life Cycle Screening or LCA Quick Scans were developed. These approaches can be used to identify opportunities for product improvements and in many cases can also detect issues that should be researched in greater depth. An illustration of such a simplified tool is the **Material, Energy and Toxics analysis** (MET). It is a simple input - output model which, when used in combination with a product life cycle, can provide a list of the environmental aspects of a product (Brezet, 1995). Another illustration of such a simplified tool is the **Material Input Per Service unit** (MIPS), designed to assess the use of resources per unit of service that is rendered. By calculating the material and energy flows for the produced goods, material intensity can be identified in relation to the *service function* of a product (Schmidt-Bleek, 1993, Liedtke, 1994).

* **Product stewardship**: within this concept, producers are responsible for the overall life cycle of a product, including the impacts of the extraction and production of the raw materials from which the products are made, the production and consumer use phase and the after consumer use management or take-back after use of the product (Kruszewska & Thorpe, Greenpeace, 1995). The old products can be taken back for revitalisation following a cascade recovery system (at first revitalise the original function, when not feasible, fulfil a lower function, finally re-use the separate materials). An example is the take-back of personal computers for re-use at the highest possible function (Roos, 1998) instead of depositing them in landfills. Another development is the concept of service and leasing of industrial products, such as the leasing of photocopying machines (Wilt, 1997).

* **Zero waste concept**: The *Approach of Zero Waste Systems* was already presented by Palmer at a symposium held in Winston-Salem, N.C., May 26-27, 1982, one of the first scientific conferences that highlighted the potential (and practice) of pollution prevention for being much better economically, ecologically and ethically than the usual practice of dilution or pollution control (Huisingh and Bailey, 1982, 84). Furthermore, the zero waste approach was involved in the design of a new refinery as a pilot project in India (Haverhoek, 1995) and a design for integrating work and living in a residential area (Pauli, 1995). Pauli (1998) defines the zero waste concept as the re-use of all components as value-added, so that no waste is discarded. The brewery in Tsumeb, Namibia produces beer out of sorghum without generating any waste; at the same time it serves as a protein factory for fish farming, is the basis of a new mushroom production unit and is a source of energy for the town (in compliance with the industrial ecology concept). However, the zero waste concept has been criticised on the basis of the second Law of Thermodynamics, which states that every action requires energy and at every step in the process one can never transform 100% of the energy into effective work.

Since the early 1990s a Zero Emissions Research Institute (ZERI) is being managed at the United Nations University in Japan. The food processing research division has organised many Internet conferences. Since 1998 they carry out joint activities with the Working Group on Food Processing of UNEP, Paris. Since 1997, the ZERI concept has been explored in several parts of the world (Pauli, 1998).

Finally, Florida (1996) found that whilst manufacturing companies can increase quality by pursuing zero defects and increase efficiency by optimising their inventory with *just in time* concepts, they can progress even further by establishing the goal of zero emissions to maximise resource productivity. Thereby they can make significant progress towards a *three zeros economy*.

* **Lean production**: According to Smith (1994), *lean production* is a restructuring process to increase profits on the long term (he uses only a business economics perspective). Romm (1994) integrates the "Lean and Clean" management concept from an environmental perspective, saying that better economic and environmental performance can be reached by the organisation that uses integrative and preventive approaches to minimise risks and wastes of energy, materials and reputation.

* **Eco-efficiency**: The Business Council for Sustainable Development (BCSD) coined the concept of eco-efficiency in its landmark report, *Changing Course*, in 1992. According to the BCSD, the concept of eco-efficiency, when applied to the production, delivery and use of competitively priced goods and services, coupled with the achievement of environmental and social goals, can result in substantial improvements that are of environmental and economic value for society and the companies that practice these concepts and approaches (World Business Council for Sustainable Development, WBCSD, 1995). In 1998, the World Business Council for Sustainable Development was a coalition of 122 multinational corporations united by a shared commitment to the environment and to the principles of economic growth and sustainable development. The members were drawn from 34 countries and more than 20 industrial sectors. The WBCSD is also connected to a thriving global network of national and regional business councils and business organisations. In the WBCSD's 1996 annual report the definition of eco-efficiency presented was: "..the production of ever-more useful goods and services- in other words the adding of value while continuously reducing the consumption of resources and the creation of pollution.." (WBCSD, 1997).

In a report of the WBCSD - Gulf of Mexico Charter (1997) the term ‘By-product Synergy’ was introduced. The report mentions six fundamental principles of By-product Synergy: Co-operation, Motivation, Communication, Innovation, Participation and Evaluation (p. 3). The method proposed to achieve these principles is a modified Cleaner Production assessment (p. 20). Furthermore, Hecht[87] is quoted as having said: "..The Concept of Green Twinning is to promote joint commercial development of one economic sector. In practice, this means the waste product of one industry can be used by a second industry.." (p. i). The reason for limiting the scope to one economic sector is not clear. Why could the company that produces waste not use the waste as a by-product itself, if another company in the same industrial sector is able do that?

McDonough and Braungart (1998, 82) criticise eco-efficiency as “..doing more with less: it is an admirable concept, but it works in the industrial system that caused the problem in the first place, slowing it down with moral prescriptions and primitive demands, but it does not stop the processes. Relying on eco-efficiency does not reach deep enough, it presents little more than an illusion of change..”.

5.3.3. *Political use of a new concept*

A new concept can be used for picturing new challenges in such a way that it attracts the attention of the public and governmental funding organisations. A new concept can change a situation and provide new markets. It can also be symbolically used and constitute sheer rhetoric, only aimed at giving a signal, or be designed in such a way that targets cannot be realised and implemented in the same way as they were announced (Hansjürgens, 2000). Matten (2003) refers to the Responsible Care Programme, ISO 14000 and EMAS as Symbolic Politics with a high symbolic content, although these are common tools of corporate environmental politics, because they indicate to the general public that the company has put certain precautions in place.

Along another line, when industry takes new environmental initiatives, governments often give industrial organisations the benefit of the doubt because they perceive industry *self-regulation* as more effective than the traditional regulatory, command and control approaches. Governments can support their preferred approaches through a variety of instruments – such as subsidy programmes designed to promote environmental systems and industrial eco-parks in the Netherlands. However, this approach, since it is usually implemented within a policy regime in the context of regression to the mean, often fosters incremental steps without changing the fundamental attitudes, principles, policies or routines of the companies.[88]

The results of the Dutch STER project (Baas, 1989) provide an illustration of this. The research model identified and worked with the different levels of management that had to be influenced by cleaner production. The model included variables at the macro level such as environmental policies, regulations, consumer preferences and the development and implementation of new technologies. Within a company, the model covered the existing orientation on, and knowledge about, the physical environment. Information about pollution prevention was designed and provided so that the company would become knowledgeable in

[87] Alan D. Hecht in US EPA, ‘Initiative on Commercial Diplomacy and Sustainable Development: Green Twinning Concept Paper’, 3rd draft, March 1995.

[88] Similarly to parametric change, which involves altering certain dimensions of products within stable frameworks to meet changing consumer demands (fashion); it does not involve learning new organisational competence (Langlois and Robertson, 1995, 136).

such a way that commitment to a pilot cleaner production project would result. However, the pollution prevention concept involved several uncertainties and deviations from the normal production practices. As a consequence of the limitations of this approach, during the launch of the first National Environmental Public Policy plan (1989), additional new concepts such as environmental management systems and regional company environmental service organisations[89] were introduced (and later subsidised) as new paths towards self-regulation and environmental performance improvement.

The proposed environmental management systems and environmental service institutions fit more effectively into a corporation's traditional approach: the environmental management system started with a top-down approach dominated by an administrative procedure and the company environmental service organisations were mainly focused on permitting and legal issues related to meeting environmental requirements. In order to address technical problems concerning pollution control solutions, a traditional environmental technical expert could be called into the company. In this situation the company manager retained power and influence (an illustration of the competing power of concepts is to be found in the PRISMA project: the results of the cleaner production assessments in one organisation were overruled by a management decision to start an environmental management system in their organisation: see footnote in Section 5.5).

Besides these governmental uses of new concepts, several companies started to internalise environmental management aspects via the development of environmental management systems, the benchmarking principles for comparing and/or improving their environmental performances (U.S. Business Roundtable, 1993, UNEP, 1994, Irwin *et al.*, 1995), annual environmental reports (beginning in the mid-1990s, e.g. DOW, 1995, 1996, Novo Nordisk, 1995), environmental performance indicators (see annex V.2 as an illustration of first explorations), and annual sustainability reports (Shell, 2003, Novo Nordisk, 2004).

The making and distribution of annual environmental reports was further stimulated under the Global Environment Initiative in 2001. According to Boons and Strannegard (2000), it is an activity of organisations to show to their surroundings in a transparent and accepted manner their care for environmental and social problems. However, the public demand for this, and trust in organisations, is low (Klok, 2002), as illustrated by the fact that the total accumulated leakages of 17800 tonnes of oil by Shell (more than the oil spill from the Erika shipwreck near the coast of Brittany in 2000) was reported in their annual report (Shell, 2002), but hardly noticed by the general public.

The next step in the evolution of corporate social responsibility is thinking about how sustainability can be measured. The social responsibility dimensions are especially difficult to quantify and integrate into the business plans of organisations. The CEFIC organisation started with indicators such as the annual number of fatal accidents and worker absenteeism per one million labour hours with respect to labour-related factors (see Annex V.3). This is a very narrow approach related to production factors. The term sustainability itself is broader and can stand for various aspects of it, such as its philosophy or its operationalisation. Traditional environmental indicators are not enough. Hart (1996) composed the following overview:

[89] In Dutch, Bedrijfs Milieu Dienst (BMD): BMDs were founded by branch organisations, often assisted by Chambers of Commerce, to assist small and medium-sized companies in dealing with environmental problems (mostly permits).

Table 5.3 Environmental versus Sustainability indicators

Environmental indicators	Sustainability indicators	Emphasis on sustainability indicators
Ambient levels of pollution in air and water, generally measured in parts per million of specific pollutants	Bio-diversity; Number of individuals of key species, such as salmon in a stream or birds in an area	Ability of the ecosystem to process and assimilate pollutants
Tons of solid waste produced	Amount of material recycled per person as a ratio of total solid waste generated	Cyclical use of resources
Per capita energy use	Total amount of energy used; Ratio of renewable energy used to non-renewable energy	Use of renewable energy; conservation

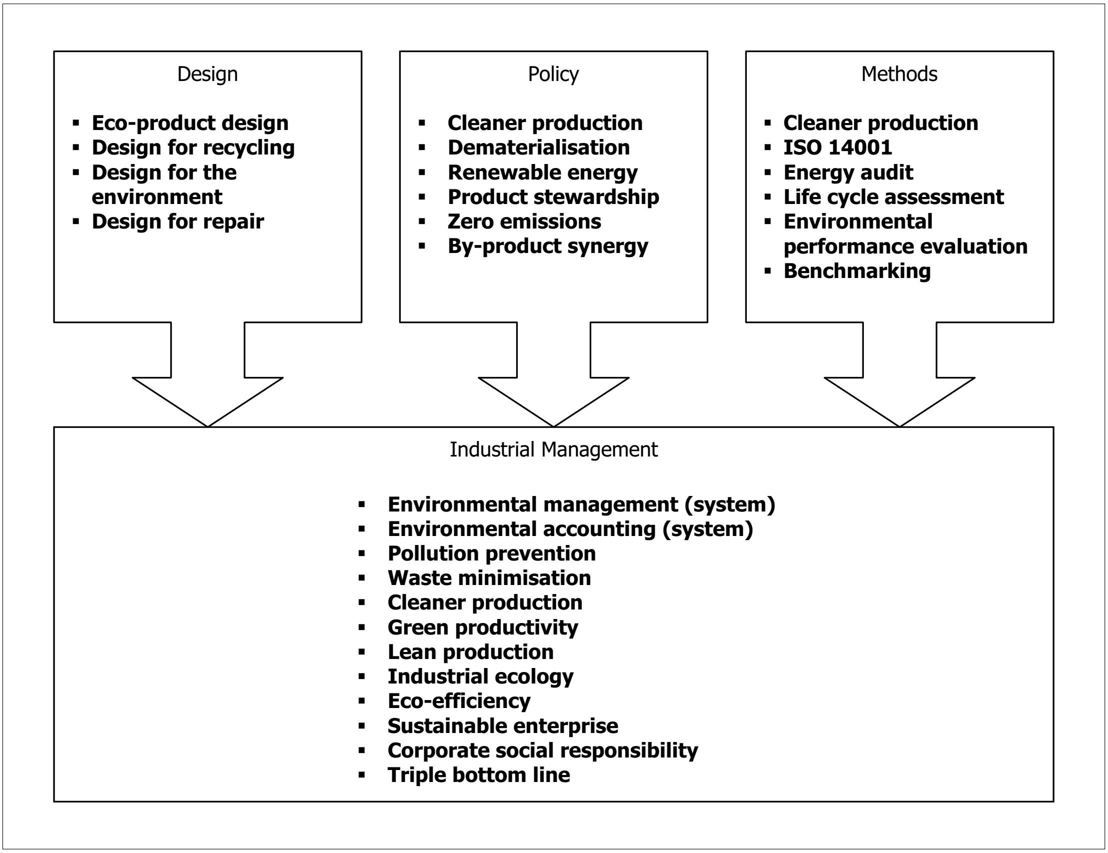
We have learned that physical data are the easiest to collect, as can be analysed of the construction of a five-level sustainable production indicator framework (Veleva *et al*., 2001) and a four-step procedure for the combination of physical environmental indicators, environmental performance measurement (e.g. sustainability) and management performance indicators (Olsthoorn *et al*., 2001). Furthermore, Olsthoorn (*ibid*) states that in an overview of environmental indicators and standardisation methods different users and functions of indicators inside and outside the firm must be distinguished.

It is obvious that sustainability indicators are more easily devised with physical process stream data than in biodiversity indicators and substitute processes such as the use of renewable energy. The power position of non-renewable energy suppliers (Lukes, 1974, Lindblom, 1977), business economics and a lack of urgency (Mandler, 1984) to change the political opportunity structure (Kitschelt, 1986) are all dimensions that greatly influence the routines. The status quo can hardly been changed which means that sustainability is mainly detected at the weak side of a sustainability classification (Selman, 2000).

5.4. **Taxonomy of eco-induced tools and instruments**

Over decades of environmental policies and research, many instruments and procedures have been developed. As analysed in Section 5.6, these have been developed either as specialisation within a professionalisation process, or as practical instruments or for political use to influence certain developments. Instruments and procedures in this sphere are environmental protection-induced approaches that often focus on one dimension. Sustainability dimensions are often viewed separately. A range of variations in industrial management, design, methods and preventive public policies were developed in order to promote a more preventive approach to help ensure sustainability, but real social changes were still marginal at the end of the 1990s.

Figure 5.4 **An array of eco-protection-induced concepts, policies and methods that have been developed and are being utilised to varying degrees in some countries**



In Figure 5.4, an overview of the different terms related to cleaner production is presented. It shows a variety of approaches, ranging from philosophy to practical tools. The differences in the translation process of these approaches by organisations is analysed both as a threat to the concept (Hirschhorn, 1997) and as a sign of the maturing of the concept. The philosophy, methods and policies of the concept are structured at the macro, micro and meso levels in the next sections.

5.4.1. *The macro level of the formulation of cleaner production*

The cleaner production concepts were formulated on the basis of two principles:

1. The *Precautionary Principle*: the principle ranges from zero discharge of persistent bio-accumulative toxic compounds to the general

approach of using precaution in the introduction and use of new products and activities.[90]

2. The *Prevention Principle*: all activities are focused on the prevention of environmental pollution and reduction in the use of energy and materials.[91]

Both principles imply the use of innovation, design for the environment and renewable energy as integrated, preventive and proactive approaches. The principles provide a frame of reference for a design to help ensure that organisations integrate preventive concepts and approaches in their policies, strategies, and product and service innovations in their investments. Such approaches may also include emphasis upon energy efficiency and the use of renewable energy because use of fossil fuels causes depletion of resources and contributes to the `greenhouse effect'.

These two principles are dominant in the cleaner production concept. They cover the philosophy of the concept, according to which existing pollution is a symptom of inefficiency in the current processes and should be eliminated or reduced as much as possible, and the generation of pollutants in new activities should be prevented. The basis is prevention at the source in a `zero discharge and toxic use reduction' framework. The concept is based on an environment-included approach and is designed to integrate its principles into processes of innovation, design and change, including usage of renewable energy. The principles do not solve discussions about what is in and what is out of the principle. In the `Cleaner production manual' (de Hoo *et al*., 1990) experts did not include recycling outside a company within their definition of cleaner production. However, other experts accepted the `re-use of materials principle' as part of the `prevention' and `design for the environment' principle. Also for those working with `industrial ecology', off-site re-use by another firm or firms is a central foundation of the concept.

Although these principles are (at a macro level) related to changes in mindset or worldview, no principles are formulated in terms of social responsibility, such as for instance an `Environmental change principle' (organisations change their philosophy and structure and educate their employees about the cleaner production concept). Principles within organisations concerning issues such as the integration of health and safety, improving labour conditions and education in a `sustainable organisational change' framework may temporarily receive some attention, but are not continuously addressed in an integrative way. The `sustainable lifestyle' principle is perceived by industry as a change process at the societal level, although certain dimensions of `going beyond single enterprises' affect the region and the whole world. The sustainability concept and the triple bottom line approach are designed to integrate principles such as: the `reduction of consumption of materials and energy' principle, the `trans-generation equity' principle, the `trans-regional equity' principle (open

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90 In order to eliminate the risks inherent in the `assimilative capacity' and the `critical load' approaches, the `precautionary principle' approach was preferred by several scientists. The precautionary principle[90] proceeded from the view that exceeding the assimilative capacity of nature by polluting compounds can only be recognised and judged after a certain period of environmental degradation. In their meeting in 1987, the North Sea ministers meant under the precautionary principle `to reduce polluting emissions of substances that are persistent, toxic, and liable to bio-accumulate, at source. Especially when there is reason to assume that certain damage or harmful effects on the living resources of the sea are likely to be caused by such substances, even where there is no scientific evidence to prove a causal link between emissions and effects.'

91 See section 3.4 for the definitions of the concept of pollution prevention.

systems), and the `trans-species equity' principle'. These principles already have had and still need a long-time dissemination process as the actuality of the WCED report (1987) shows. They have tremendous implications for the redesign of our societies and of our production and consumption systems, and for the changed roles of government and the education system in helping society to make these types of conceptual and procedural changes.

5.4.2. *The micro level of the formulation of cleaner production*

As new concepts are mostly tested under small-scale conditions, first the shift from the macro to the micro level is made. The formulation of the cleaner production concept at the micro level is focused on the methods used, such as production process assessment and input-output analyses. The methods are not new as such, but have a specific focus and application. It is also a part of another perspective on analysing industrial activities.

Table 5.4 Overview of methods applied in cleaner production projects

Methods	Description
Assessments and audits, such as for cleaner production, energy efficiency, worker's health and safety, risk reduction	Input and output data of the production process
Life-Cycle Analysis (LCA)	The `cradle to grave' environmental analysis of a product or service
Product Quality Assurance (PQA)	The standardised and certified method of product quality assurance during all phases of production
Benchmarking	Both best practice in production and product content, and the use of chemicals (USA Business Roundtable, 1993, Irwin *et al*., 1995) are analysed
Environmental management system utilisation	The integration of cleaner production within the development of environmental management systems
Environmental Performance Evaluation (EPE)	The development of environmental performance indicators (EPI) gives insight into the company's behaviour

5.4.3. *The macro and meso levels of cleaner production policies*

Another amplification of the cleaner production concept is the relationship with policies. Policies designed to foster cleaner production can originate from concept development experts, industry or government. A whole array of policies can be influenced by, and applied to, cleaner production dissemination. These policies can be based on awareness raising, knowledge transfer, stimulation or voluntary application; the government can also `force' the dissemination through the development of eco-induced financial instruments. A shift from labour-related taxes towards eco-taxes can foster such an approach. In general, policies need not be specifically designed for cleaner production dissemination; rather, they can create the conditions that will influence the concept's development, such as corporate environmental policy on the basis of cleaner production.

Table 5.5 Overview of policies that can influence the dissemination processes of cleaner production projects

Policy	Description
Materials Policy	Materials policy can focus on the closure of material loops, materials use reduction, the reduction of (persistent) synthetics and of hazard potential in general, and environmentally sound substitutes
Polluter Pays Principle Policy	Awareness of environmental costs and benefits can be raised by Total Cost/Benefit Accounting
Energy Policy	Renewable energy, Thermodynamic efficiency
Integrated Product and Consumption Policy	Environmental public policy including eco-design of products and consumer information
Environment Included Industrial Policy	Cleaner production as qualitative approach can modify the current governmental industrial policy, predominantly based on quantitative growth and the often reactive environmental policy of industries
Integral Industrial Chain Management and Industrial Ecology Policy	Another level of environmental performance is introduced through going beyond the boundaries of single plants, either towards a product chain or a region
Product Stewardship; Extended Producer Responsibility	Life time responsibility by the producer for their products

Furthermore, communication instruments such as `environmental reporting' can be fostered as a contribution to more transparency in industry performance (GRI, 2002). Also approaches such as `stakeholder dialogue' stimulate the communication and reflection on multi-actor approaches to sustainability.

5.4.4. *An overview of environmental concepts, methods, policy and tools at all levels*

Finally, the description of the various relationships with cleaner production is integrated and presented in Table 5.5. This constitutes a modification of the classification by Magerholm-Fet (1998): the concepts, methods and policies have been classified at organisational levels **at which** preventive approaches are implemented. The overview does not imply that all issues are being connected and integrated into a holistic approach. Specialisation (5.6.1), practical (5.6.2) or political (5.6.3) use can select and develop a one-dimensional approach. This is often the case with Multilateral Environmental Agreements (MEA), such as the Montreal Protocol, the Kyoto Agreement and the Basel Convention. Those agreements are implemented at the global level by special secretariats. When the agreement has an interface with pollution prevention, National Cleaner Production Centres explore the links with the secretariats, because those MEA secretariats have funds, but have no networks for dissemination. However, because the stake of the international agreement is specific, the realisation of the link is dependent on the recognition of the NCPC by their national government to be involved in such dissemination processes on the basis of cleaner production (7th UNIDO/ UNEP NCPC evaluation meeting, 2003).

Table 5.6 Classification of unit level and environmental concept, method, policy and tool

Level		Concept, method, policy, tool
Macro (society)	Global	Multilateral Environmental Agreements, Cleaner Production Declaration, Clean Development Mechanism
	National	Environmental Public Policy Framework, Green Plan, Environmental covenant
	Regional	Industrial ecology, Environmental covenant
Meso	Industry	Cleaner production, Industrial ecology, Eco-efficiency, Triple Bottom Line, Stakeholder dialogue
	Company	Cleaner production, EMAS, ISO 14000, Total Cost Benefit Accounting, Stakeholder dialogue, Sustainable Enterprise, Corporate Social Responsibility
Micro/meso	Product	Life Cycle Assessment, Material Input Per Service, Design for the Environment, Design for Recycling, Eco-Product Design, Eco-labelling
	Product services	Leasing, Temporary use of products, Co-operative use of services
Micro	Process	Cleaner production, Lean production

5.5. Preliminary conclusions about the dissemination of the cleaner production concept

This section will draw conclusions about the phases of fact-finding, the start of structured cleaner production assessment research and the growth phase of cleaner production dissemination. Several questions serve as headings of the sub-sections. The concepts, results and images of the cleaner production projects are tested against the analytic frameworks of organisational theory.

5.5.1. *How perspectives derived from company size influence expert opinions?*

The differences between large and small / medium-sized companies are well known in general, although the percentage of small / medium-sized companies (between 95 and 99% of total industrial organisations) always provides a surprise all over the world (statements such as "..in our country 97% of the companies are small, medium or micro-sized.." are often presented as if this was unique to that country). One's perspective on industry is an important basis for one's knowledge and opinions: when one knows well only one type scale of industry, the context for recommendations must also be provided. The dialogue in Box 5.1 illustrates the difference in perspective between two experts on the subject.

Box 5.1 *Illustration of different perceptions of the target group*

A brief dialogue at UNEP's 6th High-Level Expert Seminar on Cleaner Production, in Montreal, 16 October 2000:

In a keynote presentation Dr Amory Lovins (Director of the Rocky Mountains Institute) referred to the issue that four CEOs of big oil companies are already saying that oil will be replaced by hydrogen long before the exhaustion of fossil fuels (`the stone age did not end by the lack of stones'). Cleaner production is one of the frameworks for this substitution process.

Dr Zygfryd Nowak (Programme co-ordinator at the Polish Cleaner Production Centre) asked how cleaner production could be more rapidly disseminated and implemented?

Dr Amory Lovins stressed the role of demonstration projects: "..other companies cannot permit not mimicking them..".

Dr Zygfryd Nowak concluded: "..that is business as usual. We know for more than ten years that demonstration projects do not work..".

We can conclude from this exchange that one expert focused on multinational corporations and their views on future radical developments, while the other expert focused on small / medium-sized companies that scarcely or only incrementally change.

5.5.2. *What were the types of efforts to bring about cleaner production changes?*

The technical background of the pollution prevention concept steered the exploration of the preventive approach towards engineering `trial and error' attempts in individual pilot studies. Implicitly, it was assumed that the `one hit' interventions would generate incremental steps of growing awareness and involvement that would evolve into the incorporation of continuous improvement activities. But interventions aiming at changing routines within organisations are instruments in a social change process. The general characteristics of an intervention process are based on valid information on the organisation's functioning, provide organisational members with choices and gain members' internal commitment to these choices (Cummings and Worley, 1993). The preventive approach, on the contrary, had a limited learning focus on the procedure and interpretation of the assessment. And, as this type of project was mostly coupled with the company representatives who are knowledgeable on environmental problems, only a selected category of employees was involved.

Along the same line, most cleaner production projects developed from a bilateral concept supplier – receiver relationship. The engineering approach of `bringing knowledge and solving problems' was dominant. The cleaner production translation process covered the reshaping of an outside idea (the concepts and routines that fit into existing practices). The outside expert led the cleaner production assessment directly or indirectly as counselling supervisor. Although this approach is similar to the findings of Landry *et al*. (1998) that the most important determinants of knowledge utilisation are the mechanisms linking the researchers to the users for matching the users' context for the dissemination efforts and the adaptation of research outputs undertaken by the researchers, in cleaner production dissemination an organisational change approach was seldom used.

At the start and during the cleaner production assessments in single companies, results for the company management were uncertain; after the intervention the results of the assessment were discussed and, when it was not too difficult within the existing routines, some or all of them were implemented. Company management decided on the nature and extent of further developments, but from the perspective of organisational change (Czarniawski & Joerges, 1996), no planned innovation or (organisational) environmental adaptation was developed.

5.5.3. *The management of the same cleaner production projects by three different stakeholders*

Among the many different cleaner production projects, PRECARI is an unique project in the sense that three organisations in the market metaphor model - government, industry, and cleaner production experts – participated in it.[92] The positions of the different partners before the start of the project were as follows: the project initiators of the Dutch Institute for Inland Water Management and Waste Water Treatment (RIZA[93]) were in favour of, and developed, an engineering approach, based on a strict assessment and a focus on water emission reductions. The intermediary cleaner production experts[94] emphasised the importance of organisational processes in the success or lack of success of the planning and implementation of cleaner production assessments. They emphasised the risks of blindly following steps in a process without addressing the centrally important issues related to social change processes. Although the companies joined on a voluntary basis, they were generally sceptical of the probability of success of the project. The organisational characteristics and related translation strategies of the PRECARI companies[95] steered the position of the intervening parties towards elaborating the concept in the following way (see Table 5.7).

In order to understand the results, one has to know that the chemical company and the tapestry company started the project without any cleaner production knowledge. The chemical company made very few changes; whilst the tapestry company, under the pressure of the Dutch High Court to take environmental measures, developed a new cleaner production approach. The pharmaceutical company had its own interpretation of a cleaner production assessment and was more eager to engage in changing ways of thinking in the company.

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92 See chapter 4.

93 The specialised research centre of the Dutch Ministry of Transport, Public Works and Water Management.

94 Erasmus University Rotterdam: Erasmus Centre of Environmental Studies, re-named the Erasmus centre on Sustainability and Management (ESM) in 2003.

95 Chemical company, Akzo Fibers b.v.: makes compounds for car tyres (Boons & Neumann, 1994); Pharmaceutical company, DSM Andeno: makes basis compounds for pharmaceutics (Boons, 1994); Tapestry, Ossfloor: makes carpets.

Table 5.7 The PRECARI project research findings and analysis

Case	Organisational Characteristics	Strategies	Results	Position of intervening parties
Chemical company	* Declining market * Bureaucratic * Evolved process	*Compromise * Influence	* Elements of the prevention concept were adopted	* ESM-RIZA: joint learning experience
Pharma-ceutical company	* Competitive market * R&D driven * Professional	* All except acquiesce	* Prevention already in place * Discussion about mindset	* RIZA disinterested after changing project goals
Tapestry	* Booming market * Grown beyond structure * Traditional	* Acquiesce	* Adoption of structured preventative approach	* RIZA focus on technical problem * ESM focus on organisational change

The first conclusion concerned the approaches adopted by all companies, which confirmed the basic idea of the translation approach: in the intervention process, organisational members transform an outside idea into concepts and routines that fit into existing company practices. What was expected, but could not be found, was a clear-cut link between strategies and the extent to which changes were internalised. The assumption that a conformist strategy should lead to a *de-coupled* approach of the prevention concept was not confirmed. Nevertheless the tapestry company showed that it was possible to move from a confrontational, legalistic approach to a consultative, constructive approach to environmental management. The case of the pharmaceutical company was more complicated; the basic attitude of the pharmaceutical company management was the conviction that they had `a best practice' performance.[96] It was concluded that a cleaner production assessment would not be adequate and, instead, on the basis of interviews with representatives of different departments, a discussion about the integration of cleaner production in all activities was organised. As there were opposite views, the researchers doubted whether their more active and open strategy would lead to changes entailing the internalisation of the cleaner production concept in the company's activities (Baas & Boons, 2000).

These observations did not show a simple relationship between several types of strategy in reaction to institutional pressures and the extent to which concepts were internalised. Apparently other factors came into play as well. Further exploration of this issue is necessary in order to sharpen the definition of the concept of translation, especially in relation to the type of knowledge application and learning in the organisation.

Under the 'results' column of Table 5.6 can information be found pertaining to the extent to which the prevention concept was adopted in each company. The chemical company adopted certain elements of this concept (the brainstorming, the assessment). Is this a 'translation' or is it the 'non-translated adoption' of parts of the concept? And at what point

[96] The dimensions of the design sheet for new and modified processes was provided as proof – see Annex V.5.

in time should the level of translation be assessed? After a few years, concepts will have been redefined, moulded, further internalised, or discarded.

A second conclusion was that the governmental agencies involved in the intervention strategy complicated the translation process considerably: in addition to the firm, the agencies sought to shape the idea of pollution prevention into concepts and routines that fitted their own existing practices. The role of RIZA as a third party was ambiguous although there certainly were positive effects. RIZA's involvement guaranteed access to companies that otherwise would not have been open to contact for the purpose of cleaner production research. Also, RIZA provided knowledge about processes and solutions to technical problems that they had found in other companies, thus acting as a knowledge broker.

A significant negative effect was that the project and all the activities that were performed were always seen in the light of the more traditional relationship between the company and the government agency (Boons 1993). Moreover, it seemed that RIZA was more interested in the 'technical' output of the projects than in organisational changes. The latter were of greatest interest to the ESM team and the companies themselves. The coalitions of two intervening parties in the three cases differed along these lines.

A third conclusion to be drawn from the cases was that the experience an organisation had with a certain set of concepts was important in determining the intervention approach. When the concept was new (for example in the tapestry firm and the chemical company), the assessment could raise awareness via results and a brainstorming session. After that, the situation and policy of the company influenced further developments. When, on the other hand, the concept was already familiar (as was the situation with the pharmaceutical company), the intervention would have to focus on strategic decision-making processes and the intrinsic premiss on central tenets of environmental issues. The feedback of research results invited discussion about these tenets on how to integrate the concept into the decision-making processes.

The overall conclusion of the PRECARI project was that the differences in the translation process did not seem to be determined by the technologies employed by an organisation; the organisational culture seemed to be more important.

5.5.4. *What were the trends in cleaner production dissemination at the meso and macro levels?*

The conclusion about the results of the early research on cleaner production was that a great variety of strategies and tactics concerning participation in cleaner production projects emerged during decision-making processes. In projects where the decision to participate was taken (for most companies this was on a neutral, and for some on a positive basis) we conclude now that most projects ended in *back to normal*. The cleaner production projects influenced good-housekeeping measures, but the translation of concepts at other levels of the organisation – such as policy, strategy and product development – seldom occurred.

In the emergence and growth phase of cleaner production dissemination, the *back to normal* situation affected the internalisation of the new concept. Neither the spread of the concept nor the attention given to organisational change developed properly; this was either due to a lack of recognition of its importance by the disseminators, or was due to the fact that the organisation would not accept such levels of integration. In addition to the array of corporate strategies and tactics that were used in decision-making processes concerning the participation in cleaner production projects at the general management level, it is clear that there were different levels of eco-knowledge and types of attitudes. These can be grouped as follows:

- *Eco-illiteracy:* not knowledgeable about environmental pollution;
- *Eco-unwillingness:* denial of relevance of environmental management or a situation of cognitive dissonance (`we already do enough for the environment');
- *Eco-willingness:* willing to learn how to integrate (more) environmental knowledge in their company, even when they do not know where to get such knowledge, or are unable to properly monitor their current pollution.

Towards the end of the growth phase and during the transition to the mature phase of cleaner production dissemination, new environmental labels (such as eco-efficiency) complicated an integrated cleaner production development. Promoters of the integrated cleaner production approach were faced with the powerful position of big industry and trade associations, which mainly promoted incremental steps such as the development of environmental management systems in an institutionalised pollution control framework. Industry-wide organisations preferred the top-down approach of environmental management systems over the adoption of new cleaner production concepts and approaches. The lobbying of powerful stakeholders and the political balance between economic and environmental interests led to the mainstream adoption of environmental management systems by the Dutch government as their most favoured approach (see Section 5.2).

When top-down oriented managers do not accept new concepts and approaches that may require the empowerment of employees at all levels of the organisation, different approaches may be required to seek to influence corporate decision-makers. Along this line, one can think of collective acts by individuals (or communities, or a small group of university researchers in the case of cleaner production) independently from government action, working to encourage bottom-up awareness-raising.

It is increasingly clear that corporate decisions are seldom made for financial reasons alone, but that various internal and external norms and values always play a crucial role too. When an individual also involves ecological arguments in a cost-benefit analysis, the outcome of the weighing of considerations can change. Various illustrations of such change can be recognised in industry. Environmental management, environmental performance indicators, pressure by external actors such as consumers, and corporate image considerations are all persuading corporate leaders to adopt diverse ecologically oriented factors in their decision-making processes. The experiences with preventive approaches of an increasing number of companies in all industrial sectors around the world are helping to open the leadership of their companies to the idea of looking seriously at the preventive concepts and approaches.

In principle, a social dilemma is a decision-making problem. The structure of decision-making processes involving different stakeholders (Williams *et al*., 1997: centralised or decentralised, hierarchical or in consultation) influences the optimisation of the decisions of all members of the community. A decision made in consultation with, and accepted by, representatives of different levels and departments stands a better chance of integration than hierarchical decisions that neglect them. Within this decision-making context, it is also relevant to be aware of spatial and time dilemmas in relation to evolving sustainability pressures.

5.5.5. *Was the international cleaner production dissemination market different?*

If we look at the international `dissemination market', we can see that environmental technology approaches are continuing to flourish in various parts of the world. For instance, a European Union environmental technology stimulation programme for Asia, launched in 1992, was still in operation in 2001. It is amazing to realise that during this whole period the approach has remained the same. The question "Why is the implementation of cleaner production so difficult?" is not answered by cleaner production disseminators in terms of institutional, structural or cultural aspects (Dieleman, 1999), but in terms of semantics such as: "The terminology should be changed to simple commonly accepted terms (such as *efficiency, profit, loss*) and the strategy should be shifted to the reliance on facilitation processes and business tasks already known and trusted by local business communities, especially small and medium-sized enterprises". Other opinions along this line include: "You must use the language of entrepreneurs, speak about business improvement and not about the environment"; "When a company manager asks for financial assistance for environmental reasons, the banks will be reluctant"; "We must find another name for cleaner production" (Bergeron, 2001).

This narrow interpretation of cleaner technology approaches, however, does not foster a learning process towards sustainability. It does not include the emerging value issues, especially for multinational corporations, and the words *efficiency, profit* and *loss* only involve economic issues. If semantics are used to hide certain situations, the substituted words can have the same effect or even worse if they are perceived as camouflage (e.g., when the bank asks for the reason for the investment).

With respect to semantics, Hirschhorn *et al*. (1993) referred to the fact, that `..A multitude of terms and phrases define and describe the emerging preventive environmental paradigm..'. As has been described for the European Union environmental technology stimulation programme for Asia, it has also frequently been observed in other regions that much time is spent on clarification of the terms (7th UNIDO/UNEP NCPC evaluation meeting, 2003). Regional differences, both in the use of terms as such as well as new terminology for *environment included* approaches, lead to a wide variety of terms and concepts. One of the causes of the development and use of new terms is that the old term is not accepted well enough in different groups of experts and policy-makers. According to them the term does not give the optimal meaning or is perceived as not optimal or `polluted'. Also the Industry & Environment department of UNEP observed that in the opinion of some industrialists and governments, cleaner production is not an attractive term: `..There is a perception that cleaner production is driven more by donors and suppliers, rather than in response to demand from business..' (UNEP IE Cleaner Production Newsletter, 1997, p. 1). Along this line, terms relating to environmental technology have developed in many European countries, and at UNEP and UNIDO, in the direction of the term *cleaner production*. But in the U.S.A. the origin of cleaner production is still called *pollution prevention*; in the United Kingdom, cleaner production is seen as part of *clean technology*. At the same time, continuous clarification of terms that carry (nearly) identical meanings takes much time and energy.

Because the UNEP focus on the Pacific region was strengthened in 1997, a discussion about the term Clean Productivity Centres instead of Cleaner Production Centres started (UNEP/UNIDO annual NCPC evaluation meeting, 1997). Many countries in Asia have

Productivity councils as stimulators of industrial activity and waste management/cleaner technologies (Focus, 1994), so the term Clean Productivity Centre may play an important role in the future. UNEP wanted to avoid cleaner production remaining just a good idea rather than becoming a practical strategy for achieving sustainable production and consumption. One of the mechanisms was an international declaration, facilitating the move into a new era for cleaner production. UNEP and OECD joined forces for a cleaner production declaration, and launched the declaration in the Republic of Korea on 29 September 1998 (Cleaner Production Newsletter, 1999).

These illustrations are characteristic of the discussions that, from time to time, take place about the best labels for prevention concepts. However, Balkau (2000) constructed a future agenda for cleaner production implementation on the basis that it had passed beyond the early development stages. A major task now, according to him, is to mainstream cleaner production deeply into business and government, giving attention to the human factors rather than focusing so much on technology. We must also incorporate aspects and emphases of the wider environmental agenda into all cleaner production efforts. The optimisation of both the system and the components is the focus; the life cycle assessment approach should be utilised to ensure that corporate and regional decisions address the comprehensive impacts of cleaner production upon the utilisation of raw materials, energy and the production and management of all wasted materials and energy throughout all processes, products, consumption and post-consumer material's utilisation.

Robèrt *et al*. (2002) concluded that the rapidly growing number of tools and approaches designed to develop sustainability become contradictory when they are used outside of the systemic context of sustainability. According to them, a systems approach, consistent with the basic principles and requirements of sustainability shows that these tools are complementary and can be used in parallel to foster strategic sustainable development. However, the wrestling with the prevention labels during an entire decade indicates that the routines of the institutionalised environmental management systems are not easy to change.

5.5.6. *What was the influence of the societal context on international cleaner production dissemination?*

Despite the absence of a breakthrough in cleaner production dissemination, changes in the relationship between industry and enforcement agencies can be perceived. The socio-economic and institutional framework of a country or region affects this relationship. In a European Union research project covering four countries, Schnitzer *et al*. (1997) found that cleaner production projects were defined and implemented differently. They came across different approaches by national governments, such as: *laissez-faire, convince, command, and negotiate* (see Section 6.2.4). The researchers argued the necessity of a portfolio analysis of the different positions of chosen actors in a sustainable production programme.

Koppert *et al*. (1992) had found earlier that some of these differences relate to the fact that experiences are not disseminated between sectors and countries. This is partly due to the fact that the modification and/or translation by industry suits the perceived socio-economic characteristics of their industrial sector or country.

Williams *et al*. (1997) also experienced the effects of different regulatory systems in four European countries. Regulations have been a major stimulus to environmental improvement in all countries. However, the kind of regulatory signal used, combined with the socio-economic situation of the firm, gave rise to different outcomes. Public environmental policy in Denmark and the Netherlands stimulated preventive approaches in industry to a larger extent than was the case in the United Kingdom. Besides that, in the United Kingdom an important difference existed between statutory regulations by the River Board and the more permissive approach taken by local councils dealing with firms that discharge into the local sewer system. Furthermore, the outcomes in separate industrial sectors were different in the U.K. Firms undertaking activities liable to be perceived as environmentally hazardous (e.g., oil refineries) adopted a policy of `conspicuous compliance' in advance of the implementation of more stringent regulatory standards, whilst companies in different circumstances (e.g., food manufacturers) were more likely to respond 'too little and too late'. Generally, however, the response would be wholly or mainly end-of-pipe, whereby traditional firms persisted in viewing the environment as an external factor.

5.5.7. *What can be concluded from these different findings?*

The engineering approach that consists of `bringing knowledge and solving problems' was dominant in cleaner production projects. The cleaner production translation process covered the reshaping of an outside idea (the concepts and routines that fit into existing practices). The outside expert led the cleaner production assessment directly or indirectly as advice-giving supervisor; an organisational change approach was seldom used.

Recommendations resulting from the assessment were implemented, if they were not too demanding within the existing routines. More intensive application of knowledge and learning processes within the organisations very seldom occurred.

Involving government agencies in the intervention strategy complicated the translation process considerably: in addition to the firm, the agencies sought to shape the idea of pollution prevention into concepts and routines that fitted their own existing practices. Positive effects from social pressure guaranteed access to companies that would otherwise not have allowed the preventive approach, but the involvement of government agencies in the assessments is not recommended.

The experience of an organisation with a certain set of concepts was important in determining the intervention approach. When the concept was new, the assessment could raise awareness via results and brainstorming sessions. When the concept was already familiar, the intervention focused on strategic decision-making processes and the central tenets pertaining to environmental issues.

It was concluded in Section 5.5.4 that most projects in the phase of early research on cleaner production ended in *back to normal*. The cleaner production projects influenced good-housekeeping measures, but the translation of concepts into deeper strategic levels within the corporation only took place in the form of a specialised translation or modification of the concept within a professional discipline. There were variations on this development, such as: ideological translations into comparable concepts e.g., product stewardship; integration of the concept within the traditional structure of production e.g., eco-efficiency. A confusing and subversive translation of the cleaner production concepts and approaches occurred when the semantics from a prevention approach were used to support terms like cleaner technology that do not cover the cleaner production philosophy.

Finally, the dimension of power (`political use') in competing concepts was also clear to see. The promoters of the integrated cleaner production approach were faced with the powerful position of big industry and its trade associations, which mainly promoted incremental steps such as the development of environmental management systems in an institutionalised pollution control framework. Industry trade associations preferred the top-down approach of environmental management systems to the adoption of new cleaner production paradigms, concepts and approaches. The lobbying of powerful stakeholders and the political balance between economic and environmental interests led to the mainstream adoption of environmental management systems, as occurred with Dutch government support for such systems instead of the more systematic, preventive approaches promoted by cleaner production.

5.6. The cleaner production learning processes: general considerations

In this section and the following one, the social theory approach of Ragin (1994) is explored further. In Ragin's interduction research model (see Section 2.6.2), images are used in interactive research and learning processes in order to find and test data and evidence. This images and data/evidence relationship is analysed in a confrontation with ideas from social theory in the interaction and learning process with the analytical frames. The theoretical and empirical interaction processes lead to concluding representations of social life. This section covers two levels of learning processes: the projects as event that can affect the organisation and the trend of the findings in the different projects.

5.6.1. *Images and data at the macro level*

It is remarkable that 25 years ago organisation and management experts such as Child and Mintzberg did not refer to the physical environment of organisations, their production, products and emissions and the environmental regulations they were subjected to. They used the environment as a new contingency factor no different from globalisation of the markets, lower tariff barriers and more competitive pressure (Child, 1977: 180) or referred to the department of industrial relations as a department that has traditional economic contact with outside partners such as unions and governments (Mintzberg, 1979). This means that environmental management inside organisations and links with environmental regulations outside organisations still had to dawn on organisation and management expertise. Together with the knowledge that was applied in order to address environmental problems via a technical end-of-pipe approach (Chapter 4), the preventive approach faced a vacuum in organisational and management change expertise. Despite this, the assessment method was based on an iterative design of projects. In order to explore the possibilities of new *sustainability* concepts (including cleaner production as one of their operational variables), a two-way action research approach was often applied (Dieleman *et al*., 1991, Baas, 1998).

5.6.2. *Ideas at the macro level*

At the beginning of the cleaner production action research, government and industry were approached separately. Because cleaner production was seen as a business-fit concept by scientific researchers, industry was seen as the primary target group. At the same time, some government organisations were involved in funding the research and, in the case of positive research results, would be the recipient of the insights and data concerning the benefits of preventive environmental protection policy. The most important dissemination channel was the research itself. During the research project intervention, options were developed and implemented within a company. Dissemination outside a company was, however, found to be difficult.

In relation to the perception of the cleaner production concept, it was concluded that industry saw cleaner production as an environmental subject. Two issues influenced the industry routines in the 1990s: industry acknowledged environmental performance as an important issue for them to address, and because environmental impacts are not core business, the exploration of their responsibility was perceived as needing reference frameworks, such as environmental management systems and their standardisation in BS7750, EMAS and ISO 14000 verification systems. The general economic power of industry, combined with its formulation of self-regulation concerning environmental performance, gave industry a powerful position in relation to the government at the macro level. As was concluded in Section 5.2, officials at the Ministry of Environment were too inexperienced in the `field of practice' to apply counter-pressure that might have favoured the implementation of a more preventive approach such as cleaner production.

In the preparatory phase, specific information and dialogue have to include the targets and expectations of the project, the wishes of the participating company, the playing field and the conditions that have to be fulfilled for the project (in the case of a new concept, the structure and technology of a company constitute strong limitations). It is recommended to involve key managers in this setting as soon as possible to keep commitment active. However, even if one is equipped with this organisational and psychological knowledge, active, continuous attention to new concepts that cover non-core business issues (and, besides, were not requested) is often impossible to ensure.

In order to obtain a first insight into an organisation, questionnaires are frequently used. In a cleaner production assessment, the main part of a questionnaire is stocktaking, in order to gain knowledge about the energy and materials streams that are integral to the company and to its production processes. Manuals such as those developed in the PRISMA and PROSA projects sought to understand the way the corporation was organised by seeking information pertaining to its structure. The PROSA project even looked into the corporation's environmental mission statement, but not much was done with that information. Also the PRISMA project, with its structural waste prevention teams, did not pay much attention to organisational aspects of the ten companies with which it was working.

5.6.3. *Findings concerning the learning processes in cleaner production demonstration projects*

A major finding concerning the operational phase of cleaner production projects was that industry operators were involved in assessments for the purpose of fact-finding and brainstorms about cleaner production options. However, the single loop learning process generated no strategic decisions on a company-wide framework for the further development of new learning loops. In fact, it was found by the researchers that the management of organisational learning processes was not organised at all. This meant that the involved actors were not able to elaborate on the mutual exchange of lessons learned that is often vital for the creation and use of synergy in further cleaner production developments within the organisation (Zwetsloot, 1994).

Bouman *et al*. (1993) found this a major omission in this type of learning process. At the end of the first assessment loop in an `average' cleaner production project (Borgo *et al*., 1992), key persons in the organisation were unaware of each other's commitment to potential further steps. They often saw themselves as 'lonely in their environmental commitment' and because the cleaner production intervention was not seen as core business, they did not explicitly check cleaner production pathways with others in the company. In that way they blocked the process of the `company's involvement' that is seen by Bessant *et al*. (1995) as: "..the set of routines which enable a much larger proportion of employees within the firm to participate in the innovation process, and to generate a stream of incremental improvements in support of key objectives. It has far-reaching implications for R&D in extending the compass of innovative activity within the organisation to include the factory floor and the office as well as the traditional laboratory..".

Also, Remmen and Lorentzen (2000) established in the Danish research and development project *Employee Participation in the Introduction of Cleaner Technologies* (MIRT project, 1993-1996) that by setting up environmental teams consisting of representatives of both management and the shop-floor, an internal dialogue about environmental issues was placed higher on the agenda. Another finding of their research concerned various preconditions for the participation of employees in environmental activities. The social institution, that is the norms and rules that have been developed through time and that regulate the working behaviour and co-operation among the workers, is crucial to the attitude of the employees towards participation in pollution prevention and cleaner production projects.

The MIRT project stressed that employee participation was not just about information. The environmental teams formed within the companies were a guarantee that the knowledge and experience of the employees as well as consultation and negotiations were the pivotal point of the environmental activities. Correspondingly, the environmental teams functioned as a pivotal point of collective learning by ensuring connections between individual and collective learning processes based on learning-by-doing. This finding corresponds with a similar positive learning and incremental problem-solving experience of the continuous improvement team in a Dutch dairy that was successful in performing better than their sector's demanding norm[97] within one year.

5.6.4. *Trends in learning processes in cleaner production project*

After a decade of positive stories about the results of single cleaner production assessments, the recognition that more is needed to change the institutionalised practice is dawning. Although the PRISMA project (Dieleman *et al.*, 1991) has already examined barriers in the spheres of concept, technology, the economy and knowledge, leaders of many subsequent cleaner production projects have ignored or underestimated the essential significance of the corporate structure and culture in ensuring the success or failure of cleaner production implementation. Gunningham and Burritt (1997) found in their research in Australia that a lack of information and expertise, a low awareness of environmental issues, competing business priorities – in particular the pressure for short-term profits – a bounded rationality in decision-making processes, financial obstacles, a lack of communication within the firms, middle-management inertia, labour force obstacles and the difficulty of implementing cleaner technology, are the main internal barriers to the success of cleaner production. Additionally, they identified external barriers, including: the failure of existing regulatory approaches, the difficulty in accessing cleaner technology, the difficulty in accessing external finance, perverse economic incentives, an absence of markets for recycled goods, and economic cycles.

Senior managers can also have allowed a demonstration project (Whitney *et al.*, 2001) without really understanding or supporting it. Stone (2000) provided an interesting review of indicators of organisational culture – relevant to cleaner production uptake in the demonstration and control groups – before the start of the demonstration project and one year

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[97] The dairy's demanding norm was 20% below the average performance of Dutch dairies (see Section 5.1).

after. The representatives of the demonstration group experienced increasingly attention for issues such as the encouragement of the management and the seeking of community input. At the same time a higher percentage of representatives perceived barriers with the senior management and in the structure of their organisation. The representatives of the control group also increasingly felt that the structure of their organisations caused difficulties. The whole environmental performance was increasingly perceived as having a low priority and being compliance driven, with a constantly high treatment/disposal focus. Awareness raising about the senior management barriers (from 0% to 18% in the demonstration group) was of importance for the implementation of cleaner production options. It indicated a new understanding by the respondents of the effects of their senior management's behaviour. Stone's research finding that a higher percentage of the respondents (from 20% to 32%) perceived a treatment/disposal focus in their organisation was in accordance with the increased awareness that the existing mindset of the management blocked cleaner production development.

Dieleman (1999) concluded that structural and cultural factors, such as the lack of articulation of demand for cleaner production, being stuck in cleaning routines, the need for uncertainty reduction, the lack of clarity about prevention results, the company culture and the system boundaries of departments place serious limitations on change processes. Together with the fact that cost savings and financial aspects play a minor role as criteria in the development and implementation of environmental management, there exists a complex set of barriers to the dissemination and implementation of cleaner production.

In the workshop "Untold Stories" that was held during the Earth Summit Round Table in October 2000 in Montreal, Canada, representatives from all parts of the world shared their experiences concerning cleaner production failures. The participants emphasised that usually there was not any discussion of the failures (or the threats of failure) in cleaner production dissemination. These were perceived as personal failures and persons with negative experiences also felt this way and did not discuss them. The common attitude was that only success stories were to be reported. The purpose of the workshop was to learn from unsuccessful experiences. The many impediments – that individually had been seen as specific to the situation – triggered joint recognition and were collectively acknowledged as general obstacles, such as: the lack of attention to the societal context and internal infrastructure (organisational, institutional), to the constraints of both longer pay-back time (in comparison with pollution control solutions) and the low landfill prices (economic, institutional) and furthermore, the blockades against new approaches to innovation and resistance to cleaner production (power).

The main lesson that could be learnt from the discussion of failures was that a cleaner production concept needs a broader organisational analysis within the context of the projects. An analysis of the surroundings of a company must involve the current situation with respect to regulations, the economy, the geographic and cultural location of the company and possible trends in markets, and general and specific government policies influencing the application of cleaner production approaches. The internal analyses must involve the assessment of organisational structure and culture, and also assess independently from the cleaner production concept the potential for change in the organisation.

5.7. Main features of the first round of analysis of cleaner production dissemination

Overall, it can be concluded that the results of new cleaner production assessments have been used as the basis for operational manuals that can be be made use of in other companies and other contexts. It was taken for granted that positive economic and ecological results would automatically stimulate the dissemination and application of cleaner production concepts to other companies. This assumption was strengthened during cleaner production research by the findings that resources and energy savings were four to ten times as high as the avoidance of waste treatment costs. Such approaches and results were thought to be more fundamentally interesting and business-fit for company managers than traditional environmental management approaches.

However, little or no attention was then given to the fact that the first case studies had been performed under special conditions, such as special funding, an assessment team with professional assistance or supervision and allowing special intervention in normal practice. Also, important variables such as the existing corporate routines and limited responsibilities of employees, a lack of knowledge about cleaner production and, as a result of this, both a *question articulation* for cleaner production and requirements from outside the company (Dieleman, 1999) were usually neglected.

In such situations without a follow-up in the organisation (such as the evaluation of the assessment as learning process, broadening the scope of the approach by involving other departments, and implementing education programmes), the influence of a demonstration project often faded away within the company, over time (at the micro level). The traditional accounting of business economics, the engineering focus and judgement of managers in a pollution control perspective were other important factors that contributed to this lack of ongoing positive results within companies that had started applying the cleaner production approach.

At a macro level, the institutionalised configuration was often neglected. Without any changes in the surroundings of the companies, self-regulation will not usually generate a breakthrough to sustainability or is, in fact, even doomed to failure. New policy instruments – such as the 4-year environmental management plans in the Netherlands – can anticipate such changes because structural preventive approaches can be planned within a longer time frame. However, until now no fundamental changes were detected. Nevertheless, by the end of the 1990s, it could be noticed that at last, in cleaner production dissemination activities, the human dimensions of organisational change (concerning both internal continuous improvement and external dissemination) were being acknowledged more frequently (Baas, 2000, Stone, 2000).

6 Balancing Cleaner Production Dissemination Experiences with Theory

In this chapter, the amplitude extension of the bouncing ball metaphor (Figure 2.9) is reduced. The analysis is presented in Section 6.1: the context of the dichotomy of trends and policies that influence the dissemination of cleaner production; Sections 6.2 and 6.3 analyse the actors, structures and processes at the macro level; Sections 6.4 and 6.5 analyse the meso level of organisations in general, and Section 6.6 analyses the micro level of the dissemination of cleaner production within organisations. One must take into account the fact that at the meso level, the analysis in this chapter deals with the cleaner production concept. Furthermore, at the micro level, the analysis deals both with persons and single organisations. Section 6.7 provides an overview of the major conclusions about the dissemination of cleaner production concepts.

6.1. The context of dichotomies at the macro level

This section begins with an analysis of macro level trends and policies that influenced the conditions surrounding the dissemination of the cleaner production and industrial ecology concepts.

In his thirteen predictions for the 21st century, Snider (1998) saw environmental stewardship as the general emerging theme. Snider constituted a very positivistic view on developments that are only incrementally evolutionary. Several case studies in this thesis provided the insight that incremental steps also need more radical steps that are embedded in a *cork screw crul* development. Also, it was seen that the role of key persons involved in the dissemination of new concepts is important. Furthermore, the disseminators of new concepts have to take into account the fact that it is better to couple new and old knowledge into routines horizontally and that new concepts spread vertically more easily in an atmosphere of accepted continuous commitment from the top management.

Embedded in an open management system, the spread of the concepts and the education of all employees were found to be necessary conditions to ensure the future development of a sustainable industry that is physically characterised by a framework of zero emissions, renewable energy, eco-technology, non-toxic compounds and recyclable products. In this section, the types of dichotomy are explored that influence sustainability trends. Several trends are the result of perceptions that drive the processes of dissemination, modification, and translation. Within a dichotomous framework nine separate dimensions can be described. These are discussed below.

6.1.1. *Long term versus short term*

The first dimension of the dichotomous framework is the balance between long and short term, be it for vision, returns on investment, education, or organisational development. This will always be a point of discussion. The development of organisations is embedded in a market structure. In the focus of sustainability, the issue of ethics must be involved. Harper's observation (2000) that the socially less desirable goods (such as cigarettes) are reaching markets more easily than essential nutrients, must be reversed.

6.1.2. *Voluntary versus regulatory*

There has been much discussion about the limits of regulatory approaches – they have a limited enforcement reach (Peppel, 1995), and generate demotivation and follower reactions – and the issue of trust in self-regulation.[98] It is a question of regime: at first, when environmental public policies are developed, they often have a command-and-control policy orientation. This orientation is often seen as the required foundation for regulation, on which other instruments can be developed. In the case of well-developed regulation enforcement, this foundation is needed as a stick behind the door. The better performers will not need it, but the bad and/or criminal performers can be legally dealt with if they do not fulfil their responsibilities under the law. But experiences in many parts of the world reveal that environmental regulations are seldom adequately enforced due to lack of will, lack of funds, lack of knowledge, and/or lack of capacity. Also in such situations leapfrogging to voluntary approaches is not possible, because similarly to the regulatory framework, conditions such as access to resources and transparency of policies are hardly fulfilled.

6.1.3. *Social process development versus physical results*

The fact that the majority of industrial managers has an engineering background creates an unfavourable bias, given the necessity of involving social science knowledge in the integration of new expertise within and between companies. The physical results are clear to see, but the way to get there (with an organisational change process) is either not known or is denied owing to the often held belief that new technology will solve the problems.

6.1.4. *Environment versus economy*

The debate around the environment versus the economy has gone on across the world for many years. This is illustrated, for example, by McBurney's book *Ecology Into Economics Won't Go* (1990), and is formally countered by, for instance, the White Paper 'The Economy and Ecology' of the Dutch government (1997). The ultimate translation is the so-called win-win approach that both the economy and the environment will be better off if certain approaches are used; this has become one of the main paradigms in Dutch politics. In various coalitions of political parties, the phrase *ecology and economy can go together* emerged as a political ideology as a result of a power equilibrium between opposite opinions. Although ecology and economics do go together in some cases, this principle is not always applicable to human activities. In fact, this underscores the dominance of the economy. When the business economy is not expected to win (and the general rule of thumb of industrialists for return on so-called environmental investments is less than 3 years maximum) then the investment is not performed. This means that a better environmental performance without much financial return needs citizens or governmental pressure. Such governmental pressure without public protest takes time, generates bargaining and compromises. Most of the time a piecemeal deal is the outcome, and sometimes even this cannot be internationally enforced – as with the US administration refusing to sign the Kyoto Accord in 2001.

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98 According to the Dutch Minister of the Environment in 2001, the Dutch 1991 packaging covenant between the government and packaging industry failed to reduce waste tins and (small) plastic bottles in the Netherlands; his plan to start a deposit system for tins and small plastic bottles was not carried out during his tenure (that ended in July 2002). A new minister was as yet content with a public campaign on this subject.

A study by the Stockholm Environment Institute (1999) examined the cost arguments generally presented by industry and its representatives in the negotiation of environmental regulations in five cases, among others the United States Clean Air Act and the Montreal Protocol on Substances that Deplete the Ozone Layer. Industry stressed the high cost of compliance during negotiations, while the industry's actual costs for implementation were far lower than had been predicted during the negotiations. In the case of the United States Clean Air Act, the over-estimation of compliance costs was over 300%. The Stockholm Environment Institute discovered several reasons for the outcome:

1) Negotiating positions taken by various stakeholders are dynamic. One category of industrial stakeholders can have direct benefits that run against another category of industrial stakeholders.
2) In some cases the strategy adopted after an environmental law has been passed has not been the one for which costs were discussed during the negotiations. The case studies indicate that technical advances, innovation and economies of scale can provide various options for reducing production unit costs in Northern industrial countries.
3) Regulatory approaches to environmental improvement can impose a burden on companies, and industry often opposes them. However, forward-looking, receptive and innovative industrial leaders increasingly recognised that properly designed regulation need not increase costs and good regulations have often enhanced competitiveness in well-run companies. Porter and Van der Linden (1995) stress that regulatory agencies have an important role in stimulating such industrial improvement processes.
4) Cost comparisons are plagued with a number of inherent difficulties such as:
   - The claims made by industry are deliberately vague;
   - Cost claims by different stakeholders refer to packages of measures;
   - Costs were reduced due to the unforeseen or neglected potential to improve current technologies and improve efficiency;
   - The potential for industrial innovation was under-estimated.

Individual environmental risk-assessments (having a high or low profile of such risks) and societal policy attitudes (critical load, assimilative capacity or precautionary principle)[99] will contribute to the debate whether the environment and the economy can be reconciled or not.

6.1.5. *Common interest versus self interest*

It is often said that the prisoner's dilemma (Hardin, 1968) mainly plays a role in small and medium-sized companies. The majority of those companies are not directly confronted with environmental issues and they often think that environmental measures always cost money and that they are already doing a great deal. Following that argument through, the dilemma is translated into the classic concept of cognitive dissonance in the publication of Festinger (1957).

In case of cleaner production projects, nearly all managers had, despite the positive results of a cleaner production assessment, reasons to prefer their own convenience on economic (the

[99] A relationship between the export and import of pollution was assumed in a research study for the 1991 North Sea Minister's conference: the U.K. is a major pollution exporter, and the U.K.'s policy attitude is based on the assimilative capacity concept; the Netherlands imports as much pollution as it exports, and the policy attitude is based on the critical load concept; Germany suffered extremely from the heavy pollution out of Central Europe in the 1980s, the German policy attitude is based on the precautionary principle (Baas *et al*., 1990).

costs of the needed organisational changes), strategic (the reduction of uncertainty) and social (the perception of lost individual independence) grounds.

6.1.6. *Stimulation versus enforcement*

This is part of the 'Voluntary versus Regulatory' dichotomy. It has been argued that regulatory approaches have a limited enforcement reach (Peppel, 1995) that creates demotivation and negative reactions from the regulated organisations. Added to regulation, the stimulation of activities via social and economic instruments can motivate companies to develop pro-active policies within their environmental management that can build public trust in self-regulation.

6.1.7. *Convergence versus divergence*

The current trends show evidence of movement in both directions. Convergence can be the outcome of a process in which change management aimed at preventive innovative approaches is integrated. With respect to knowledge utilisation, change comes about through a process of iterative interactions between three *streams* of activity: defining the problem, suggesting solutions, obtaining political consensus. Change occurs when these streams converge, presenting a challenge for proponents of reform (Porter and Hicks, 1994). Vickers (1999: 87) refers to a variety of views in organisations; rather than seeking to impose a dominant culture, the healthier response can be built on diversity. Besides that, the focus on certain items is characterised by ebb-and-flood movements, such as the specific political attention on the external safety issue in the Netherlands in 2001. When an integrated approach is developed, the divergent tendency can be compensated and incorporated. One element of the integrated approach will receive the greatest amount of attention, but the interconnectedness in the integrated approach also affects the other elements in a positive way.

6.1.8. *New versus old knowledge*

Research into the cleaner production concept was a core activity for some university researchers: it involved collecting and testing new knowledge. That new knowledge had to be generated and explored in organisations that had not asked for it. It was clear that at first there was no demand articulation within the organisations for cleaner production. Secondly, in their environmental perspective cleaner production was not core business. Thirdly, most of the organisations were not used to large-scale research being conducted in their midst.

From an information-processing perspective, exposure to new experiences increases the level of uncertainty in a sub-unit; also, top-down new knowledge intensifies vertical flows (Schulz, 2001). The power of the management is threatened when new knowledge is gathered bottom-up. During cleaner production assessments, the fact that such bottom-up vertical flows of information could have negative effects was underestimated. When it did, it resulted in limited management commitment to implementation and further development.

6.1.9. *Translating cleaner production versus environmental management systems*

The last dimension of the dichotomous framework is the potential conflict between cleaner production and environmental management systems. Stakeholders such as governmental regulators, environmental advocacy organisations (spokespersons for nature and public opinion), and influential customers influenced the company management of environmental problems. From a translation perspective, two new concepts, cleaner production and environmental management systems, competed for integration into existing knowledge. A new concept is appreciated more rapidly if the translation is incremental and fits into existing corporate routines. In the case of two new concepts, the least controversial concept will be adopted first. In this instance, environmental management systems were more compatible with existing corporate routines than cleaner production concepts.

Meyer and Rowan (1977) point to two problems that organisations can meet when adopting new concepts if they are dependent on institutionalised elements, rules or structures. The efficiency of the production process can conflict with the institutionalised rules. It can conflict with costs; it can conflict with the embeddedness of institutionalised rules at an abstract generalised level, while the production activities take place under specific conditions. Also, inconsistency created by incompatible institutional elements may provide additional sources of conflict. Meyer and Rowan argue that decoupling them solves these conflicts between institutionalised rules and efficiency. Through decoupling, the organisations are able to maintain standardised, legitimate and formal structures, while the activities vary in response to practical considerations. The environmental co-ordinator function is an illustration of this. Standardisation gives managers a reference framework that they can use as motivation and legitimisation for new activities in their organisation.

6.1.10. *What do the dichotomies teach us?*

A change in the industrialists' perception of many variables is needed for considering preventive management on the basis of cleaner production and industrial ecology. Because these concepts are still perceived as having an environmental basis, these variables are very difficult to influence within industry. Although, increasingly frequently a longer-term view is being adopted, traditional production patterns have scarcely changed. In particular, in the case of cleaner production assessments, it was found that the translation of the concept into a company's unique technical and organisational concept is very difficult. The conclusion about environmental management is that managers are adopting the external institutionalised expectations and belief systems represented by rules and standards such as the ISO standardisation and environmental management systems rather than adopting new concepts that are not institutionalised.

For the development and dissemination of new concepts, the status and authority of key actors play an important role. According to this finding, a format for the dissemination of a new concept or issue has to take into account the fact that managers are more inclined to apply instruments and standards than to start learning and change processes of new concepts. This does not mean that the format should be rigid. A more flexible format can combine a structure and a process, providing a framework for the main questions and solving problems.

To get there requires the integration of other types of knowledge. For cleaner production dissemination in new areas, the integrated approach starts with an analysis of the organisational surroundings. At the same time, the continuous commitment of the top management to achieve vertical dissemination of new knowledge must be secured; the availability of a key person strengthens the possibility of spreading new knowledge horizontally. Information about the new concepts helps to condition the beginning of an awareness-raising process. When the new concepts are recognised and acknowledged as being valuable for the organisation, education and training must follow. Within companies, dissemination involves a cleaner production assessment and the development of a policy for a multi-level and multi-disciplinary approach, leading to the acceptance of the concept and the development of a continuous improvement framework.

In the process of general dissemination of the cleaner production concepts within a region, the same steps have to be taken. The analysis of the organisational surroundings – including institutional arrangements – identifies the key stakeholders, the major professional associations and key organisations and provides the elements for a network design supporting the dissemination process. Furthermore, a multi-disciplinary approach can cope with the different types of policy-making, such as general and stakeholder policy-making.

The issue of sustainable development brings uncertainties that contribute to the need for new knowledge. This new knowledge involves many high-level disciplines and generates a growing complexity of interconnectedness. Because of this, society is continually developing towards a network structure. Although currently environmental issues are not considered challenging within industry, the old practice has been challenged. Within the pollution control paradigm, elements of the pollution prevention paradigm are emerging. Table 6.1 shows an overview of issues that have been institutionalised in the pollution control context. Frequently it has been found that the pollution prevention/cleaner production practical paradigm fits with an efficient industry and that it is also better suited to the need for more transparency and new integrated thinking in environmental policy.

Table 6.1 From pollution control to pollution prevention: a shift in focus and emphasis

Category	Pollution control	Pollution prevention
Field of concern	Some pollutants	All pollutants
Problem solving	Effect	Cause
Unit of reference	Institutions	Persons
Risk perspective	Acceptable risk	No risk, 0-discharge
Values	Scientific	Scientific and moral values

The preventive approach does not tackle problems at the level of their effects but rather focuses on their causes. Moral values (such as ”the industry is accepted, not the pollution”) are added to scientific values that are isolated from society. Although industrial society generates safety and environmental risks, acceptable risk accounting based on theoretical modelling is frequently questioned. The Precautionary Principle is based, at least in part, upon not accepting risks in advance (Dethlefsen, 1993) and the Precautionary Principle’s ethics and research are based on 0-discharge and zero-waste (Pauli, 1998). This means, that not just some but all pollutants are taken into account. Uncertainty about hazardous wastes has received more attention worldwide[100] and from the Dutch government (SOMS, 2001). In relation to some accidents in the Netherlands in Enschede and Volendam,[101] the Dutch

[100] Such as the theme of the Fourth Princess Chulabhorn International Science Congress in Bangkok (Thailand) in 1999: Chemicals in the 21st Century; Chemicals for Sustainable Development.

[101] The disasters in a fireworks company in Enschede (2000) and a pub in Volendam (2001) revealed a severe breach of safety regulations and caused the death of many people.

government has increased its focus on risk management and risk prevention-based regulations.[102]

Considering sustainable development, many variables play a role. The concept of sustainable development gives rise to an array of interpretations by several actors, from rejection to acceptance as a framework for discussion, within the dominant institutional context and the power-relationships. Also Goodin's concern (1982) that even when we can anticipate the outcomes, we cannot anticipate our evaluative response prior to actually experiencing those outcomes, provides limited holdfast. However, dissimilar translations and interpretations of new concepts also mean that processes of change can be effected. These processes can be effected by the sum of too much complexity (some compare them with the *Invisible hand* interpretation of Adam Smith) or can be intentionally influenced. In any case, several conditions need to be met for the facilitation of such processes. However, efforts to change a structure must always follow possible patterns within the structure, otherwise they fail (Collins, 1992).

6.2. A look at major actors, regulation and policies at the macro level of the institutionalised concepts' market structure

Having analysed the possible dichotomies in the development of new concepts, I now turn to other industrial issues, such as the expertise of industrial top management (as a macro indicator of change in educational background), the public policy culture and policy types, and the characteristics of the relationships between governments, industry and experts.

6.2.1. *The expertise of industrial top management*

The question is whether the background of managers has changed. Icke *et al.* (1997) studied the technical and other expertise of top management in industry in the period 1984–1993. They found the following dominant developments in the 1980s and 1990s:

- The need for up-scaling to gain competitive advantage with regard to economies of scale and market shares;
- Internationalisation/globalisation: the increasing need to achieve global scale on the world markets.

Markets are increasingly steered through technological developments. According to Solow's growth theory (1992, 6) technical progress is the sole condition for a steady growth in labour productivity. Icke *et al*. (1997, 45) distinguish three types of industry: industrial companies with eminent technological and innovative products (higher tech), companies producing mass (consumption) goods (middle tech) and the rest, mainly trade companies (lower tech).

Technological expertise is found in all higher tech companies and in less than 50% of the companies in the other categories of industry. Compared to 1984, no reduction was found in the technical signature in large corporations: 64% of the companies (n=67) had at least one director with a technical signature component. This means that the organisational change dimensions of a new concept must involve technological issues as part of the translation

[102] Despite the agreed assessment reports on the basis of the Seveso Directive, the large companies in the Rijnmond area were required by the local EPA to provide new risk assessments in 2002.

process. The type of technology dimensions that can be influenced as part of an integrated management approach depends on their place in the system.

In higher tech companies, the design phase in particular – in relation to the application of costly materials in sometimes heavily polluting production processes for products with a short life-cycle – is the focal point. In middle tech companies, the routines at the basis of encoded knowledge are generally very important.

6.2.2. *The institutionalised environmental regulation structure*

An example drawn from the transition period in Central Europe can be used to illustrate the dominance of environmental regulation institutionalisation along traditional lines. The changes in Central European countries rapidly mimicked the development in the *Northern* environmental policy approach. Advocates of the Northern traditional environmental policy approach directly profited from the existing environmental crisis: there was an environmental regulatory framework, but no enforcement, and there existed extremely heavy air, soil and water pollution. The Northern countries, especially the neighbouring ones, were threatened by this pollution and wished to solve these problems. The funding countries shaped the conditions for the introduction of cleaning and end-of-pipe technologies. Of course that approach foresaw in an urgent need, but at the same time blocked a leap-frogging transition to preventive environmental policy. Nevertheless, some environmental policy institutes (SEI, 1991), universities (European Union - TEMPUS education modules transfer projects) and key actors tried to introduce the cleaner production approach. During the knowledge transfer process, they were confronted with a system in which the orientation towards new knowledge and changes was neither learned nor applied.

Box 6.1 Visiting a chemical company in the Bohemia region

During a Cleaner Production conference in Prague in September 1991 (Stockholm Environmental Institute, 1991), the Black Triangle region (a heavily polluted region covering parts of Eastern Germany, Poland and Czechoslovakia, with dead forests and heavily polluted rivers) was visited, along with a chemical company. The plant was obsolete and had not been properly maintained for decades; the air and water pollution was physically very heavy, confronting the participants with a strong smell and dark red and black waste water. The company manager apologised for the situation, saying that a lack of finances and a lack of new, high-tech equipment prevented them from making improvements. When conference participants remarked that good housekeeping could bring improvements without costs and even with benefits, the manager explained that "..everyone at the company and at home did good housekeeping..".

The short message contained in Box 6.1 illustrates a situation where people have no common understanding about the subject. In such a situation, the transfer of knowledge between organisations will not succeed. The organisation that lacks the knowledge about the new concepts has to become aware of that, before information and education will find a fertile ground. University researchers used that type of knowledge transfer to convey knowledge about cleaner production to companies, governments and other organisations. A model – in which a joint project was performed under the supervision of the knowledgeable organisation – led to a learning process for the other organisation, that was able to master the cleaner production concepts themselves. Such learning processes were used in the Stimular project (from a university to a newly designed governmental facility organisation), the PROSA project (from one university to another university) and the Preventive Environmental Protection Education (PEPE, in EU-TEMPUS)[103] project (from one Western European university to students and faculty of four Central European universities).

In Czechoslovakia,[104] the nomenclature at official levels just below the top was not knowledgeable about modern environmental policy developments, but it did occupy positions of power in the country after the political transition. However, young academics, searching for new approaches and new organisations, were able to connect to the latest knowledge about networks and stakeholder approaches (Mid-European Cleaner Production Roundtable, 1994). They started new organisations, often small environmental consulting firms, and created networks with government, industry, universities and new financial institutes. Their networking activities provided the basis for one of the first National Cleaner Production Centres and knowledge dissemination by governments. It fertilised the soil for developing national public policies based on cleaner production (Government of Czech Republic, 2000, see Annex IV.1).

6.2.3. *The experience of government policy-makers and industry environmental management*

For a state-of-the-art statement in 2000, four representatives of government and industry in the Netherlands were asked about their opinion on the following question:[105] `Do the follow-ups to the concepts of clean technology, pollution prevention, integral chain management, and environmentally induced product policy, constitute a fundamental shift towards sustainable companies, or are they just superficial fashionable actions taken by companies?'

The national government representative answered that environmental management systems are no fashion: a historical line of progress has been unfolding, from environmental management systems, change management and product-induced environmental management, towards communication via environmental reporting and product information.

The representative of a provincial government stated that governments were early in adapting the prevention concept, although there was no follow-up to management concepts.

The experience of the representative of a large national company with two large companies was that both followed the same development, from process to product-induced environmental management systems.

The general trend was from reaction towards enforcement, and then towards mechanisms of improvement. The representative of a multi-national company said that environmental management is not separate from general management, although there are always certain fads. Other observations about the experiences revealed that a period of 10 years is too short

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103 The framework of Trans-European Mobility Scheme for University Studies (TEMPUS) task force of the European Union.

104 Czechoslovakia split into the Czech Republic and the Slovak Republic in 1993.

105 The comments were formulated in reaction to two propositions in the Changing Nature of Business workshop at 7 April 2000 at the Erasmus University in Rotterdam.

for making such fundamental changes, that differences world-wide are considerable and that a certain level of environmental management is being crystallised.

The second question was: `Does the development of sustainable companies require relationships with other stakeholders?' The national government representative was of the opinion that the different definitions of sustainability require different stakeholders. The representative of a provincial government reflected that his province had started a process from the search for sustainability, meetings with different stakeholders, and co-operation, towards the formulation of a design for the future. Two major long-term projects were the result of this. The representative of a large national company thought that the sustainability concept is developing towards network structures. The representative of a multi-national company stated that the chemical industry needs stakeholders. Sustainability is developing within company management: it is an internal process that stimulates external policy. Based on the renewable material's issue, sustainability is recognised as good business.

All representatives experienced environmental management systems as a fact in the industry, although there were different shades of opinion on the approach. The governmental representatives valued the environmental management system unreservedly, while the representative of a multi-national company formulated his positive opinion more prudently. The representative from the province made special efforts in facilitating the development of the sustainability concept. The industry representative reflected upon practical experience in working with the sustainability concept. Different types of expertise, stakeholders, networks, renewable materials and energy usages are industrial management aspects that define the orientation of the path towards sustainable industries. At the level of the national government, the appraisal was less pronounced. The governmental representative put into words that the concept needs both more integration into national policies and a type of elaboration other than the existing environmental policy framework.

6.2.4. *Reflection on policy types*

The literature on general industrial policy suggests that different economic strategies are effective in different socio-economic contexts (Whitley, 1992). Within the European Union research programmes, it was found that sustainability projects were defined and implemented in different ways in different countries or sectors of industry in Europe (Schnitzer *et al*, 1997). Some of these differences relate to the fact that experiences have not been disseminated between sectors and countries (Koppert *et al*., 1992). Mostly, such differences are due to the fact that, to a certain extent, an approach is always translated by firms and governments to suit the socio-economic characteristics of the country/sector in question.

Public environmental policy can be of a reactive type, counting on formal regulation and control, or a proactive type, which is more informal and flexible, or somewhere in between these two poles. This means that in a self-regulatory infrastructure, other capabilities are required than in a command and control situation. Cleaner production functions better in a dialogue structure than in a situation where just meeting the requirements is enough. Schnitzer *et al*. (1997) examined the development of specific ways to motivate actors in four different European countries. Within this context they found the following government positions:

- *Laissez-faire*: The actor has only a few instruments at his disposal and has a poor communication capacity. The only possible role is to leave it to others and/or do nothing;
- *Convince*: Only a few policy instruments are available, but many communication skills can be applied. In this case, industry has to be convinced of the superiority of cleaner production and other approaches by the power of arguments;
- *Command*: In this case, the actor can force others into action out of a strong position. It is about the power of instruments and the possibilities to enforce them. However, in the case of cleaner production this has proven to be a bad position;
- *Negotiate*: In this pattern, the actor has a base to keep in reserve. The primary approach is negotiating with other actors to get results. The power of negotiation is the main determinant.

This research project provided lessons about the importance of taking the surroundings of organisations into account. The (inter)national dissemination of the cleaner production concept did not give special attention to this issue. Also in the dissemination process the assessment procedure applied during demonstration projects dominated the approach. For this reason Schnitzer *et al*. (1997) developed a self-help guide in order to facilitate the launch of a local or regional sustainable production programme. This programme was developed after several cleaner production programmes had failed because some of the important actors had not been included, or had been included too late.

6.2.5. *Conclusions about institutional changes at the macro level*

The conclusion of Section 5.7 was that there have not been any radical changes in the institutional context of the dissemination processes of cleaner production and industrial ecology. The educational background of industrial top management had scarcely changed; neither had there been any changes among the types of policy-making in different European regions. Also, it was believed that environmental management systems can be used to foster self-regulatory responsibility within industry. On the other hand is hardly paid attention to the development in the Netherlands that the environment became partly integrated within the subject of geography in secondary schools and that environmental management, although mainly instrumentally and externally focused upon production processes, has been institutionalised in large companies. Besides specific training in environmental management, there also begins to be some attention to the integration of sustainability issues into educational curricula at academic levels.[106]

[106] As illustrated during the International Conference on Cleaner Production & Pollution Prevention Inside Stories for university education development (Hermosillo, México, January 2002), the 1st and 2nd International Conference on Engineering Education in Sustainable Development (Delft, The Netherlands, October 2002 and Barcelona, Spain, October 2004), and the International Journal of Sustainability in Higher Education since 2000.

Box 6.2 *Tolerating the fact that environmental requirements are not met*

The Zuid-Holland Water Authority faced a forced change in its regulatory system. They had a traditional attitude, involving environmental regulations, while at the same time, during the period 1987 – 1991, they tolerated situations where a company did not meet environmental requirements. In that period, the licensing system had reached optimal results with regard to what companies were willing to do in keeping with their marginal economical possibilities in the competition with other companies on the world market. The permission to temporarily exceed the maximum emission loads was applied as an informal development within the policy of the Dutch water authorities (Vroegop, 1996). After a certain time, there was a discussion emphasising that this informal policy had to be tested by objective criteria. This view was not accepted by public opinion. Environmental NGOs and politicians stated that the period of tolerating the fact that environmental requirements were not met had to end. A new top management at the Zuid-Holland Water Authority re-launched strict regulatory enforcement.

Currently, some water authorities are striving for a more interactive relationship between companies and the water authority, because companies became frustrated by requirements that can only be met by end-of-pipe solutions instead of solving environmental problems more fundamentally as a part of general investment. Some departments in the regional Dutch EPA forged such a relationship by being involved in the development of environmental management systems within the large companies in the Rijnmond area. Although the agency is still operating along traditional regulatory lines, the carrot or stick approach is being informally developed in relation to the environmental performance of companies. The execution of the first generation of 4-year company environmental action plans constituted a test for the acceptance of changing relations in general within the Rijnmond EPA organisation.

However, the interpretation of the results by the Rijnmond EPA differed from the industrial interpretation that was agreed upon in the government – industry covenant.[107] At the end of the 1990s, the dialogue within the Rijnmond EPA about its future approach was centred on the dilemma: `Will the environmental performance of a company be the basis for trust in self-regulation of the company or will strict conformity with environmental management regulations be the primary task?'

The province of Zuid-Holland (1999) formulated its public policy approach of sustainable development as follows: `..We strongly stimulate social cohesion to create a social, sustainable and green province of Zuid-Holland. The balance between social, ecological and economic development dominates the public policy programme. A strong economy is necessary, but not at all costs; a clean environment and the quality of life are also of great importance..'.

[107] A representative of the Rijnmond EPA said `..what is the difference with the situation without the 4-year action plans?..', while a representative of the Facilitating Organisation Industry (FOI), responsible for feedback on the results to the government, was satisfied with the results of the first round of the 4-year action plans (interview B. Klemmensen, May 1997).

6.3. The processes of concept-induced changes at the macro level

How can change happen? How do you connect new concepts at all levels? Understanding what is happening at the micro level hooks on institutional, structural and cultural complexity (Dieleman, 1999). Insights into those complexities help to provide important views about the actors and their systems boundaries. Their personal backgrounds and experiences (knowledge, motivation and commitment) and the organisational contexts – such as competitive or co-operative adaptability, centralised or decentralised orientation, the capability and ability to identify and transfer innovations, the power (restricting or sharing) and the status of the management – are all phenomena that are very difficult to change. And when change does occur, its scale is difficult to assess: are the changes of a first or second order and what is the time frame for the research? As Grubner (in Ausubel, 1997) said: `..we often fail to appreciate the speed and rhythms of social clocks..'.

And who will provide the fondament for fundamental change on a subject that is not core business? Governmental organisations can make requirements, but respect the company as "black box"; or, in case of disinterest or unwillingness on the part of a company, can even be misled (Peppel, 1995). Concepts may be developed outside industry and also get tested in restricted conditions, where individuals play an important role in the implementation within their organisations. This means that in case of fundamental change, the role of education comes into sight. When networks of various stakeholders provide the conditions for the development of tacit knowledge about new concepts, the next step is to operationalise tacit knowledge into explicit knowledge that can be used in practice.

In relation to concept development, the focus of the introduction of cleaner production was mainly translated in isolation within the boundaries of an organisation: outside actors introduced the concept for further elaboration. Depending on commitment and urgency, the translation by the organisation might affect the routines. Most of the findings in cleaner production projects are based on assessments of selected processes (see Annex V.1). The analysed improvements can be characterised as incremental steps: when the results are implemented, they are limited to the adaptation of materials and production processes. Organisational change is not involved in that approach.

In relation to the dissemination of the cleaner production concepts, it was believed that providing evidence of an individual company's positive environmental and economic experience with cleaner production would be enough to automatically lead to rapid and widespread mimicking by other companies on a voluntary basis. Because the cleaner production concept was based on a change in environmental management perspective, it was not in line with the concepts of enforcement through regulations. And, although the government also perceived the cleaner production concept as business-fit, they continued to be locked into the roles and routines of a pollution control approach that did not provide any change in the context of external influence on the industries.

In seeking to answer the question whether the elaboration of cleaner production constitutes a paradigm shift in concept innovation, it can be observed that the scope of the environmental management infrastructure is changing for the major societal stakeholders. Some key changes have been taking place. Among them, the following may be the most important:

a) At government level, regulatory approaches have been extended with self-regulation and stakeholder policies;

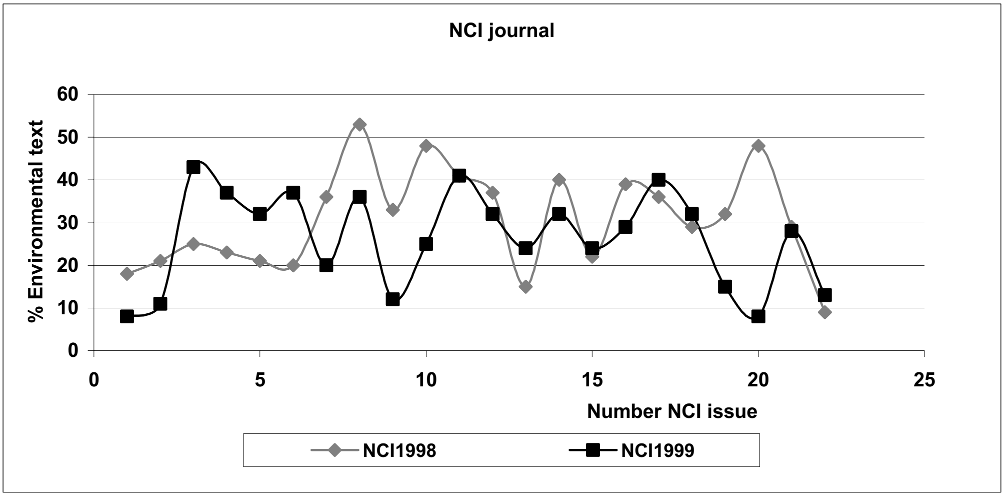
b) At the industrial level, internal environmental management is changing: there is a move away from using employees who have gained their insights and skills via on-the-job learning towards operational management by newly-trained management;
c) At the strategic level within some companies, there has been a move from a primary focus on end-of-pipe approaches to including pollution prevention policies and technologies;
d) Further, within some companies there is a shift from an internal environmental focus to more open approaches that include stakeholder dialogue and corporate social responsibility policies;
e) At the environmental advocacy group level, group strategies have grown – from protesting only to a combination of action, dialogue and facilitating policies;
f) At the personal level, *green champions* have found new motivation in sustainability aspects such as social concern, intergenerational equity, formal position and empowerment, and gained a credibility that can help broaden the scope of their stimulating activities: from environmental management (via cleaner production and industrial ecology) towards sustainability development;
g) Furthermore, part of the change is based on diffuse issues, among other things the newly-trained employees, whose environmental thinking is more implicit, and who are more favourable to using environmental management as an integrated management approach instead of as a mere instrumental necessity.

Undoubtedly, environmental issues are increasingly being integrated in industrial activity and this may be considered as a fundamental change in industrial management. Negatively formulated, since the late 1990s no company can afford to deny the environmental aspects of production and products. It has also become clear that internalisation and self-responsibility are necessary processes in an integrated management approach to uncertainty (Hommes, 1988). Also, as the Shell/Esso Brent Spar case taught us, a company does not automatically receive public approval through a governmental agreement on intended actions relating to the environment (the responsibility for a sound environmental performance is everybody's, not just the government's).

What kind of developments can be observed in the late 1990s and early 2000s? Are they traditional and incremental (Norberg-Bohm & Rossi, 1997) or radical (Williams *et al.*, 1997) or a combination of both? Different companies employ different approaches, depending on their company culture. But in essence, has there been much change towards sustainability? Although the environmental burden of pollution per unit of production may have decreased, the total amounts of pollutants released as well as the energy and resources used are still out of balance with nature's carrying capacity. Additionally, the environmental burden is increasing due to the rebound effect as well as because of continuing human population growth.

In the period 1998 - 2000, environmental issues received continuous attention in the bi-weekly journal of the Association of the Dutch Chemical Industry, the VNCI. Coverage of environmental issues was on average 30,1% in 1998, 24,7% in 1999, and 24,2% in 2000 of the total text (NCI journal, 22 numbers annually in the 1998, 1999, and 2000 volumes). Figure 6.1 shows the fluctuation per journal issue in 1998 and 1999:

Figure 6.1 **Overview of the amount of text about environmental issues as a percentage of the net total text in NCI Journal issues (1998 and 1999 Volumes)**



The nature of the articles[108] ranged from sometimes defensive opinion pieces to items drawing attention to emerging issues. Currently, CEOs of many multi-national corporations claim that "sustainability" is the basis of their activities. As illustration in the 1999 GIN conference, some CEOs explored social responsibility in order to legitimate the exploration of new markets (Rossi *et al*., 2000).

In a report of environmental management research by KPMG/NIPO (2001) – about Dutch companies – it was observed that company managers often consider end-of-pipe technology and cleaner production as being the same. The basis of this belief is that environmental issues are not core business and thus do not provide many incentives to acquire new knowledge. In general, findings concerning the cleaner production dissemination practice stress that although environmental technology has developed integrated circular flow techniques, end-of-pipe technology still plays a dominant role in the industry as a rational response to environmental regulations. This may arise from short compliance schedules, specific technological pathways or simple cost-effectiveness.

Generic technologies (often end-of-pipe), developed by dedicated equipment suppliers, often diffuse more quickly than genuinely clean technologies (Skea and Smith, 1997). The same outcomes have been found in Asia,where the Asian Development Bank (2001) concluded that industry was making increased use of end-of-pipe pollution control equipment, ranging from air filters on smoke stacks to catalytic converters on cars. Even though there is a preference for pollution prevention, end-of-pipe pollution control equipment remains an economically viable response to some air and water pollution problems. This is

[108] In the opinion pages of the NCI journal, the editor reflects a perceived tendency of continuous government threats (involving eco-taxes, and benchmarking, CO_2 and NO_x policy) by using traditional defensive employer's language and referring to the negative effects on international markets (see issues 18 and 21 of the 1998 volume).

still being stimulated and favoured in several dissemination programmes, such as the European Union's environmental technology stimulation programme for Asia (Bergeron, 2001).

The Swedish Delegation for Sustainable Technology (2000) stated that one might say that the object of sustainable technology is to reduce the overall risk of adverse environmental impacts, whilst that of purification (end-of-pipe) technology is to ensure that emissions, pollutants and waste products are prevented from escaping into nature. Furthermore, it is stated that in the present situation both sustainable technology and purification technologies are needed to reduce negative impacts on the environment. However, their report concludes that the dissemination of sustainable technology is difficult and time-consuming. This implies that end-of-pipe technology is simpler, and is preferred for this reason .

With respect to the philosophy of the preventive approach, the bottom line has often been illustrated with the saying: `.. a gram of prevention is better than a kilogram of cure..'. But you cannot manage a problem that you do not know about. In the case of cleaner production, the method is not to solve the problem but to prevent it. This is a deduction in two ways. Firstly, a new problem has to be present before it can be recognised, also as regards prevention. The inventor and first advocates of the pollution prevention approach can be compared with experts in a pre-problem phase according to the theorem of Downs (1972). Secondly, the problem that has to be prevented is deduced from other processes such as the life-cycle of production processes, and their products and services as core business of organisations. Here the reluctance to change and inertia relating to the use of existing routines are similar to Downs' diminishing attention and marginalising phases.

Discussions about the proper semantics for new preventive concepts related to industrial activities illustrate the observation that it takes much time and personal energy to discuss what cleaner production is; this is to the detriment of what we could learn from evaluating cleaner production concepts and their practical improvement. One possibility of dealing with this is worldwide standardisation. Under the ISO 14001 designation and other chapters of this environmental management system design, environmental management and auditing were standardised. Avoiding the question, for the time being, of whether the substance of this standard is adequate or not (Hobbs *et al*., 1997), it can be said that ISO 14001 ensures worldwide acceptance of the many issues of environment management.

The case of the cleaner production and pollution prevention concepts is different. As a general conclusion, it can be stated that the original cleaner production/pollution prevention concepts were/are not industry's mainstream approach. The term *good housekeeping* is generally known. Based on that, the translation of the concept followed the line of specialised professional educational training and became a part of new concepts such as industrial ecology and sustainable enterprise. It was also modified in practical applications and policies, of which some were supporting of, and others were different from, the cleaner production philosophy. With the current focus on cleaner production, standardisation of the terms (by which organisation?) is not expected. The UNEP's International Declaration on Cleaner Production in 1998 was designed to generate more attention at the high policy levels of nations, large corporations and global institutions; it stresses cleaner production and the links between the different terms as preferred options towards sustainability. This is useful when terms such as eco-design express the in-depth elaboration of specific issues under the umbrella of cleaner production. When this is not directly clear to persons, confusion about the terms comes in. As long as professionals in this field too frequently have to explain the meaning of the terms they use, they will continue to be confronted with a tangled web of terminology.

As a consequence, the actors' perceptions in the market metaphor are heterogeneous and translated according to their own worldview. Large subsidy programmes in the Netherlands that involve many stakeholders – such as consulting firms for the dissemination of preferred environmental management systems, and labour unions involved in educating their staff members – continue to dominate this area (Buys and Hofman, 1991). Industry and government prefer environmental management systems that are standardised on the basis of encoded knowledge; cleaner production experts favour the guiding principles of cleaner production (including a mix of encoded and tacit knowledge) that are business-fit in their perspective. In the perception of industry, cleaner production is an environmental issue, although the efficiency elements at the good-housekeeping level are translated within their activities. This know-how has mainly been disseminated via significant other fora, such as branch organisations and specialised expert and technical journals, and not so much via academic journals (which would fit better in an academic perspective).

This also applies to governmental organisations such as ministries of environment. Their focus is on the solutions to environmental problems such as the facilitation of eco-tools and instruments that are based on the body of knowledge created by specific assignments and general publications. The publications of academic bodies about the results of their scientific activities are read and exploited by very few outside academia.[109]

6.4. The meso level of organisations and cleaner production

At an organisational level, environmental management systems have been implemented (based on existing environmental technology practices). As a conclusion it can be stated that industry associations and the Ministry of Environment have stimulated the development of environmental management systems in the Netherlands. The incremental changes in existing environmental management routines have dominated the translation process of incorporating environmental issues into company management. More recently, some good housekeeping practices have been assimilated.

In the starting phase of cleaner production dissemination, the fact that in most of the pilot projectsd the message of cleaner production brought about uncertainty about results and did not deal with a direct problem (and consequently not a direct need) formed a major barrier. Cleaner production illustrations provided by other countries were not convincing. Often the organisation's reluctance was translated in the reification (Morgan, 1980) that `..the organisation already does so much on environmental policy..'. Mimicking did not work without institutional pressure, even, in a later dissemination phase, the mimicking of cleaner production projects in the surrounding area or in company subsidiaries. In one case, when there was a problem (a tapestry manufacturer was taken to court for environmental violence – see Boons, 1993), the tapestry became sensitive for starting cleaner production learning processes that went beyond single-loop assessments. In this case coping with threatening externalities provided a better motivation and legitimacy for both management and

[109] According to a representative of the Dutch Ministry of Environment during a workshop on eco-induced change processes in industry, Rotterdam, 7 April 2000.

employees to explore new approaches. The one-loop assessment brought much food for thought and learning: the possibilities of cleaner production, the substitution of toxic compounds, the tacit knowledge of the employees, and ..`the dream of one manager: a green carpet'. As a consequence of evaluating all these issues, a new full-time position was created to catalyse the further development of the process, including the learning experiences and processes of change in the organisation.

But when a special reason for going further was absent, managers preferred the environmental management systems above the uncertainty of cleaner production outcomes as a corporate approach to the translation process. When they joined cleaner production projects, and independently from their starting position, the translation usually stopped after a single-loop cleaner production assessment and the eventual implementation of some good-housekeeping measures. Following the line of the market metaphor, even when actors utilised more integration and prevention of environmental issues by applying new practices such as good-housekeeping, eco-design, and total cost/benefit accounting (or environmental management accounting), the traditional corporate routines in the system did not change fundamentally.

When, on the other hand, an efficiency investment (with the help of technological innovation) into the production processes is made, the results are the other way around. An interesting illustration of this is that the new cracker refinery installations at the Exxon plant (Flexicoker) and the Shell plant (Hycon) in the Rotterdam harbour area received compliments from environmental advocacy organisations for their pollution reduction. But the plant managers had to admit that the environment had hardly played a role in their decision-making process. The decision was mainly based on the wish for a more competitive position through technological innovations that created increased profits. Remarkably, this unintentional practice, in essence the *environment-included innovation approach,* might be the optimal pathway towards sustainable development (Baas, 2000).

And when, in some companies, such as in the dairy case presented in Chapter 4, a continuous improvement team is at work, its incremental steps keep within the harmonic framework of the previous corporate routines. The incremental approach does not affect the underlying guiding principle of cleaner production. This means that the shift in mindset – if any - is not radical.

For the implementation of new concepts – especially in SMEs – special attention is required to the facts that there seems to be too much information to digest and too little time to devote to possible improvements. During the process of providing information aimed at awareness-raising and during demonstration projects, the concepts are modified, specified and translated under different labels. It is considered that the many concepts that have emerged with the growing attention given to environmental management, are not the core business of companies. However, encouragingly, more companies are now working on the integration of environmental aspects into their company's management. The traditional outsider view of companies as *black boxes with their own responsibility* is changing towards a stakeholder approach. In particular, multi-national corporations have become involved in the sustainability debate, which requires that a much stronger societal responsibility has to be embedded in their total operations. The joint environmental, social and business economics approach in the large industrial companies is increasingly being perceived as their integration into sustainability (the triple bottom line).

6.5. **The meso level: are organisations becoming increasingly similar?**

The question of whether organisations are becoming increasingly similar has been discussed many times (DiMaggio & Powell, 1983, Sahlin-Andersson, 1996, Boons, 1999). For example, the emergence of environmental problems has often resulted in homogeneous forms of environmental management.

At first, the practical approach to solving environmental problems was dominated by technology at the operational level. The employee who was responsible for dealing with environmental issues performed his/her job in a reactive relationship with the government. The application of end-of-pipe technology belongs to this period.

The preventive concept made it clear that other disciplines and functions are of value to processes of organisational change. Whether such changes should be the result of radical or incremental processes has seldom been discussed. Hirschhorn (1997) assumed that pollution prevention would lead to radical changes in industry. On the contrary, Cebon (1993) assumed that incremental steps would lead to changes in industry. Cebon views three decision-making stages as critical with regard to incremental changes: identifying a pollution prevention opportunity, finding a solution appropriate to that opportunity and implementing that solution. Three important aspects of organisations affect these three stages: their culture, their ability to process information and their politics.

In general, the uncertain relevance of new, unsettled knowledge pulls it vertically to the centre of an organisation, where its exposure to remote and different knowledge is greatest (Schulz, 2001). Also Afuah (2001) argues, in the case of a technology change, that firms that are organised vertically with new technology will perform better than those that are not. However, Volberda (1998) states that strategic management planning and methods have had their benefits, but have also led to a dogma that contributes to a standstill and decline of organisations. Volberda observed evidence of a turn from a prescriptive to a descriptive approach of corporate strategic management. Prescriptive management is based on a top-down approach, is planned and is analytically viewed as a perfect rationality. Descriptive management is based on a bottom-up approach and is spontaneous and visionary in a bounded rationality context.

The type of management that is running an industrial company is also part of the context in the analysis of the cleaner production implementation process. With a bottom-up approach, the involvement of persons in organisations was marginal and was co-ordinated via the employee responsible for arranging the requested permits and treatment of waste. Because end-of-pipe technologies are physically quite separate from the rest of the production processes and are managed in the margin of organisations, the conclusion of this thesis is that a platform for understanding holistic cleaner production approaches is lacking. The organisations consist of separate circuits, such as a set of routines focused on the co-ordination of the primary process and a set of routines caring for environmental issues, designed to gain legitimacy for those activities (Meyer & Rowan, 1977). Also, there is a gulf between the knowledge applied by technical management and the practical knowledge applied on the shop floor. This pattern can also be seen in the length of employment in one position: plant managers and most of the engineers rotate frequently; operators, on the other hand, often keep the same job for a lifetime. This phenomenon is part of the cultural and institutional aspects that prevent the integration of tacit and encoded knowledge.

In the development of environmental management, the same phenomenon occurs. The reactive approach was changed by the awareness that other solutions could be more efficient and business-fit. More integration within general management meant that more actors at various levels in the organisations became involved in this management process. Although increased attention to, and management of, environmental issues has changed corporate environmental management - and has become the foundation of companies such as Ecover and the Body Shop - encoded knowledge of environmental management and standardisation systems have dominated recent developments.

Various tools and instruments, formal environmental policy statements, and corporate strategies support environmental management systems. But for now, `..the dream of the sustainable enterprise - the final stage of the corporate journey, apparently characterised by the subordination of profit to environmental performance - (*still*)[110] appears to be just that..' (Roome, 1992). Of course the clock for social change needs time. Furthermore, it will always be difficult for new concepts to be tailor-made for all types of entities. However, based on an economic approach outside corporations, financial instances are finding increasingly better investments results in environmentally-aware, well-organised companies. In this way, the concepts of cleaner production have influenced the sustainability debate positively.

The dissemination of new concepts first faced the fact that entrenched standard operating procedures and other routines (Saunders, 1976) had important effects on decision-making processes concerning cleaner production by regulating the access of participants, and the patterns of negotiation and consultation. This was because it affected the participants' allocation of attention, their standards of evaluation, priorities and perceptions, identities, and resources. The hermeneutic approach of cleaner production was concept-driven, with the implicit assumption that one-loop assessments results would both generate new loops in the organisations and disseminate the concept to other organisations. Accordingly, the cleaner production concept-driven research was assumed to generate radical 2nd order changes via learning loops with demonstration projects, dissemination and continuous improvement. Also Hart (1995) assumed that pollution prevention is important for sustainable development, because it is the first step in a learning process about the company's need for appropriate capability development. At the start of cleaner production assessments it was implicitly assumed that the assessment loop would create the required receptivity both to tactical and strategic learning. However in relation to the dimensions of power, it was mainly the internal individual position that influenced the information and interpretation that constituted the data for decision-making on further cleaner production processes. In almost all cases, the existing routines were scarcely influenced by the *one hit* intervention.

The findings of Argyris and Schön (1978), namely that most organisations do quite well in single-loop learning but have great difficulties in double-loop learning, were confirmed in cleaner production projects, although the learning was limited as regards content and the number of company representatives. The conclusion of Argyris and Schön was based on case studies in which organisations faced a problem. In that situation the participants, acting as agents of organisational learning, were able to detect and correct errors as long as the original objective – to produce X – was not questioned. Many of the cleaner production projects were not based on existing problems, so a question articulation and motivation for a solution was often absent. Other motivations must be present, such as in the case of the dairy company (Dieleman *et al*., 1991): the plant manager's motivation and perception were shaped by the

[110] My addition.

information about cleaner production by a significant other that fits to his own preference of a good environmental performance.

6.6. The micro level of organisations and cleaner production

What we have seen until now is that at the micro level, cleaner production assessments in demonstration projects generated incremental, temporary, 1st order change in cleaner production learning processes at the level of good-housekeeping and for a limited number of persons within a company. Besides that, the concept was translated within professional sub-disciplines such as eco-design and total cost accounting. 2nd order changes in cleaner production implementation were either stand-alone incremental changes, or involved the use of methods such as brainstorming sessions and continuous improvement teams. Radical 1st order changes, such as cleaner production innovations, were scarce.

In the start-up phase of the cleaner production dissemination research, cleaner production projects were distinctive projects for an organisation. There was a high level of uncertainty about the results, and the approach involved a research model that was not usual in the organisation. In general, the uncertain relevance of new, unsettled knowledge pulled it vertically to the centre of an organisation, where its exposure to remote and different knowledge was greatest (Schulz, 2001). The structure of the cleaner production assessment did not work like Schultz's analysis in order to avoid the routines of environmental regulatory thinking. In the cleaner production assessment method, top management commitment was required at the start of the project, but continuous feedback and communication were ignored in the assessments. Although cleaner production was presented as a business approach, the assessments were usually primarily focused on environmental issues. The assessment results could be sufficient, but provided no incentives for a breakthrough in environmental perception. The lack of management commitment to further dissemination affected the vertical spread and breadth of organisational learning. The horizontal spreading and translation of the new knowledge was limited to good housekeeping. The single-loop interventions only affected learning processes at the level of 1st order changes.

There were differences in the attitude of the participating companies; most of them were perceiving the projects as one-hit interventions. But even when the companies were positive about the results of a cleaner production assessment, they often lacked the willingness and organisational capacity to change and continued with their safe normal practices.

The general lessons learned from the failures worldwide (see Section 5.9.4: UNEP, 2000) support the conclusion that the cleaner production concept needs a broader type of assessment, including a surroundings and an organisational analysis. The surroundings analysis must involve the current situation with respect to regulation, economy, location and possible trends in markets, and general and specific government policies influencing sustainability. The internal analysis must involve the assessment of organisational structure and culture and must assess, independently from the cleaner production concept, the possibilities for change in the organisation. The learning and innovative capability of an organisation is, in relation to this approach, critically dependent on its capacity to mobilise tacit knowledge and foster its interaction with explicit knowledge. This is relevant for both in-company innovation and network development.

In general, the dimension of good housekeeping was well spread; the dimension of new knowledge, however, could be translated into old knowledge – (eco)-efficiency – and mastered in routines within incremental learning processes. At the level of organisational and technological development, and with new investments, the changes were diffuse. Environmental aspects were reflected within new investments, but a full integration was still marginal. For Instance, the environmental co-ordinators of large subsidiaries of multi-national corporations in the Rotterdam harbour and industry complex were involved in decision-making about environmental investments, but only 50% of them were involved in decision-making about general investments (Baas, 1994).

6.7. Summary of the major conclusions of cleaner production dissemination

In general, the findings reveal that although environmental technology has developed integrated circular flow techniques, in practice end-of-pipe technology still plays a dominant role in the industry. At an organisational level environmental management systems have emerged (based on the existing practices related to end-of-pipe and clean technology, and with the implementation of good housekeeping practices). Briefly summarised, they were mainly 1st order changes with small improvements and adaptations that did not affect the system's core (Levy & Mery, 1986).

Table 6.2 Strong and weak aspects of the focus of cleaner production project variables

Variable	Strong focal aspects	Weak focal aspects
Character of approach	Engineering process	Social process
Organisational process of change		One-hit intervention Departure of external project team members before implementation Implementation of assessment results Continuous improvement
Management process	Bottom – up	Need for continuous commitment
Learning process	Encoded	Tacit
Dissemination	Demonstration projects that work	Development of cleaner production dissemination policy in management, networks and stakeholder approaches

With respect to funding, some organisations were directly related to the development and/or dissemination of the cleaner production concept. Other funding organisations had other targets and used the projects as a vehicle for those targets. In the development of funding – from single dissemination project to the stimulation of the concept, via cleaner production programmes – the Dutch Central Innovation Centre played an important role as an intermediary organisation. The Ministry of Water Management and Transport and the Ministry of Economic Affairs were connected more closely to the innovative characteristics of the process-driven cleaner production concept than the Ministry of Environment, which had started with pollution control as a basis.

On the whole we can conclude that the industry perceived the new cleaner production concept as belonging to environmental public policies, whilst the Ministry of Economic Affairs perceived the concept as belonging to industrial innovation policies. The introduction of the new concept received funding because of the status of the parties that supported it, namely the universities. Not all funding organisations were eager to fund the substance itself of the new concept, but perceived their contribution as an instrument towards the fulfilment of other targets.

The lessons that can be drawn from the emergence of the cleaner production concept are that the perception of the concept, derived from the institutionalised framework of organisations, played an important role. Furthermore the power position of single actors, who wanted to test the value of the new concept, is a variable to provide incidental funds for cleaner production research of the concept in its emerging phase. The success of the first demonstration projects made more funding possible in the initial growth phase of the concept. In the final growth and early mature phase, the funding was fine-tuned, as in the case of multi-annual *Schoner produceren* (Cleaner production) programmes in the Netherlands.

Despite the general perception of the *cleaner production "sirens"* (Baas, 2001) that preventive approaches were attractive for all stakeholders, the "temptation" of the concepts seemed to be counteracted by the confinement of organisations inside the pollution control infrastructure and mindset. Besides this, industrial organisations are more strongly influenced by stakeholders to take the direction of preventive environmental performance. In particular, multi-national companies face internal and external institutional pressure (Scott, 1995) to develop and implement concepts of sustainable companies.

Ecologically-induced organisations (Boons *et al.*, 2000) that have participated in cleaner production and single-loop learning processes based on technically encoded knowledge have generated small improvements and adaptations, but have not changed the core of their system until now. It can be concluded that the cleaner production concepts spread rather well in the area of good housekeeping and in decision-making processes concerning new technologies (Williams, 1997). However, the full internalisation of the cleaner production approach[111] was different. The normal preventative practice still is mainly made up of the traditional decision-making followed by an inspection of the environmental impacts. A paradigm shift towards an environment-included (internalised) decision-making style inside company management was scarcely to be found: `..That might be the reverse interpretation of the story in the Odyssey that the industrial raft will, despite resistance to the temptations of the singing of the sirens, still hit the rocks..' (Baas, 2001).

In relation to the questions: `How did companies translate the concepts of cleaner production and industrial ecology into action? How did the concepts of cleaner production and industrial ecology implementation processes deal with the learning processes? What can be concluded about the processes of change leading to the implementation of the concepts of cleaner production and industrial ecology?', the research shows that at the meso level, the environmental management system concept fitted with the self-regulation wishes of industry and the government. This was in contradiction to the pollution prevention approach, which involved uncertainty about the results of the project. Furthermore, the representation of different types of staff and different operational levels in a bottom-up assessment approach influenced the existing power position in the company. Management commitment to such a project could be secured in a manner that only reflected the technical production process. The main approaches to participation in such projects in the emerging and growth phases of the cleaner production concept were neutral in the following sense: experiencing social control,

[111] Under a full internalisation of cleaner production is meant that in every company decision the environmental aspects are included in a preventive way.

`we cannot say no' (allow), giving priority to an environmental management system (neutralise) and the accommodation of the project (pacify). Also a positive approach was cautious: balancing between expectations and reluctance (balance) or the translation of the concept into an institutional model (influence).

Although the cleaner production concept was said to go into the organisational's black box by starting to focus on the issue of attitudes, it was only marginally in practice. Of course, the assessment process addressed issues of organisation, technology and finance, but only in a deducible way. The main focus was upon the technical assessment; and as a result of the limited time and commitment allotted to doing research, the learning processes – such as where to find information about reducing environmental pollution – were not adequately developed. The implicit assumption that the assessment loop should create both the receptivity to tactical and strategic learning and continuous improvement was taken for granted for a long time. It prevented the researchers from paying more attention to the structure and culture of the organisation and to the ability of the assessment model to deal with that. In further pollution prevention developments, the attention to social change processes continued to be neglected.

All together, the dissemination of the cleaner production concepts has been very instrumental. Changes in the institutionalisation process of cleaner production were seen by governments (in their development of cleaner production approaches) as a new policy area that asked for the organisation of prevention teams in provinces and large municipalities. As most activities were based on formal and encoded knowledge, efforts to develop more simplified methods such as quick scan approaches were preferred. This development was found to be insufficient in order to influence the transition towards sustainable societies.

All together, at the macro level, there are indications that the concepts of cleaner production have influenced the transition processes towards greater awareness of involving social aspects in the concept of sustainability. The cleaner production concepts have gotten rid of the defensive industrial approach toward environmental issues and have in this way at least indirectly created an opening for sustainability discussions within industry. One of the central themes of institutional theory is that organisational characteristics are not only determined by efficient solutions to the co-ordination problems, but that they can also be understood as an attempt to gain societal legitimacy. Meyer & Rowan (1977) base their hypothesis on these separated circuits within organisations: a set of routines focusing on the co-ordination of the primary process, and a set of routines meant to gain and keep the legitimacy for those activities.

The cleaner production concepts have become acknowledged in parts of companies concerned with the legitimacy of environmental management, consulting firms, branch organisations, as well as within several government departments (awareness-raising programmes facilitated by the Ministries of Economic Affairs and the Environment, expertise development at RIZA, provincial and large cities prevention teams). Professionals and academics carry out research about the prevention concepts and publish their findings in scientific journals. After more than two decades of experience with cleaner production, dissemination of the concepts has progressed so that many corporate leaders now know something about cleaner production, especially about simpler good- housekeeping measures.

Also, it was found at the end of the 1990s that in cleaner production dissemination, attention was given more frequently to the human dimensions of organisational change designed to ensure continuous internal improvements and external dissemination (Baas, 2000, Stone, 2000). Although cleaner production concepts had been portrayed as being based on a business perspective – rather than on a regulatory perspective – the fully integrated concepts of prevention have not been incorporated into the strategic decision-making levels of companies.

7 The Period 1989 – 2000: an Eco-Industrial Park in Practice

Eco-industrial parks are applications of industrial ecology. They utilise material flow assessments in order to make decisions about coupling resource streams between different companies so that that they can exchange waste materials, raw materials and energy among each other, thereby reducing the net inputs and outputs of the industrial park (artificial ecosystem).

This chapter describes and analyses the emergence and results of an industrial ecology project in the Rotterdam Harbour and Industry Complex in the period 1994 – 2002; it also presents some simular industrial ecology developments across the world.

The ***IN****dustrial* ***E****co****S****ystem* project in the Rotterdam Harbour and Industry Complex (INES project, 1994 - 1997) was inspired by the Kalundborg *Industrial Symbiosis* project that is briefly reviewed in Section 7.1. The description of the INES project starts in Section 7.2 with the results of a questionnaire that was designed to gain understanding of both the state-of-the-art of environmental management systems and of the knowledge of environmental co-ordinators of new concepts, as well as their perception of their position in the company in the year 1994. That knowledge was the basis for a workshop with environmental co-ordinators at the start of the INES project that aimed to improve ecological and economic performance thanks to industrial ecology projects that cross the borders of single autonomous companies in a geographical area. The results of the questionnaire also provided insights into the existing regional co-operation of the environmental co-ordinators during the implementation of internal environmental care systems in their companies.

The follow-up project, INES Mainport (1999 – 2002), is described in Section 7.3. The INES Mainport project elaborated on several INES sub-projects, explored new approaches (such as cluster management), involved stakeholders in a Strategic Decision-Making Platform, and developed a vision and mission statement for the INES Mainport project. During that period, the industrial ecology concept was applied both to industrial parks comprising various companies and to chemical sites of only one corporation containing many of its own plants or different corporations (*co-siting*). In Section 7.4, it will be seen how under the label of co-siting, plants in several industrial complexes started to become connected in an industrial ecology construction, for instance in the Dutch industrial complexes of DOW Terneuzen, the Huntsman (formerly ICI) Rotterdam plant area, the Shell Chemicals Pernis plant area and the DSM industrial area in Geleen. Not only intended actions, but also side effects from the processes of liberalisation in the energy sector, have influenced the development of industrial ecology in practice (see Section 7.5). The way in which the dissemination of industrial ecology developed worldwide (Section 7.6) mimicked the Kalundborg approach. The institutional dimensions of these dissemination processes are described in Section 7.8. Before that description, the trends of industrial ecology in the Netherlands are discussed in Section 7.7. Section 7.9 recapitulates several dimensions of the industrial ecology developments in the Rotterdam Harbour and Industry Complex. This is followed by provisional conclusions on the development of industrial ecology in Section 7.10.

Industrial ecology is a label under which a diversity of linkages between production and consumption processes is grouped. From an institutional perspective this diversity can be categorised according to system boundaries of co-ordination linkages influenced by the choice of *optimisation domain*: either via product life cycles, material life cycles, sectors of industry, geographical areas, markets or a mixture of these domains (Boons and Baas, 1997). Co-ordination can also be conducted by intermediary organisations such as a supply chain organisation or eco-industrial park managers.

A number of inherent problems associated with the system boundary of the Rijnmond region were found during the INES project in the Rotterdam Harbour and Industry Complex; the problems were related to the dynamics of the evolving industrial ecology. In Chapter 8 this development will be analysed both in terms of *static* and *dynamic* issues associated with regional types of industrial ecology. The aim is twofold: to provide a useful analytical framework for the investigation of regional industrial ecology, and to develop a prescriptive approach that can stimulate such industrial ecology. This approach is based on a social science application in contrast to the techno-economic approach of current conceptual and empirical research that draws on developments in the Dutch policy context. The development of the concepts of industrial ecology in relation to industrial parks, and especially the case of the industrial ecology project in the Rotterdam harbour area, will be analysed. The conceptual research is based in sociological and economic research, ranging from organisational learning to the analysis of industrial districts and organisational management theories.

The year 1989 can be regarded as a starting point because of the re-emergence on the environmental agenda of industrial ecology in the wake of an article by Frosch and Gallopoulos (1989). The U.S. Academy of Engineering promoted the concept very much. Also a link with the Japanese Ministry of Trade and Industry was established and strengthened in the course of several workshops in the period 1993-1994 (see for instance Richards and Fullerton, 1994).

In practice the concept of eco-industrial parks evolved from waste exchange between companies towards integrated regional ecosystems. The implementation of industrial ecosystems was considered on existing (*brown fields*) and new (*green fields*) industrial areas. An industrial ecosystem must be designed in relationship with the characteristics of the local and regional *ecosystem* but its development must also match the resources and needs of the local and regional *economy*. According to Lowe (1996), these dual meanings reinforced the need for working in an inquiry mode: learning from the experiences of other communities developing industrial ecosystems is important.

In this part of the thesis an analysis is made of the INES project, on the basis of the data gathered by the author in his role of interactive researcher and observer of industrial ecology projects, together with interviews of key actors. After the start of the INES Mainport project (1999 – 2002), an observation position in the strategic platform in the project was utilised. During the INES Mainport project the decision-making process of a new industrial area – called Maasvlakte2 – was unfolding. During this period, *industrial ecology* and *new industry*[112] emerged as concepts for designing the new industrial space.

[112] The label *New industry* is used for new activities in the field of metallurgy, recycling, raw material technology and energy technology in the soon to be reclaimed Maasvlakte2 area (Conference *New industry*, Delft, March 2001).

7.1. **Kalundborg, the world's industrial ecology reference**

The most famous reference in the field of applied industrial ecology is the *Industrial Symbiosis*[113] project in Kalundborg in Denmark. Every book (including this thesis), numerous articles and conferences about industrial ecology make repeated reference to the Kalundborg industrial area. This is often followed by the observation that there is no other recognized mature example of industrial ecology in practice (Industrial Symbiosis Expert Symposium, Yale University, 2004). The Kalundborg situation has been copied all over the world since the mid-1990s. This means that the new eco-industrial parks are all at an early development stage, either in the design or in the starting phase. In discussions of, and references to, the Kalundborg system it is seldom reported that that Industrial Symbiosis programme grew organically on a social-economic basis in a small community where plant managers knew and met each other in a local community atmosphere.

In the last thirty years of the community's evolution, a partnership grew between several industrial plants, farmers and the municipality of Kalundborg. This partnership led to huge improvements in the environmental and economic performances of the Kalundborg region (Christensen, 1994). The core partners in Kalundborg are a power station, an oil refinery, a plasterboard factory, an international biotechnological company, farmers and the municipality. These partners voluntarily developed a series of bilateral exchanges such as:

- The refinery provides the plasterboard company with excess gas,
- The power station supplies the city with steam for the district heating system,
- The hot cooling water from the power plant is partly redirected to a fish farm,
- The power plant uses surplus gas from the refinery in place of coal,
- Sludge from the biotechnological company is used as fertiliser in nearby farms,
- A cement company uses the power plant's desulphurised fly ash,
- The refinery's desulphurisation operation produces sulphur, which is used as a raw material in the sulphuric acid production plant,
- The surplus yeast from the biotechnological company is used by farmers as pig feed.

The Kalundborg site is described in many publications; one of these, Gertler's thesis at MIT (1995), has been greatly influential as a frequently cited source of information. Additionally, some actors of the Kalundborg plants themselves have disseminated the concept in various presentations across the world, such as at the UNCED conference in Rio de Janeiro in 1992, at the 4th Greening of Industry Network conference in Toronto (Christensen, 1994), and at the 2nd European Roundtable on Cleaner production in Rotterdam (Boons and Baas, 1995).

Managers at the Kalundborg site played the most important role during the development of Industrial Symbiosis. The small community of Kalundborg provided the platform for social meetings during local social activities such as school board meetings, music and stage performances. In that atmosphere, information exchange about problems and production helped to identify solutions beyond the single company level. In the beginning, this was on a purely economic basis. Later, environmental issues underpinned the legitimacy of the (`so-called') win-win approach of positive environmental and economic performance. Although the original design of the industrial park is traditional, new companies such as the gypsum

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113 The *Industrial Symbiosis* label was introduced by the spouse of a plant manager in Kalundborg in Autumn 1989 (According to Jørgen Christensen in New Haven, 8 January 2004).

plant and the fish farm were attracted thanks to the industrial symbiosis concept. The Industrial Symbiosis programme can be classified as a techno-economic programme with positive ecological results.

7.2. The INES project in the Rotterdam Harbour and Industry Complex

Due to its geographical location at the end of the river Rhine and near the North Sea, the Rotterdam harbour developed as the largest port in the world during the period 1960 - 2000. The harbour and its surrounding industrial area occupy a region that is 1 to 2 kilometres wide on the Northern and Southern banks of the river Rhine and about 40 kilometres long from East to West (starting in the Rotterdam urban area and ending at the edge of the North Sea). The harbour area occupies a transit position on the way to Germany, with many transport and storage facilities for both fuel resources (like coal and crude oil) and other goods, that are transported by inland waterway shipping, rail and road haulage. Value is added to the crude oil in the many refineries and petrochemical facilities. The industrial area has been an *environmental sanitation area* for many decades. The regional Environmental Protection Agency and Water Authority regulate all companies. Many, but not all,[114] companies are involved in various covenants – voluntary agreements between government and industry – such as the covenants on the reduction of Hydro Carbons, the Chlorine Fluor Carbon reduction programme, the implementation of environmental management systems, and the 4-year environmental management plan of a company.

The INES project in the Rotterdam harbour industrial area started with the participation of 69 industrial firms in 1994 (Boons & Baas, 1995). The project was initiated by an industrial association, active in the joint interests of industrial companies in the Europoort/Botlek harbour area near Rotterdam.[115] At the start in 1958, the interests dealt with the development of a social-cultural infrastructure for new employees, living in their new neighbourhoods. At a later stage, the focus shifted to quality systems, education, logistics and environmental problems. For instance, at the start of the INES project in 1994, most of the Deltalinqs companies had an ISO-9000 certified quality management system, and some were in a final stage of certification. As regards environmental management systems, 31% of the companies had implemented them and 62% were in different phases of implementation in May/June 1994.

Originally, the approach to environmental problems was very defensive. Later, a more constructive attitude was developed through the stimulation of environmental management in companies. Subsidies for the development and implementation of environmental management systems were also used for the supervision of this implementation process in the period 1991–1994. The industrial association stimulated the acquisition of knowledge about environmental management and the feeling of responsibility of the companies through a communication structure involving meetings of environmental co-ordinators in six similar sectors of industry.

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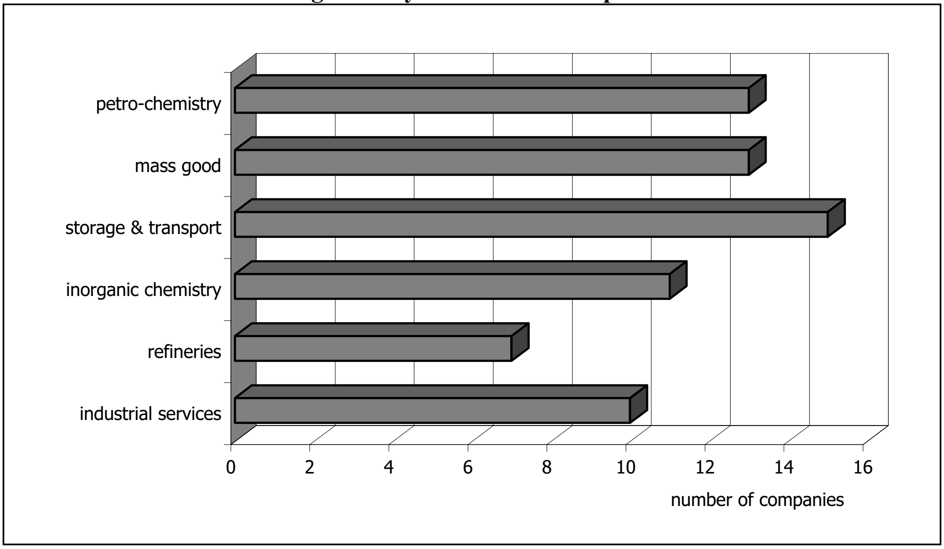
[114] One U.S. multinational corporation perceives the covenant as a risk in case of unexpected circumstances; they prefer to participate in separate projects of the covenant that are in conformity with the management policy of their organisation.

[115] The Dutch name was `Stichting Europoort/Botlek Belangen' (or Stichting EBB, in English: Association of Europoort/Botlek Interests); after a merger with another association of harbour-related companies in 2001, the new name was: Deltalinqs. The new name will be used systematically, including for the period when the name was EBB.

Figure 7.1 **Number of companies by industrial category in the communication structure of environmental management systems in the Europoort/Botlek area**



A consulting firm organised these meetings every three months; the main issues were information about new developments in environmental management systems and the exchange of implementation experience by the companies. This information supply by an expert and information exchange involving colleagues in recognisable situations fulfilled the needs of the responsible environmental co-ordinators completely.

The design of the INES project started after a cleaner production workshop in 1992 organised by the environmental science department of Erasmus University Rotterdam and the clean technology research institute of the Technical University Delft at the request of the Deltalinqs industrial association. The positive evaluation motivated the search for funds for a joint environmental innovation project through a partnership between the industrial association and the two universities, combining scientific knowledge about technology and economics.

The funds for an industrial ecology project were provided in 1994 by several government organisations, each with its own specific reasons:

- *Rotterdam Port Authority*: their reasons varied from the evaluation of self-regulation, the potential for fewer emissions, better use of scarce space, and for some representatives an added criterion was selling sites to new companies;
- *NOVEM*:[116] this organisation managed an *integral chain management* research programme and its subsidy on the basis of the Dutch National Environmental Public Policy Plan of 1989. Under the condition that the projects should be based on chains of five links, they perceived the INES project as a contribution to their programme;
- *Province of Zuid-Holland*: this public body perceived the industry's initiative to launch the INES project as a further expression of a new understanding of

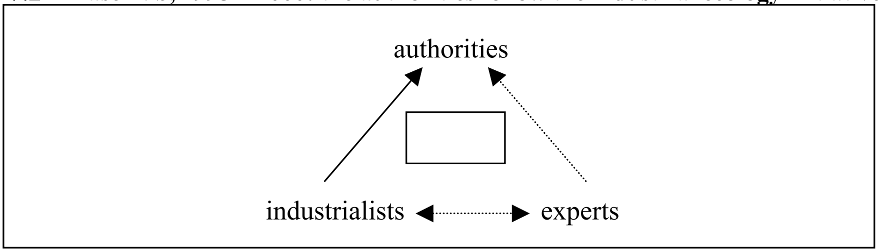
116 A company that grants research subsidies on behalf of the Dutch Ministry of Economic Affairs and the Ministry of Environment.

environmental performance and as a revitalization of the traditional approach, that involved hard bargaining processes;

- *Rotterdam municipality*: the project fitted in the city's policy to stimulate pro-active industry;
- *European Union harbour renovation programme*: intended for the renovation of old decayed harbours (and often used to re-develop them as new locations for attractive apartments), funds could also be used for industrial innovation in harbour areas.

The INES project team was chaired by a consultant and was composed of the environmental staff of the industrial association, the chairman of the environmental management communication platform of the industrial association, and researchers from the Technical University Delft and Erasmus University Rotterdam. The project team informed a supervision committee made up of the chairmen of the six environmental management working groups and reported to a steering group of funding organisations and a group of several government organisations that functioned as sounding board. Although the government representatives stayed far away from the details of project development, they had a very positive perception of the industry's initiative. Also the view that voluntary initiatives need space to develop contributed to another *who follows who* picture:

Figure 7.2 **Phase IVb, 1995 – 2000: the authorities follow the industrial ecology initiative**



The INES project (1994 – 1997) was a learning process for all the organisations involved. Information about the INES project was first provided to the Deltalinqs member organisations during a workshop in April 1994. Professor Huisingh of Erasmus University and two representatives of the Kalundborg Industrial Symbiosis project presented data about cleaner production and industrial ecology. The Kalundborg site representatives saw many challenges for industrial ecology during their orientation visit in the area. The systematic, holistic search for the possibilities to share resources across firms - symbiotic linkages to use the language of industrial ecology - was new in the region, although several bilateral arrangements already existed.

An illustration of existing industrial ecology projects is Eurogen C.V., a joint venture by a French oxygen producer, an American and a British chemical company and a Dutch energy supplier. They started exploring co-operation on the basis of separate needs at the beginning of the 1990s. The American company needed new installations, the British company faced environmental problems, the French company wanted to construct a new (highly energy-consuming) oxygen facility and the Dutch company was looking for environmental investments. Although it was not consciously planned as an industrial ecology system, the synergy of all separate environmental, economic and operational needs, that acted as the drivers for the co-operation, resembled an industrial ecology approach. The different national corporation backgrounds and cultures caused much delay. After two years of bargaining and preparation, the four organisations started their joint venture for electricity and steam generation using rest warmth and waste-water in 1995. The Eurogen project generated the basis for further joint activities such as: water cascading, extension of the utility complex, and joint transport for employees.

It is worth noting that the INES project was introduced to both environmental managers and co-ordinators, and local plant managers. The project was performed in co-operation with the environmental co-ordinators of the companies. Co-operation between industry and academia with a view to developing and experimenting with applied science for environmental purposes was a new experience.

At this stage, the existing environmental management system communication infrastructure for environmental managers provided the personal contacts needed for information exchange and connecting professionals. This infrastructure facilitated the introduction and acceptance of the INES project as a useful new approach in environmental management. As industrial ecology is about linking companies in various industrial sectors, university researchers preferred another communication infrastructure, that would be more suitable for such a construction. However, the success of the existing environmental management system communication infrastructure for environmental managers led the project's management to continue using that communication infrastructure.

7.2.1. *An environmental management questionnaire and its results*

An awareness-raising and education workshop was prepared on the basis of the results of a questionnaire sent out in May and June 1994 that inquired about the implementation of environmental management systems in the Deltalinqs member organisations and about the knowledge about industrial ecology and sustainability concepts. The survey was meant to give indications about educational needs in a one-and-a-half day training workshop for environmental co-ordinators. The survey was explained and handed over to the six different environmental management communication groups. Out of the 69 member organisations in the Botlek/ Europoort area, 55 organisations took part in the education workshop.

The response rate to the questionnaire was 46% of the 69 member organisations. The 15 storage & transport companies and the 13 bulk good transit companies had the highest response rates (53% and 61%); the 11 inorganic chemistry companies and the 13 (petro)chemical companies showed the lowest response rates (36% and 38%). The lower response in the (petro) chemistry and inorganic chemistry categories is remarkable, because they have more potential for industrial ecology than the other categories. At the same time, this can be an excellent reason for a prudent approach at an early stage of development. Furthermore, the differences in response are also influenced by the corporate structure and country of origin. The chemical companies surveyed were mostly plants belonging to multinational corporations with their headquarters in another country. This can affect the opportunity for company representatives to participate in the survey, as the following anecdote in Box 7.1 shows.

Box 7.1 *One corporate structure with two different outcomes – answering a questionnaire about environmental management systems in the INES project in 1994*

A multinational corporation had two facilities in the Europoort/Botlek area. One facility belonged to the corporation's European division, with its divisional headquarters in Belgium. The second facility was directly accountable to the corporation's headquarters in the U.S.A.. The first facility received permission to answer the questionnaire. The second one did not receive approval from the Head Office for liability reasons; the case had been assessed in a U.S. context.

One of the conditions of the Ministry of Environment relating to the covenant on environmental management systems (EMS) was that implementation progress should be measured regularly. If progress was found to be insufficient, new legislation should be drafted. The progress reports about this covenant were performed two years before (KPMG, 1992) and two years after (KPMG/IVA, 1996) a review within the framework of the INES project in 1994. The progress reports investigated the phase of implementation according to the standard EMS model decided upon in the Dutch Parliament (Tweede Kamer, 1989). This involved measures of the eight agreed elements of an environmental management system: an environmental policy mission statement; an environmental management programme; the integration of environmental management into business activities; internal information about and training in the environmental management programme; reporting, monitoring and registration of the programme; the internal control and environmental audits to check the results and find new action points, and after passing through these eight elements of an environmental management systems, anchoring the environmental management system in the company. Although the INES project questionnaire was not designed in relation to the other progress repports, it is interesting to compare the data concerning the eight elements of environmental management systems implementation.

In comparison with the national progress reports, the group of Deltalinqs companies were leading the field both in the formulation of environmental policy mission statements, and the development and integration of environmental management programmes (see Table 7.1). A major explanation is that the chemical industry had taken the lead in environmental management because of its particular structure – large firms with high risk and pollution potential. However, the lower scores achieved by measures concerning internal control and environmental audits points to them being slow in the implementation of the programme.

Table 7.1 Number of companies in the INES project that achieved a specific element of an Environmental Management System (n = 31), compared to research on the implementation of Environmental Management Systems two years before and two years after the INES project in 1994

Elements and anchoring of the environmental management system	Number of elements achieved in INES '94	Percentage of elements achieved by total number of companies surveyed		
		INES research '94	KPMG research '92	KPMG/IVA research '96
Environmental policy mission statement	27	87	35	56
Environmental management programme	19	61	40	54
Integration of environmental management	17	55	19	20
Internal information and training	16	52	21	42
Reporting	13	42	35	38
Monitoring and registration	17	55	44	35[117]
Internal control	12	39	48	62
Environmental audit	11	35	48	62
Anchoring the environmental management system in the company	13	42	Not applicable	Not applicable

Another reason to pay more attention to the creation of environmental management systems was that many of the companies' employees were personally worried about a negative environmental performance by their company. The positive mood of employees towards the environment is often suppressed at the level of operational tasks. The data presented in Box 7.2 illustrate these points.

Box 7.2 *Employee compensation for perceived environmental risks posed by their company*

In research on the origin of decision-making processes for the application of clean technologies (Williams *et al*., 1997) several employees were interviewed in each company. In the case of a chemical company, four out of five interviewed employees stated spontaneously that they were members of an environmental advocacy organisation. This was probably a personal reaction for being employed in an industry with high environmental risks. It can also be an illustration of what Gabriel (1999) calls the *hidden depths* in organisations – something underneath their surface. Gabriel's hidden depths involve a complete absence of challenges to the (mostly tacit) knowledge, needs and motivations of employees that can be better utilised.

[117] Including their own measurements in their system, such as air and water emissions.

Fifty-two percent of the workers' councils[118] were structurally involved in environmental management systems, 19% of them were informed about the development of these systems. Information about the environmental management system was circulated in the company's magazine for employees (32%), during departmental consultation (61%), as part of the daily activities (52%) and during training (42%). New employees were informed in general (18%), during the introduction of the system (18%), during departmental consultation (13%) and in training and instruction (29%).

The environmental co-ordinators were frequently asked for advice in decision-making procedures for most of the environmental investments. In cases of general investment advice, they were asked less, as Table 7.2 shows:

Table 7.2 Involvement of environmental co-ordinators in the investment decision-making processes (n = 32)

Frequency	Environmental investment in %	General investment in %
Always	75	38
Not always	22	53
Never	3	9

The original *Deltalinqs environmental management system project* was planned for the period 1991 – 1994. The INES project (according to the Deltalinqs staff, the `so-called' *external* environmental management system) was expected to follow up in 1994. Because several companies were still busy with environmental management implementation, they paid less attention to the INES project. Nevertheless, only 10% of the companies thought that they were relatively slow compared to non-Deltalinqs members in the same sector; 40% of the Deltalinqs companies' respondents thought that they were faster and 50% thought that they were keeping up in comparison with the non-member companies in the same sector. Among the Deltalinqs companies' respondents, the same number had the impression of being either slower or faster (21% each), while many more had the impression that they were keeping pace (58%). These data show that the collective Deltalinqs approach was perceived as faster in implementation than the rest of the industrial sector.

Table 7.3 Perception of progress concerning the implementation of environmental management systems: comparison of Deltalinqs with other companies in the same sector (n = 30)

Other company in	Being slow in %	Keeping pace in %	Being fast in %
Industrial Sector	10	50	40
Deltalinqs	21	58	21

[118] Every company with more than 35 employees needs to set up a workers' council in the Netherlands. The workers council has the right of information, advice and/or decision-making in dialogue with the company management about issues and areas mentioned in the Dutch `Law on Workers Councils'.

The KPMG/NIPO study on cleaner production in 1999 shows that 18% of the respondents find themselves ahead of other companies in their industrial sector, 75% are in equal position and 3% lag behind. This piece of research was performed in a variety of industrial sectors. There are several reasons for the differences in perception. The effect of *seeing oneself as performing better* (Baas, 1989, Lammerts van Bueren, 1999) played a role in the comparison with other companies. Also the role of information was important; the information circulated to the Deltalinqs companies was structured and fine-tuned. Single non-member companies had relatively less access to that structured information. The Deltalinqs member companies also shared the same information. Furthermore, the comparison with other Deltalinqs companies was based on better knowledge of the other companies. This led to a comparison based on knowing the other companies instead of a general impression. It also meant that the structured Deltalinqs approach had achieved good results.

Table 7.4 Perception of commitment of the most important categories of personnel to EMS (n = 30)

Category of personnel	Passive	Co-operative	Pro-active
Top management	3	18	9
Middle management	5	19	4
Operators	8	19	3

The data in Table 7.4 makes it clear that the development of a pro-active approach to environmental management systems provides a basis for the implementation of all elements of an environmental management system. The mean of the environmental management system was co-operative in mid-1994. Representatives of the top management were able to take the initiative towards a pro-active approach on the basis of their position to at least develop a vision and mission statement. In contradiction to this, the operators at the shop floor level were limited by their system boundaries.

The company's environmental management system contact persons differed in their activities and time spending, both as regards internal and/or external time spending. The task of implementing environmental management systems was most frequently found as a new task in the function of environmental co-ordinator. For the implementation of environmental management systems both part-time as well as full-time positions had been created. As the traditional environmental co-ordinator was responsible for external contacts concerning environmental regulation, the question emerged whether the responsibility for implementation and maintenance provided a greater workload within their companies. The next survey question tried to cover this issue.

Table 7.5 The division in the number of part-time/full-time and internal/external activities and contacts of environmental co-ordinators/managers (n = 27)

Activities / contacts	Part time	Full time
Internal > external	6	12
Internal = external	4	4
Internal < external		1
In total	10	17

Respectively 60% of the part-time and 71% of the full-time environmental managers had more internal than external activities and contacts. The environmental managers who spent equal time on internal and external activities and contacts constituted 40% of the part-timers and 24% of the full-timers. There were two other issues: how much time is spent on specific environmental issues, and which issues are perceived as important.[119] Table 7.6 presents data that show the mean and (between brackets) the variety of internal activities and contacts of environmental managers.

Table 7.6 The mean and spread of environmental managers' perceptions of their internal time-spending and the importance of a specific environmental issue (n = 31)

Activity / contact	Time spent	Importance of subject
Licensing procedure / control	2,7 (0 – 5)	2,4 (1 – 6)
Development of environmental management systems	1,8 (1 – 6)	2,5 (1 – 5)
Management of waste streams	2,4 (0 – 5)	3,2 (1 – 5)
Soil sanitation	4,3 (0 – 6)	5,4 (2 – 6)
Improvement of process technology and production	3,8 (0 – 6)	3,1 (2 – 5)
Instruction & training of employees	3,6 (0 – 6)	3,5 (2 – 6)

In their own company, environmental co-ordinators spent most of their time on the development of environmental management systems. The importance of this activity was perceived as equal (or slightly less) to licensing and control procedures. The management of waste streams required more time than licensing and control procedures, although its importance was perceived as smaller (4th rank position). Soil sanitation was consuming the least time and its importance was perceived as very low.

The mean and (between brackets) the variety of the data concerning external activities and contacts of environmental managers are provided in Table 7.7.

119 The activities and contacts are ranked: 1 is the most important or the most time-spending, 6 is the least important or the least time-spending, 0 is not applicable.

Table 7.7 The mean and spread of environmental managers' perception of their external time-spending and the importance of a specific environmental issue (n = 24)

Activity / contact	Time spent	Importance of subject
Negotiation with the government: Licensing procedure / control	2,4 (1 – 4)	1,9 (1 – 5)
Dialogue with other companies on environmental management systems	2,1 (1 – 4)	2,3 (1 – 4)
Search for information / Asking advice	2,2 (1 – 4)	2,2 (1 – 3)
Surroundings: information / complaints procedure	4,5 (3 – 6)	3,6 (2 – 5)
Doing training courses	4,1 (1 – 5)	3,9 (1 – 5)

The environmental co-ordinators also spent most of their time on the development of environmental management systems, in dialogue with colleagues outside their companies. However, negotiations with the government about the licensing procedures and their control are perceived as the most important. The search for information and advice outside the company is both as regards time spent and importance placed in 2nd rank position. The communication structure of the environmental management system project generated a basis for information sharing among colleagues from other companies; this made it easier to ask for advice and to consult public and private organisations. In 1994, the importance of training and the development of a communication structure with stakeholders were perceived as low, as also shows the limited amount of time devoted to those subjects.

In order to obtain a better understanding of the internal network of the environmental management system co-ordinators, these were questioned about their internal contacts (see Table 7.8 at the next page). Qualitative information about the frequency of their contacts with other employees in their company was also collected.

The internal networks of the environmental management system co-ordinators are large, and the frequency of their contacts – for instance with the plant management – is high. This contact network situation should be conducive to a *change agent* role, but the co-ordinator's position lacked power (Lukes, 1974); at the same time, environmental management system co-ordinators often said spontaneously that they had a limited set of internal relationships. The `feeling lonely in the company' is a typical predicament for traditional pollution control management. Li (2001) wrote about the disconnectedness of environmental issues; environmental managers feel isolated and create an underground network. Such an underground network was not found in the results of the 1994 INES questionnaire: despite the fact that 50% of the environmental co-ordinators were involved in all investment decision-making processes and the high number of contacts with all departments within their company, many of them felt isolated and not valued. Managers at the end of their career often occupied this position (Hanf, 1986) and felt a lack of power and motivation to create informal networks.

Table 7.8 The spread and number of contacts of the environmental management system co-ordinators with different departments (n = 31)

Organisation department	Never	Seldom	Regularly	Often	Not applicable
Plant manager		1	19	10	
Research & Development	3	5	5	1	13[120]
Department dealing with quality, labour conditions & safety			11	13	4
Engineering department		3	15	11	1
Production department managers		1	16	12	
Process operators		9	14	4	2
Administration/bookkeeping	1	9	16	3	1
Waste management		3	15	8	3
Contacts in total	4	31	111	62	24

For reasons of information exchange, the Deltalinqs organisation created a communication, information and training infrastructure for the development of environmental management systems via an official network that met the need of environmental co-ordinators for information exchange at a professional level. Environmental co-ordinators met four times a year. Of all environmental co-ordinators, 73% participated in all meetings, 20% participated once or twice a year, and 7% never participated (n = 30). Eighty-three percent of the environmental co-ordinators had contact with colleagues in other companies, 17% had no contact at all (n = 30). Most of the environmental co-ordinators concluded that the implementation of environmental management systems needed continuous attention.

Nevertheless, new approaches such as pollution prevention, environmental management systems, and new (economic and voluntary) policy instruments require continuous expertise development of the co-ordinators. That knowledge development has not been adequately addressed. Van der Woerd (1997) concluded that the implementation of environmental management systems means control of existing government rules and does not automatically lead to any searches for preventive options.

The discrepancy between the environmental managers' perceived limited influence and their real number and variety of contacts leads to the conclusion that their power to bring about more radical changes is weak. Their position in the company needs to be recognised as requiring new skills and leading to new developments, such as initiating industrial ecology and sustainability change processes. In the results from the questionnaire it was found that the environmental co-ordinators were often roughly acquainted with new concepts (mostly on the basis of individual taste), but most of that knowledge only related to the pollution prevention concept.

[120] Many members of the Deltalinqs association are production plants without any R&D departments.

Table 7.9 Acquaintance of environmental co-ordinators with new preventive concepts (n = 31)

Concept	Well known	Familiar on the whole	Hardly familiar	Unknown
Pollution Prevention	15	14	1	
Integral Chain Management	7	17	6	
Industrial Ecology	3	9	9	9
PRISMA[121]	6	13	5	6
Cleaner Production	8	12	6	3
Sustainable Development	6	16	4	5

Pollution prevention was the most well-known concept, and industrial ecology the least well-known. Because the cleaner production concept and information about the PRISMA project were less widely used than the term pollution prevention, it was clear that the large Dutch chemical industry was scarcely familiar with new environmental developments, as separate from the government policy, in the Netherlands itself. A partial explanation is the fact that many plants in the region are subsidiaries of foreign multinational corporations. The regional plants aligned themselves with their corporation's policy. Apart from this it was remarkable that plant managers said that they knew and valued the cleaner production concepts. However, they did not translate this into new training opportunities within their plants. Their preference went to the development of environmental management systems that were better fitted to the culture of encoded knowledge and top-down approaches.

Table 7.10 provides information about the positions of employees that environmental managers perceived to be key internal persons for the effective dissemination of environmental management systems.

Table 7.10 Environmental co-ordinators' perception of key persons for the dissemination of environmental management systems (n = 31)

Position in company	Frequency
Managing Board	17
Departmental manager	15
Environmental co-ordinator	12
Process operator	3
Anybody	2
Quality management officer	1
Workers' council	1
Systems manager	1

The environmental managers perceived the managing board, middle management and their own position as the most important for the dissemination of environmental management

[121] PRISMA is an acronym for the Dutch demonstration project Industrial Successes with Waste Prevention, Dieleman *et al.*, 1991.

systems. This perception is in line with traditional top-down approaches. In contrast, a workers' council was not perceived as having the power to influence the dissemination of environmental management systems.

7.2.2. *Knowledge about new prevention concepts*

In the 1994 questionnaire, pollution prevention was the most well-known concept (50% of the respondents answered *well-known*, 47% of the respondents answered *familiar on the whole*), and industrial ecology the least well-known (30% of the respondents scored *hardly familiar*, 30% of the respondents scored *do not know*). Cleaner production and the PRISMA project were well known respectively by 28% and 20% of the respondents and 43% and 41% of the respondents were familiar with these concepts on the whole.

Within the international context of most of the firms the term *pollution prevention* is better known than the newer term *cleaner production*. However, it is familiar thanks to literature rather than practical experience. In the first half of the 1990s, the industrial leaders in the Rotterdam harbour and industry area thought that they knew all about pollution prevention. When it became clear that they did not, they argued that they could consult the best environmental consultancies in the world and learn the latest information about this and related developments. But this attitude was based on the traditional pollution control approach.

Chemical production processes are strictly constrained by technically fine-tuned and safety conditions. Those conditions have been learned in an encoded knowledge infrastructure that seldom encourages organisations to develop the ability to be reflexive. Three out of the four types of learning described by Vickers and Cordey-Hayes (1999), learning by interaction, learning by using and learning by learning, are excluded in this situation. Only some cleaner production projects - one with the regional regulatory government and one with the provincial environmental advocacy federation in the second half of the 1990s - generated a *learning-by-doing* situation in an atmosphere of tolerance that scarcely affected further developments. The role that needed to be played by policy to encourage wider social learning about cleaner production beyond the learning agendas of the firms (Vickers and Cordey-Hayes, 1999) was recognised in the design of the INES project (1994). The first of the three project objectives was the optimisation of cleaner production in the companies. The results of other cleaner production projects and the earlier attitude of the industry led the national government to say that the cleaner production concept was already well known. No subsidy was provided for that part of the INES project. This standpoint was not confirmed in the INES questionnaire; it also neglected the need for organisational change if continuous cleaner production improvement is to be achieved. That knowledge was not empirically available.

7.2.3. *The INES Declaration*

The results of the INES questionnaire about the implementation of environmental management systems and knowledge about new environment-related concepts were the basis for the design of the industrial ecology training workshop for Deltalinqs member organisations in September 1994. During that workshop several participants expressed the wish to have an INES project statement on existing and new environment-related concepts. During the workshop a group of participants spontaneously drew up an INES Declaration for the companies in the Europoort/Botlek industrial area, based on the following elements: company environmental management system, cleaner production, integral chain management, industrial ecology and sustainable development (see Box 7.3). The declaration was fully accepted by all participants and presented to the Deltalinqs board member responsible for environmental issues. Although this declaration was not formally accepted by Deltalinqs or by individual companies, it illustrates the thoughts of environmental co-ordinators and managers about their preferred approach to sustainability.

Box 7.3 *The INES Declaration, formulated by 50 environmental co-ordinators and members of the Deltalinqs organisation*

1. The companies in the Europoort/Botlek industrial area aim at continuous reduction of environmental pollution, under economically feasible conditions. The companies use an internal *Company Environmental Care System*, designed to integrate environmental management into the production process.
2. Each company is committed to the optimisation of processes through organisational and technological developments in such a way that *the production of solid wastes and emissions is minimised.*
3. Each company aims at the selection and design of products and processes so as to achieve a *minimum use of resources with a minimum generation of pollutants in the entire product life cycle*.
4. Each company will make efforts, together with other companies in the region or with related companies in other regions, for *the realisation of useful applications of waste products, energy and waste streams from each other*.
5. The efforts of the company will be increasingly addressed to the search for, and the application of, the latest *Clean technology*, so as to realise a situation of *Sustainable Technology*.

7.2.4. *The design of INES sub-projects*

At the end of the awareness-raising and training workshop in September 1994, another questionnaire (on a floppy disk) was provided to the participants with questions about the three major resources, products and waste streams. Participants were instructed on how to complete the questionnaire after the workshop. This company questionnaire led to fifteen potential sub-projects and the following preliminary observations:

- The response was high (80%);
- The questions about the worst waste streams created a focus on waste management instead of preventive approaches within the resource and product management of the companies;
- The questionnaire provided data for the definition of 15 possible industrial ecology projects (see Table 7.12);
- Most of the 15 sub-projects had a limited scope as regards to the number of links in the production chains;
- The type and size of the region was an important issue in the scope of an industrial ecology approach;
- The sharing of utilities constituted a first incentive for alliances between companies in the energy & environment field;

- ➢ Independent facility organisations (for the INES project two university groups) seemed to be in a position to help catalyse the linking of companies within the framework of joint ecology/economy initiatives (they were above all trusted in the prudent use of confidential information).

The fifteen potential sub-projects were discussed with the environmental managers and adjusted for pre-feasibility studies. Despite the good response to the second questionnaire, the data were not consistent enough for the proper performance of a production chain analysis (direct relation between resource streams and losses), which would help select a smaller number of representative prevention sub-projects. In order to avoid a premature selection, based upon inadequate information, the decision was made to perform pre-feasibility studies of all fifteen potential sub-projects. The sub-projects were clustered into four categories: prevention, chain management, energy/utilities sharing, and joint treatment.

The university researchers became project leaders of all INES sub-projects in this phase. They gathered additional information via a literature search, interviews and project team meetings with company representatives to establish a more adequate formulation for the analysis of industrial ecology, the potential of pollution prevention, economics and commitment of the companies. The pre-feasibility research phase confirmed two preliminary findings:

1) Hardly any long production chains exist in the region (the chain comprising terminal - refinery - (petrol) chemical production is typical of a longer chain);
2) The dynamic field of ongoing projects in the region sometimes shows overlaps or contradictions. Most of these projects have a `single issue solution' focus.

After this phase, three sub-projects were selected for further fine-tuning. The selection process used the following criteria for making the selection: the relevance of the approach for improving environmental performance, the economic potential and the company's commitment. A four-point scale was used to score the results of the pre-feasibility studies according to the variables. Environmental relevance had the highest impact: a successful qualification expected a score in the range of 3 – 4 for all variables. The category `Successful Potential Qualification under conditions' was only acceptable under the condition that environmental relevance should score the highest. An overview of the scores in the INES sub-projects selection process is presented in Table 7.11:

Table 7.11 INES sub-project selection process

Potential Qualification	Environmental relevance	Economic potential	Company participation potential
Successful	Score 3 – 4	Score 3 – 4	Score 3 – 4
Successful under conditions	Score 4	Score 1 – 2	Score 1 – 2
Not successful	Score 1 – 3	Score 1 – 2	Score 1 – 2

The INES project selection team scored each sub-project individually in two rounds. The selection team judged the fifteen sub-projects according to environmental, economic and commitment criteria. The decision-making model of the INES project looked like the *garbage can model* of Cohen *et al*. (1972), in which actors only indirectly influence the final decision, that can be based on a convergence of ideas, opportunities and solutions, while the outcome of their input is moving in the direction of acceptance of both contingency and control as elements shaping the process of change. In the case of the INES project, the decision-making processes by the industry representatives were not neutral. The first round was conducted on the basis of the separate sub-projects; not only did the average score of the individual inter-subjective selections play a role, but some decisions were also influenced by the political agenda, for instance in the case of the threat of a new, very expensive sewer system for a small amount of inhabitants-equivalents of household water in the region.

The second round in the selection process was based on the clustering potential, including the number of links in a given production chain. The sub-projects were scored on their environmental, economic and management commitment potentials, and the number of links in the production chain. The total score led to the creation of four different categories (see Annex VII.1): good prospects for performance by the companies themselves; good prospects under the condition of further research being conducted in the INES project; good prospects, but not feasible in the short term; and no prospects at all within the INES framework because of the scope and size of the project.

The selection process ended with three feasibility projects: joined systems for compressed air, wastewater circulation and a bio-sludge reduction system. Apart from these selected projects, the execution of the following sub-project is remarkable as regards awareness-raising around an industrial ecology project. After its first presentation, the defined project was commercially explored, independently from the INES project (Box 7.4).

Box 7.4 *The breakthrough of* a*wareness concerning the potential of a sub-project*

Natural gas, a by-product of oil drilling in the Rotterdam harbour area, has historically been flared when it cannot be re-injected into the ground to avoid atmospheric release. Noone involved in natural gas exploitation in the Rotterdam area spontaneously realised the opportunity for productive use of this low-caloric natural gas resource. When a natural gas project was designed, the sub-project was commercialised within one week.

Similarly, environmental managers were unaware that the use of compressed air systems by companies in Rotterdam harbour had significant environmental consequences or that the energy requirement for compressed air represented 7% to 15% of the total electricity use for those companies. After the identification of the opportunities represented by the natural gas and the compressed air sub-projects, the former was commercially implemented within one week; the latter took five years before implementation. Another sub-project, concerning the use of surplus steam capacity and CO_2 by other companies, residential areas and greenhouse horticulture, was on a different scale. The industrial association and an energy distributor jointly discussed how to utilise approximately 2200 MW of heat that was emitted into the air.

A pipeline system to connect suppliers and buyers in the region was a first option for further study. It was calculated that such a pipeline system would cost € 112,700,000 and would require government funding for the new infrastructure needed for energy distribution in the region. This steam project was further elaborated in the follow-up INES Mainport project (see Section 7.3.1).

7.2.5. *Overview of three feasibility studies*

Five INES sub-projects were classified in category II. As the steam sub-project was beyond the scope of the INES project and the by-product sub-project was too diffuse, the INES project team decided to explore three feasibility studies: the compressed air utility sharing, the waste water and the bio-sludge sub-project. The sub-projects are briefly described in the following sections.

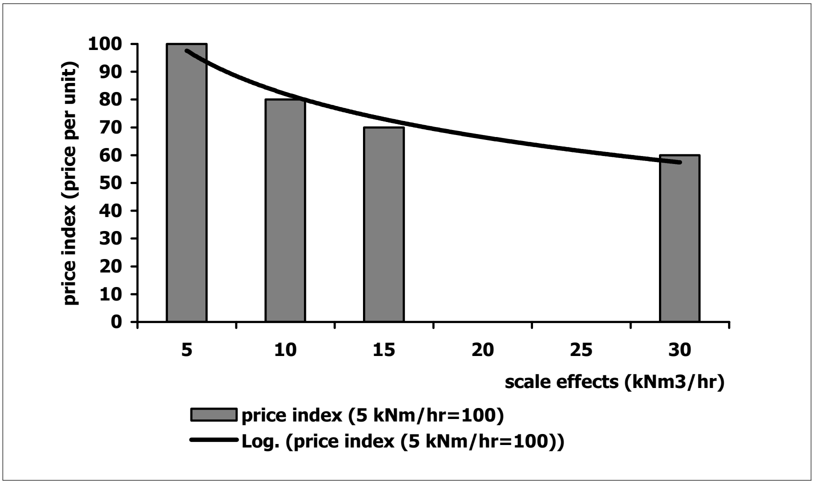
Compressed Air Utility Sharing

At the time of the sub-project, every company had its own compressed air system with much back-up capacity, often in stand-by operation. The maintenance engineering staff always managed these compressed air systems, that were seldom seen in an environmental perspective. Many environmental managers were surprised once it was found that those compressed air systems represented between 7% and 15% of the total company's electricity consumption.

The companies participating in the pilot project were an air supplier, an organic chemical company, an inorganic chemical company, an aluminium-processing company and a cement company. It was assumed that the companies in the pilot project could achieve the following results in the economic and environmental spheres: the price of compressed air can be lowered by approximately 30% and energy consumption could be reduced by approximately 20%. When the real use of compressed air was measured, it was found that it was much lower than expected (7,000 Nm^3/hr instead of the anticipated 12,000 to 15,000 Nm^3/hr).

Another finding was that the total energy consumption could be reduced in two ways. Firstly, by lowering pressure, preventing or reducing leaks, and by a re-design of the existing pipeline system, companies could save approximately 20%. Secondly, by installing a central supply through a ring pipeline system, companies could save approximately another 20%. The results meant at the same time that the economy of scale for price reduction became too low. The partners decided to explore the expansion of the number of companies to restore the original price effect. Figure 7.3 presents data on the price effect of expanding the network based upon a commercial offer (Silvester, 1997).

Figure 7.3 **Scale effects of the linked capacity on the price per unit of compressed air**



Compounding the problem of diminishing economies of scale, the supplier was very busy with the installation of a larger system for the delivery of compressed air to the largest refinery in the region. As a result, it gave less priority to the INES compressed air sub-project. In addition, not all of the potential users were enthusiastic about the INES sub-project, although they did not reject participation completely.

The commercial implementation should have been completed in 1998, the period between the first and second INES project; that period was a hiatus, lacking the active participation of an intermediary organisation. As a result of these factors, both the supplier and the companies using compressed air decided to avoid the risks of a new system. However, by 2000 another supplier had realised the project with another cluster of companies (see Section 7.3.1).

Wastewater

This sub-project had a highly political enforcement potential because of the Water Authority's intention to build a wastewater sewer in the whole industrial area. Though the process wastewater was treated before release in nearly every company, the Water Authority also wanted to reduce the non-point emission sources. The plan was based on the estimated 1990 data, namely that process water, housekeeping water (offices, toilets, canteens) and rainwater, add up to 80,000 inhabitant-equivalents. The INES sub-project showed that many companies do not have a monitoring system of their various water streams. However, research showed that the actual untreated emissions were less than 10% of the estimated 1990 data. It was concluded that the environmental benefit/financial cost ratio[122] for a new sewer system was out of balance for all parties, except the regional Water Authority.

Nevertheless, the planning for the sub-project increased the awareness that water management improvement can facilitate a remarkable reduction in water emissions and the use of clean water. A limited stocktaking within about 20 companies revealed that the exact

[122] Approximately € 20,000 for 6,500 inhabitant-equivalents.

data on the quantity and quality of water use made an optimal application of water management feasible. The use of the so-called pinch technology[123] showed how it is possible to use a certain water quality at the highest level of need of the company's production process or an industrial ecology cluster of companies. By doing this, re-use of several wastewater streams could result in a 10% reduction of total water use. Some case studies were presented in a workshop to inform members of all of the companies. The target group *Water* of Deltalinqs led the process to develop an optimal water use and cascade circulation both within the companies as well as in clusters of companies.

Bio-sludge

The total, annual amount of waste bio-sludge produced by 12 companies was about 57,000 tons, including a 3% dry component of 1,900 tons. The actual logistics and treatment costs were approximately € 1,200 per ton of dry component. A pre-feasibility study revealed that there was not one single solution for the actual and future bio-sludge treatment. However, the problem could be approached at two levels:

- Optimisation of the management of the biological treatment facilities of each company to prevent, or at least to reduce, the production of bio-sludge within their companies;
- Installation of a joint central mechanical compression installation; a feasibility study was performed to combine this installation with the use of dehydrated sludge (90% dry component) as substitute fuel for coal in an electricity works or in a cement company.

Due to the implementation of primary waste minimisation within the companies, a bio-sludge reduction of between 10% and 20% was expected, which could result in annual savings worth between € 250,000 and € 500,000.

7.2.6. *Considerations on the findings of the INES project*

The 1994 – 1997 INES project provides many examples of different industrial ecology levels, for instance the use of a systematic approach to stimulate the formation of an industrial ecosystem. Furthermore, the INES project revealed the need for more information pertaining to resource and material streams and transformation processes (cascades, facility sharing) and for feedback on usable information. The INES project also provided a model for co-operation between companies through the optimisation of non-core issues – e.g., joint supply of compressed air (30 – 40 % energy reduction) and a company clustered use of wastewater resulting in approximately 10% water use reduction (Baas, 1998). It was found that awareness-raising processes in connection with the potential of industrial ecology are time-consuming. Also it was found that a neutral intermediary organisation provides the optimal conditions for the participation of many companies. At the level of involving other actors in such regional approaches, the INES project revealed the need for the participation of stakeholders from society, academia and environmental advocacy organisations.

At the policy level, the INES project came across interesting issues, such as the tension between production chain management (promoted by the Dutch Ministry of Environment) and industrial ecology (promoted by the Deltalinqs industrial association). The general

[123] The functional specification of the wastewater was researched for re-use at the highest level in production processes.

features of the concepts differ in the way that the feature of chain management is vertical in an industrial branch column, and the feature of industrial ecology is horizontal in the several industrial sectors. This difference does not mean that the two concepts are contrary, but in practice some opposition was experienced.

The INES project was partly funded by the Ministry of Environment owing to its involvement with chain management development in multinationals. However, the project was geographically limited to the Botlek/Europoort area near Rotterdam, while most of the chains crossed the border of the region and/or the country, as in the case of the transportation of coal to the German blast-furnace plants in the Ruhr area. The range of (bulk) chemical compounds, energy resources and semi-manufactured products is more difficult to (`chain') manage than consumer goods. Crude oil and the refined compounds are the basis for many industrial sectors, but are not continuously found in the same condition in a production chain. Richard (1995) challenges the existence of linear and static chains and emphasises that, in practice, these are actually webs and fans of chains.

Although it is obvious that technology plays a key role in chain management and industrial ecology, no special attention was focused on technological development. The first sub-projects in the INES project demonstrated the technological optimisation of non-core business issues such as a joint supply of compressed air and an exchange of wastewater use.

The evaluation of these two and other industrial ecology sub-projects has taught us that certain conditions are needed to optimise the exchange of resources among members of a network or within a cluster of organisations (Côté & Hall, 1994; Allenby *et al*., 1994; Lowe, 1996; Boons & Baas, 1995; Jacobs, 1996, Dijkeman & Stikkelman, 1999, Baas, 2001, Kincaid & Overcash, 2001). These include:

- *understanding of the industrial ecosystem concept*: while pairs of companies will look for possible exchanges, the greatest benefits will come from a more systemic approach. Managers should be informed and motivated, for example by means of workshops and reports on cases demonstrating the economic and environmental values of resource exchange.
- *existence of an organising or support system* (Côté & Hall, 1994): a high performance industrial ecosystem needs some agent concerned with the network as a whole. Individual companies will self-organise to manage their own (bilateral) exchanges. An office must support them while seeking opportunities to optimise the larger system. Also Kincaid and Overcash (2001) concluded in a two-year study pertaining to the potential by-product partnership in a six-county metropolitan area in North Carolina, U.S.A., that "..what is lacking in most communities, is an agent to promote the vision of the web of materials, water, and energy flowing between neighbours and to gather the local information about by-products available or raw material requirements needed to build this web..". The role of facilitator in the development of symbiotic exchanges was also analysed in the INES Mainport project (Baas, 2001);
- *trust*: good prospects for the network require that the participants can trust the partners in the network (Baas, 1998). Perceived risk usually relates to the estimated probabilities of several outcomes (Das and Teng, 2001). In implementing the strategic alliances in industrial ecology networks, the associated gain perspective is the incentive.
- *assurance of future support*: company leaders who recognise the value to them of being in a by-product exchange network will want to know that there is a structure committed to maintain the network.

- *flexibility*: the network will grow and participants will change, but also the environment will change. An industrial ecosystem will need to remain flexible and adaptive. The diversity of the composition of the industrial ecosystem is important. For example competitive aspects are obstacles for communication about core business. Also size aspects are important. Large firms are likely to provide more expertise and time.

7.2.7. *Communication in the INES project*

At the launch of the INES project, the infrastructure for the implementation of environmental management systems could be used very satisfactorily. The existing working groups in this infrastructure were based on *similarity* to get an optimal understanding of each other's experiences. This approach is an illustration of mimicry that worked rather well with the implementation of a similar concept. For the information about what the INES project would cover, the approach worked very well. However, industrial ecology covers processes such as utility sharing in companies, and an array of processes between companies in identical and different industrial branches, or clusters around one factory such as an electricity works as a linchpin. The universities' proposal for new communication structures, built around the industrial ecology project and cluster management, were not accepted.

7.3. **The INES Mainport Project 1999-2002**

The INES (<u>IN</u>dustrial <u>E</u>co<u>S</u>ystem) Mainport project was a four-year project that focused on initiating and supporting industrial ecology initiatives, mediated by a small professional organisation of the Deltalinqs industrial association . The INES Mainport project (1999 – 2002) was developed within the framework of the ROM-Rijnmond covenant[124] as a follow-up to the INES project from 1 January 1999. The project involved societal stakeholders in a strategic decision-making platform starting in September 1999.

The decision-making platform members were challenged to write a position paper about their ambitions in relation to long-term themes and to identify appealing activities for the subsequents two years. However, there seemed to be a misconception by the project management about the positions of the platform members and the expectations concerning their contributions (see Table 7.12). The platform members were willing to provide advice, but could not effectively function as sounding board with only 2 or 3 meetings a year.

[124] A physical planning and environmental regional policy covenant between national and regional governments and the industry, based on Rijnmond area development plans for 2010. The policy covenant for the Rijnmond area was signed on 9 December 1993 under the heading of `A responsible balance between the strengthening of the Mainport Rotterdam and the improvement of living conditions'.

Table 7.12 Overview of actors in the INES Mainport project strategy platform (1999–2002)

Organisation	Number of actors	Expectation concerning contribution
Industrial association[125]	3	Supervision of projects
"Captains of industry"	3	Commitment and recommendation
National Industry Association	1	Commitment
National Government	3	Financing, commitment, removal of legal barriers
Provincial Government	1	Financing, commitment, removal of legal barriers
Municipal Harbour Board	1	Financing and commitment
Environmental Organisation	1	Comments and suggestions from an environmental perspective
University	1	Scientific comments and suggestions from an international perspective

The INES Mainport 1999-2002 project followed up the previously performed studies of the INES 1994-1997 project and set up sub-projects on the themes presented in Table 7.13. The overview of initiatives and issues in this table required different levels for concrete decision-making. Besides, there was a relationship between the concrete form of concepts and the time needed for their development and implementation. The time needed to implement new concepts in a complex network that also required decision-making by corporation headquarters abroad (as was the case with the INES project), was beyond expectation.

Table 7.13 INES Mainport project themes from preceding studies

Theme	Background
Systematic approach to Industrial Ecology	Cluster management will stand more chance to succeed with a clear action plan to stimulate industrial ecology in the industrial settlement policy in the regions of Rotterdam and Southwest Netherlands
Water	Industrial use of water can be improved. The delivery of different water qualities, cascades in water use, connecting water and residual warmth, integration of process water production and nature development (green water) and improved use of rain water can be part of the future water systems in the area
Soil	How do we upgrade the environmental profit from each invested Euro in soil sanitation and management?

[125] Including a representative of a consulting firm for the project management until 2001.

CO_2/Energy	Two clear lines were defined: * Energy 2000: ENECO, the energy supplier, supervised the study of energy production and use for the next century; * application of industrial rest warmth: investigations discovered that 2200 MW of high caloric warmth are lost each year in the Deltalinqs area. A number of projects were defined (and some Subsidy could be obtained) to explore usages of waste heat.
Rest products/ Waste management	More is possible at the level of waste products exchange and the joint management of waste streams (re-use of sulphur, treatment of crude oil sludge, joint treatment of bio-sludge, cascade use of off-spec products, ballast water, de-sulphuring capacity, treatment of cargo remainders in storage and transshipment
Utility sharing	* What are the possibilities for large pipeline systems, including underground transport? * Which facilities and equipment can be jointly used by a number of companies? * Can these facilities and equipment be exploited commercially or as a public utility? Identified opportunities: chilled water, compressed air, waste heat
Logistics	Logistics will constitute a bottleneck in the coming decades. Co-siting and clustering provides possibilities to make improvements, but the supply and transportation of the resources will be increasingly problematic. Innovative logistical concepts must be integrated to provide clear choices for industrial location and functioning policies and procedures.

7.3.1. *INES Mainport sub-projects in 1999*

The INES Mainport project supervised four sub-projects in 1999: phase 1 of a joint water use project, a feasibility study of eight partner projects for the utilisation of industrial rest warmth,[126] compressed air sharing and a study on *Industrial ecology in chemistry*.[127] The sub-projects' objectives are described in the following paragraphs.

Water to match the needs of a company

After an awareness-raising feasibility study in the INES project, in this phase an inventory of the use of the ingoing and outgoing water streams was performed on the basis of quality, quantity and costs issues within approximately 35 companies. The data were collected for four industrial clusters in the Europoort, Botlek, Pernis and Maasvlakte areas. A number of concrete sub-project initiatives were defined. During visits to the companies, it was noticed that the level of knowledge about the companies' water infrastructure strongly varied. Surface water was used the most. Approximately two-thirds of the total water costs were spent on demineralised water[128] and drinking water. One-third was spent on wastewater treatment and effluents. The data showed that seven companies were responsible for 90 % of

[126] In Dutch: Benutting Industriële Restwarmte (BIR-project).

[127] Partnership project ECO-015 of the Programme Mainport development Rotterdam (PMR programme).

[128] In demineralised water, sodium replaces magnesium, calcium and ferro ions for use in specific production processes.

the water use. The most important saving was the substitution of drinking water with industrial water. This change resulted in annual savings of € 8 million.

Utilisation of Industrial Rest Warmth (BIR)

After it was determined that the establishment of a pipeline infrastructure for the whole area was not feasible, smaller scale projects were investigated. The BIR project involved eight partner projects in the Botlek and Pernis industry clusters. The estimated total investment was € 83.6 million. The Dutch National Project Office for CO_2 reduction plans was requested to provide a 30% subsidy in March 1998. A 27% subsidy was reserved in November 1998. A partnership of seven Deltalinqs companies tested the technical, operational and economic feasibility of the eight partners' sub-projects during 1999. They decided to reject four sub-projects, three for economic reasons, one on grounds of discontinuity of supply:

Table 7.14 Steam supply sub-projects and the reasons for their rejection

Steam supply project from	Reason for rejection
Air Products to Shell Chemistry	Economic: pay-back time is longer than 30 years
AVR to Dapemo	Discontinuity in steam demand of Dapemo
Lyondell to Climax	Economic: not feasible
Esso to ORC	Economic: not feasible

The four projects represented 63% of the estimated investments for the total of eight sub-projects. This meant that also 63% of the subsidy was rejected. One of the two largest remaining sub-projects was dropped because of the closure of the Kemira Agro plant in Pernis.

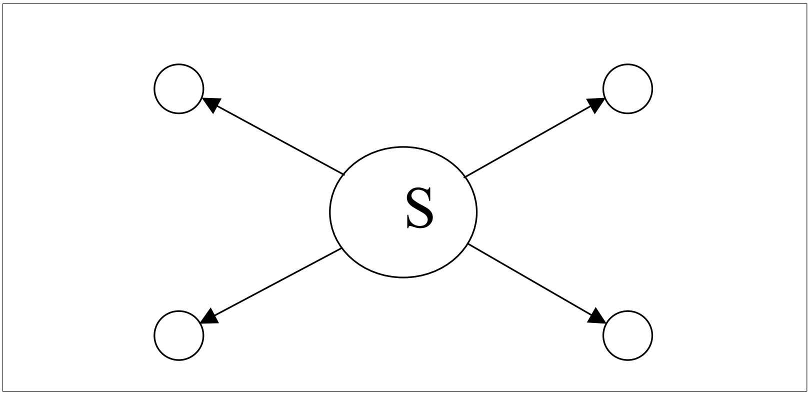
At the beginning, despite the enormous steam surplus, nearly all managers of large plants had reasons to prefer their own facilities for economic (the costs of the required infrastructure) or strategic (the perceived loss of independence) reasons. That is why during the period 1997 – 2001, the steam supply sub-project had to be downsized from a holistic regional approach to a number of small cluster sub-projects. After this approach too appeared to be economically unsuccessful, a feasibility study for warmth delivery through a private company was performed (CE, 2003).

Another large project kept being under study, under the condition that coupling the rest industrial heat of Shell Pernis (and later of Esso/Exxon) to the Rotterdam city district heating system should be economically viable and that the responsibility for the coupling between industry and city should be organised clearly. In 2002, the Rotterdam municipality decided to provide a guarantee for the extra funds that had to be invested in a heating system with temporary equipment in a new residential area nearby the Shell industrial site in Pernis. When all conditions for realisation were finally met in 2004, the coupling of the 6 MW of Shell's rest industrial heat with the city's district heating system would make the temporary equipment redundant; 3,000 houses would benefit in the Hoogvliet residential area in 2007. The heat supply system could be extended to 50 MW for the application to 25,000 houses in 2020 (R3 Project, 2003).

Compressed air sharing

The *Air sharing project*'s objective is the central generation of compressed air for distribution to different users in an area. The structure of the project is one supplier with several, in this case, four customers:

Figure 7.4 **One supplier of compressed air and its four customers**



The central installation of HoekLoos was operational from January 2000. HoekLoos invested in the installation and the pipelines; they ran the process, maintained the system and were responsible for ensuring a continuous supply of compressed air. They delivered compressed air to Cytec, DSM Special Products, AVR and Kemira Pigments. Preliminary results showed 20% costs and energy savings, and CO_2 saving of 4150 tonnes each year. In 2002, the delivery was extended to seven plants in total (see Section 8.6 for further developments).

Management summary of the `Industrial ecology in chemistry' study

The sub-project[129] was conducted in partnership with the Rotterdam Municipality Port Authority. The project's two objectives were to find a solution for the lack of space for new companies – to strengthen the gateway function of Rotterdam – and at the same time to improve living conditions in the Rijnmond area.

Within the project, 43 existing industrial clusters have been analysed with the help of an **I**ndustrial **E**cological **C**luster **IN**strument[130] (IECIN), that functions as an assessment and steering instrument for the optimisation of industrial ecology clusters. The 43 identified clusters were classified with the IECIN model according to the type of complexity of co-operation in the industrial park. For 12 of the clusters, the type of co-operation, the type of companies and the impact on employment were also described.

The analysis of the clusters identified the industrial ecology aspects that influenced the settlement needs for new companies. The industrial ecology aspects were divided into ten categories of settlement requirements, such as settlement locations, infrastructure and logistics, residential and living conditions. Furthermore the success and failure factors for

[129] Project Maasvlakte Rotterdam: PMR ECO-015 research project.
[130] The IECIN model, developed by INES Mainport, Grontmij and SMV2.

industrial ecology clusters were divided into three phases of the appraisal-implementation cycle within the industrial ecology cluster: feasibility, selection and implementation.

The chemistry trends in the 21st century were translated into two illustrative clusters of the presumed basic products such as the (strongly) growing ethylene and derivatives production in the future. The following conclusions were drawn from these studies:

- industrial ecology is current practice in some chemical companies and has been primarily supported and initiated by certain companies;
- industrial ecology is important for the Rotterdam Maasvlakte Project because of:
  a. space saving through more efficient production in clusters with higher productivity per m^2, co-siting, rationalisation of logistics, and the transition of petrol-chemistry to bio-mass chemistry;
  b. improving the efficiency of land use thanks to up-scaling and better physical planning;
- existing environmental laws and regulations are not yet appropriately fine-tuned to support or facilitate optimal applications of industrial ecology activities;
- the integration of policy instruments is a potentially important further step in the development of industrial ecology activities in this region;
- Mainport Rotterdam has built a good name in the sphere of co-operation between companies (via Deltalinqs). Industrial ecology is a fine-tuning of that activity;
- any company in the Mainport Rotterdam area can become a member of one or more clusters in the future;
- co-operation inside clusters makes it easier to obtain external financing.

7.3.2. *INES Mainport sub-projects in 2000*

In dialogue with the strategic decision-making platform of the INES Mainport project, several new initiatives, as well as new phases of ongoing sub-projects, were developed in 2000. These include the five sub-projects described in the following paragraphs.

* *Water to match the needs of a company, phase 2*

From the first phase of this water management sub-project, it was learned that in three clusters of co-operating companies, significant advantages were achieved through the transition to the use of surface water as industrial water and the use of industrial water as basis for chilled water. These advantages are both economic and environmental. In dialogue with the Deltalinqs companies and NOVEM it was decided to design an alternative water supply for the second phase. The starting point is the realisation of a future supply of industrial water and chilled water from the *Brielse Meer*[131] surface water for three clusters of companies. The goal is to supply water of appropriate quality (*industrial water*) for the actual needs of the companies involved in the clusters. In this way, the quality of supplied water can be adjusted in order to achieve a reduction in treatment efforts (energy, chemicals) and costs compared to drinking water.

* *Law and regulations with respect to industrial ecology*

The government wanted to stimulate and reward, and remove eventual barriers for,

[131] The Brielse Meer is a lake near the industrial area.

sustainable corporations and industrial areas. The sub-project's concern was: `What instruments can the different government levels (national, provincial, local) use and/or improve to stimulate the achievement of industrial ecosystems in the Mainport Rotterdam?'.

Participants in the sub-project included the Ministries of Environment, of Economic Affairs, and of Water Management, the province of Zuid-Holland, and the Rotterdam Port Authority.

* *Bio- sludge*

The environmental and economic aspects of the joint treatment of bio-sludge produced by twelve companies were studied in the first INES project in 1997. The conclusion was there was not one general solution, but several options for costs reduction. However, the technical and financial premisses changed in the period 1997-2000. This was the reason why the data needed to be updated. The aim was, on the basis of recent data, to re-define the optimal treatment routes of bio-sludge and to investigate better economic possibilities for the treatment of bio-sludge.

* *Cooling from waste heat*

Waste heat can be utilised through absorption cooling to decrease the temperature of cooling water and realise cold storage. The project *Cooling from waste heat* had the following objective: "The increase of the production and improvement of energy efficiency and the decrease of CO_2 emission of companies in the Rijnmond area through absorption cooling based on waste heat". The project combined expertise on the influence of outside temperature on processes with expertise on absorption cooling based on rest warmth.

* *Resource loops*

Resource loops (flow charts) were mapped out on the basis of the analysis of the exchange of water, by-products, utilities and warmth between companies in the Mainport Rotterdam area and the information gathered from surveys. The flow charts provide a schematic reproduction of the material streams in industrial ecology clusters. They described (qualitatively and quantitatively as much as possible) the potential for exchange between companies.

A number of strategic longer term projects were also developed, and are described in the next few paragraphs.

* *Fossil fuel scenarios*

The potential to realise substantial reductions in operational business costs was one of the key drivers for companies co-operating within clusters. Companies can reduce material input costs and lower waste treatment disposal and environmental charges through greater recycling and waste reduction within clusters. Currently, crude oil and natural gas are the principal energy sources for refineries and chemical industries within the Mainport. Combustion of these fossil fuels contributes significantly to the greenhouse effect and exacerbation of global warming. It has been recommended that non-fossil fuel sources replace crude oil and natural gas in order to achieve greater sustainability in the petro-chemical sector.

The DTO programme (a Dutch Interdepartmental Research Programme on Sustainable Technological Development, Weaver 2000) had set future sustainability objectives to promote the use of biomass as a substitute to the use of crude oil and natural gas as fuels and raw materials. This was considered by stakeholders to be an important development in the attempts to improve the sustainability of industrial production within the Mainport Rotterdam.

Initially, it was necessary to determine the current availability of biomass that can substitute existing fossil fuel-based energy and raw materials, before commencing detailed research that leads to implementation of long-term developments within the Mainport. The actual production and market potential within the Mainport need to be critically determined, with particular emphasis on the quantitative and qualitative analysis of potential available biomass streams (the reproduction of a fossil fuel balance), the market demand for biomass substitution, the existing level of local knowledge, the current locally-developed technological concepts for biomass utilisation, and the indicative analysis of technical and economic feasibility with respect to the input of these streams in the current situation (fossil fuel scenarios).

* *INES Mainport eXchange (IMX)*

In recent years, an increasing number of companies within the Rotterdam Mainport area had co-operated to form industrial clusters in order to collectively improve efficiency and re-use of water, waste materials and energy. The potential to realise substantial reductions in operational business costs was one of the key drivers for companies co-operating within clusters. Companies could reduce material input costs and lower waste treatment disposal and environmental charges through greater recycling and waste reduction within clusters.

The key objective of the INES Mainport eXchange (IMX) was to develop a Mainport area information system which:

- exchanges knowledge about re-use and processing of wastes, heat and energy, materials, utilities, knowledge and expertise within the Mainport area; and
- stimulates market mechanisms to facilitate trade in the material and energy streams.

Initially, the project will result in the development of an Internet information system about the exchange of waste materials. Subsequently, the system will be extended to include heat and energy, utilities, resources, knowledge and expertise.

7.3.3. *INES Mainport project: medium to long-term strategy (until 2020)*

The INES Mainport project had the potential to be a new step in the industrial ecology typology. The initial INES project followed a traditional approach, in which stakeholders were kept at a distance. Although the economy in the INES Mainport project continued to dominate the bottom line, space has been created for new organisational approaches and targets, such as:

- the establishment of an intermediary organisation to generate and stimulate INES sub-projects;
- the involvement of new actors from higher levels in industry, government, academia and an environmental advocacy organisation;
- the start of a dialogue about regional developments based on a sustainability perspective.

It can be said that new perspectives were being explored in the starting dialogues between new partners at higher levels in industry and government. The initial INES project was not spectacular in its physical results. In the initial phase, it was possible to wonder whether the industrial ecology sub-projects involved the risk of simply being an artefact of the industrial ecology research approach. If the resulting sub-projects are weaker than cleaner production projects, then the wrong impression about industrial ecology can emerge and overshadow the intentional outcomes of going beyond company level. However, the social processes involved in environmental cluster management (the participation of more than three companies in an environmentally justified construction) should not be underestimated. As was already the case in the initial INES project, in the INES Mainport project it took time to convince other industrial company management of the advantages of such a new approach.

At the level of an industrial association, the situation sometimes resembled a prisoner's dilemma. If no new initiatives were taken, industry could become vulnerable to direct regulatory pressure. The development of internal environmental management systems and 4-year environmental plans in the Dutch chemical sector was supported by government. The government regarded the first round of these 4-year environmental plans as a learning process for all partners. It was accepted that the plans were not spectacular but were valuable first steps, both from the industrial and psychological/sociological, and from the environmental and economic points of view.

However, if the contents of the second round did not improve upon that foundation of limited successes, criticisms from regulators could be expected and in particular, they would be likely to respond with the implementation of stricter regulations. As a result, industry is trapped into being an active partner in a new industrial relationship. This is not a bad thing, because a stimulating context, such as the question asked by a government representative about involving `captains of industry’ in the INES Mainport Strategy platform, can increase synergy between the sub-projects. On the other hand, what can be expected? New technologies? New products? Or new networks of actors? Maybe in the longer term, but currently the 4-year environmental plans have not led to a breakthrough in relation to emissions reduction in the traditional investment system. There is no coupling with psychological/social processes to re-develop the organisations involved in order to create new patterns of product design and production installation development. These kinds of psychological/social processes can essentially initiate and structure the evolution in awareness that is needed to achieve a radical breakthrough.

Against this background, the documents for the development of the INES Mainport project explored new approaches for the region. At the beginning of 2000, the chairman of the strategic decision-making platform thought that the project was too much focused on the short term and wanted to formulate a renewed medium to long-term strategy. The following main issues were discussed: the necessity of an eco-park management structure that can steer sustainable area policies, a process development path for the useof the currently wasted surplus energy, the development of membrane and nano-technology, and the implementation of the DTO back-casting approach (Weaver *et al*., 1999) in the region.

In the Deltalinqs workshop *New chances for industrial ecosystems*,[132] five discussion groups with a deliberate participant structure[133] formulated the following items:

[132] The INES Mainport project workshop *New chances for industrial ecosystems* on 9 June 1999 was attended by 46 participants in total: 36 from industry and consulting firms (among them 8 guest speakers), 5 participants from government (among them 1 guest speaker) and 5 participants from specialised institutes (among them 2 guest speakers).

Group 1 discussed the optimal use of existing pipeline infrastructure, around the following question: What can we do as regards the planning of utilities at the level of clusters in the coming 10 years? And furthermore whether investment into the industrial ecology infrastructure should be done by government and/or the provider (This is a policy issue in the PMR discussion).

Group 2 discussed the development of a database for spare parts, second-hand compounds, resources, semi-manufactured articles, energy, residues/by-products, personnel, pipelines, end products, and knowledge. Furthermore a pilot project on *cold storage* and the slowness of regulation were considered.

Group 3 discussed the enrolment of energy-demanding companies (new and removal), `cold-demanding' companies and projects, metallurgic companies, and an asbestos treatment facility. Additional issues that were identified included the following questions: How can we utilise the surplus of electricity in the region? How can we cluster steered synergy via the optimisation of intensity, e.g., through the measurement of space intensity?[134] Should Deltalinqs provide an overview of surplus and lack of energy and residues? Can EZH[135] capture and bind CO_2 from flue gases? Can pyrolyse products from biomass be utilised to go within refineries?

Group 4 discussed whether DSM's tar incineration could be combined with AVR's process to achieve a more efficient generation and delivery of steam. The group established that KEMIRA produces 25 tonnes/hour of pure CO_2, but their demineralised water plant had not been in production for twenty years. Finally, an extension of COGEN to other companies (still on the basis of steam capacity) was possible.

Group 5 discussed the issue of regulation and the role of facilitation by government.

As an overall conclusion about the discussions, it can be stated that general initiatives such as the organisation of a database, of a web site and of a newsletter, were supported. The workshop was strongly dominated by technical solutions. Social issues, such as car-pooling, and the co-operation about, and organisation of, e.g. joint emissions of water and air, was scarcely discussed.

Twenty-seven officials[136] attended a different workshop for government about the INES Mainport project. The objective of developing policy for the project was elaborated in two working groups, one on the development of a database, the other on the issue of residues. Their conclusions were that, as regards the database government has an insufficiently detailed knowledge about database input; but does have an understanding of `residues'. This can have a positive effect on an enrolment policy for new companies. Furthermore it was concluded that continuous information exchange between industry and government is very important.

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[133] Discussion group 1 was made up of participants from several stakeholders; discussion group 2 contained participants from industry: Shell, HoekLoos, Elf Atochem, ENECO, Akzo Nobel, Kemira; discussion group 3 included participants from EZH, Nerefco, Eastman, and some advisers, discussion group 4 consisted of participants from industry in the Botlek area: DSM, Kemira, Esso, and discussion group 5's participants came from government, the regional chamber of commerce and academia.

[134] In tonnes per square meter per year ($t/m^2/y$).

[135] An electricity supplier with a production facility in the area.

[136] The INES Mainport project government workshop on 2 September 1999 was attended by representatives of the province of Zuid-Holland (5), the regional EPA: DCMR (10), ROM-Rijnmond (1), Engineering department of Rotterdam (4), Ministry of Environment (3), Ministry of Water Management, directory Zuid-Holland (2), Municipality region Rotterdam (1), Environmental Advocacy organisation North-Holland (1).

The workshop on residues concluded that environmental benefits through coupling of residue streams are limited. Industry saw the avoidance of inconvenience – time-consuming procedures – and financial advantages as incentives. The workshop participants did not object to that but they did not automatically see a reduction of environmental pressure.

The overall conclusions and ideas of the government workshop were that for the organisation of industrial ecology, one must not look at environmental permits, that hydrocarbons can be used as cost accounting balance in an area bubble construction and that the possibility of *generating cold* out of waste heat was worth exploring. It could save 10% of the utilised energy and result in an annual emissions reduction of approximately 9 million tonnes of CO_2 in the Rijnmond area.

As an overall conclusion, it can be stated that there was a gap between the two conceptual approaches expressed in the two workshops. The government officials were less optimistic about the pollution reduction possibilities than the industry representatives. Along this line there was also a divergent appreciation of the database: government officials had limited expectations about its potential value whereas the industry representatives had great expectations. Finally, government officials considered that the current regulatory procedure was also suited to fostering industrial ecology. This was in contrast to the industry representatives, who experienced much paperwork, time-consuming procedures, uncertainty and sometimes the rejection of requests for financial support.

7.3.4. *The pace of implementation of voluntary agreements in the INES population*

Leaders of several companies considered that the array of regulations and voluntary targets were in accordance with their own company's internal policies and procedures, whereas leaders of other companies only saw them as further evidence of growing government regulatory pressure and experience them as excessive. With respect to the implementation of an environmental management system (EMS) in the participating companies of the INES project, Figure 7.5 shows the relative speed of adoption by different companies of the concepts of industrial ecology. Some belong to the early adopters or front-runners category, while others definitively are part of the other categories (Brown, 1983).

Figure 7.5 **Speed of implementation of an environmental management system (EMS) within the companies in the Europoort/Botlek area in 1994 by category**

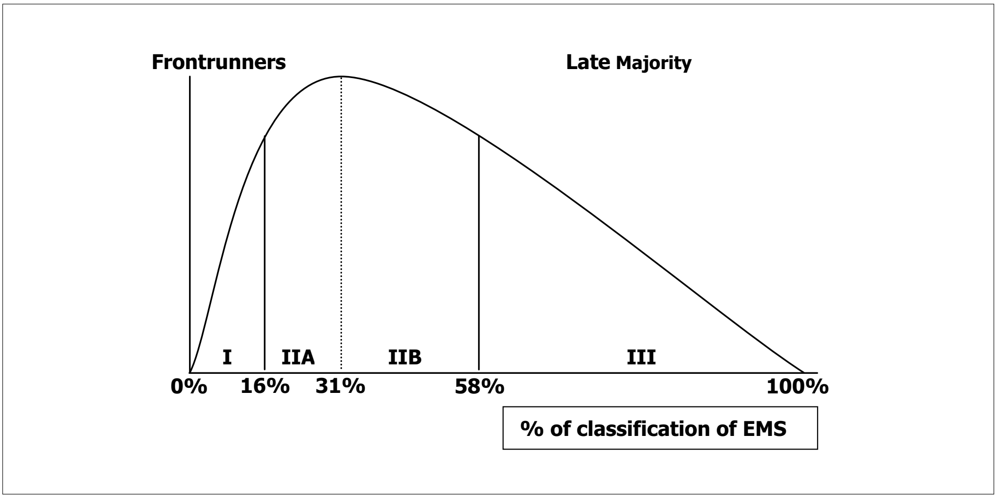


Figure 7.5 comprises the following categories relating to the speed of implementation of environmental management systems: I Frontrunners; IIA Slightly quicker than average; IIB Slightly slower than average; III Slow.

Furthermore, different organisations have different cultures, especially in relation to their country of origin, that influence the progression from one category to another category. But one of the most hierarchical companies provided the best performance in the region. This is a proof, that we have to take into account, that the various organisations find themselves in different stages of the life-cycle of (environmental) management and responsiveness to new approaches. This means that an obsolete approach with actual positive results, can block developments from an industrial ecology perspective. Additionally, a pro-active company policy can be confronted with reactive solutions that are not in line with their philosophy. These findings added complexity to industrial ecology developments, because the findings led to smaller-scale sub-projects than the concept's perspective allowed.

Finally, not all companies in the Rijnmond area joined the covenants. One company, which boasted the best regional environmental performance in their sector, stated that covenants were too general for them, because they did not know in advance what new requirements could emerge. Instead, they participated in separate sub-projects within the framework of the covenant that fitted in with their needs and interests.

7.4. **Large Dutch Industrial Complexes**

Besides in industrial sites with different companies, industrial ecology concepts can also be explored in large industrial complexes of one company. Such industrial complexes often involve bilateral relations between different plants running for many years. The industrial ecology concept can develop beyond that stage. The DOW industrial complex in Terneuzen (the Netherlands) is illustrative of this development.

At the start of the industrial complex all 30 plants were responsible for their own wastewater handling, as no central wastewater treatment facility was built. From the beginning DOW Benelux explored the preventive approach as much as possible through the development of clean technology (Spaas, 1994) and two environmental management systems: EMAS and ISO 14000 (van Seters, 1997). They were also part of the DOW's *Waste Reduction Always Pays* (WRAP) programme. This original U.S. concept was analysed in the 1980s at DOW's Terneuzen facility; the European perspective was different from the American perspective, and the acronym was translated into *Waste Reduction Action Plan*.[137] There were more differences in perspectives between Europe and the U.S.A., as Box 7.5 shows.

[137] From 1994, Dow Europe also translated the acronym WRAP as *Waste Reduction Always Pays*.

Box 7.5 *Divergent perspectives on environmental performance requirements in the U.S.A. and the Netherlands*

In October 1988, an environmental manager of the U.S.A.'s Chemical Manufacturers Association reacted as follows when he heard the information about the proposed 70% - 90% reduction targets concerning emissions and wastes in the Dutch Environmental Public Policy Plan of 1989 then being formulated: "..Under this plan, DOW should immediately leave the Terneuzen site in the Netherlands..". Confronting the environmental manager of DOW Benelux with this statement in November 1988, he said, that "..the Dutch chemical industry is able and willing to cope with clear targets within a certain time frame..". DOW Benelux fully co-operated with the Dutch National Environmental Policy Plans (1989, 1990) that provided a transparent framework and more preventive thinking, and challenged DOW Benelux to develop innovative approaches that resulted in a better environmental and overall performance in their Terneuzen industrial site.

The development of the water supply is illustrative of the new industrial ecology thinking. The DOW plants in Terneuzen were using three million m^3 of fresh water per year in 1998 (¼ of the total fresh water use in Zeeland). The extension of the capacity of the Nafta-cracker in 1999 was expected to take14 million m^3 fresh water per year. Today, DOW has a contract with the regional public utility Delta and U.S. Filter to use the salt water of the Oosterschelde instead. U.S. Filter uses membrane filters for desalting the Oosterschelde water. Delta and U.S. Filter are now taking care of the total water supply at the DOW industrial complex (total investment into the water plant was € 16.8 million; the CO_2 saving will be 108,000 tonnes/ year). In this way industrial ecology thinking and action are increasing at DOW's industrial complex in Terneuzen. In 1995 the electricity system was contracted out to three companies; of the total generation of 450 MW from industrial process warmth DOW only needs 150 MW. In 1996 the compressed air supply was contracted out.

DSM also outsourced its energy generation at the Geleen industrial complex in the South of the Netherlands in 1996. Electricity supplier EPZ built a Heat/Power installation with a capacity of 240 MW for steam supply for all five plants. In 1996 DSM produced half of the needed energy themselves in coal installations. The new installation will produce power in a cleaner and more efficient way (de Volkskrant, 17/02/96). DSM views the activities of the different plants at the Geleen industrial complex as industrial ecology (RMNO, 1997).

A new advance in industrial ecology is the development of co-siting concepts. Based on economic decisions at higher corporate management levels, parts of an industrial site can be sold while the owner of the site continues to be responsible for the infrastructure and for maintaining the permits of the site. In the Europoort/Botlek area, the Huntsman industrial site, the former Nerefco Botlek refinery site, the Kemira site, and the Shell chemical site (having sold four of their six chemical plants) provide a good illustration of this phenomenon.

The former Akzo-Nobel industrial site (Kleefsewaard) in Arnhem embodies another restructured co-siting concept with the involvement of nine new companies.

7.5. General trends influencing industrial ecology

The preventive approaches to cleaner production and industrial ecology require time to catalyse changes in the traditional environmental management practices. A change in the direction of preventive concepts is influenced by general trends in society. As a result, the key actors in three categories of organisations, industry (Duffy, 1997), local government (Reijenga, 1995) and innovation-catalysing organisations (van Vliet, 1999) are helped by internalising other developments such as a growing awareness of the preventive approach and its application in the `real world'.

The industrial symbiosis movement is also influenced by six other trends:

- *Public services liberalisation*: companies are no longer compelled to have contracts with the regional public utilities. They are allowed to purchase their utility needs from different suppliers;
- *Exclusive attention to core business*: large companies focus on their core activities and contract their non-core activities out to other companies; those companies can explore the demand for utilities as their core activities; the privatised *public utilities* can also develop new products such as *grey water* supply (water that does not need to have drinking water quality). An illustration of the privatisation of a public organisation and its more exclusive focus on its core business is provided by the water supplier in the Europoort/Botlek region. They always supplied drinking water to households and industry. Currently, they also produce distilled water. A water storage basin was renovated for the production and storage of demineralised water, Brielse Meer water (surface water) and industry water. In the new situation they conduct more research on new purification techniques.
- *Supply chain management*: the quality and environmental requirements from one company put to others in the product chain;
- *Cluster management of companies*: the strengthening of economic and environmental performance thanks to the generation of strategic alliances (see Porter in Chapter 8);
- *Co-siting*: the enrolment of new companies at a corporation's site while the site's owner continues to be responsible for the infrastructure and permits for the site;
- *The growing benefits of complementary expertise and services*: the dialogue with stakeholders is bringing new issues forward, such as expertise development in specialised institutes and insight in long-term developments in regulations.

All these developments have strengthened the focus on dialogue and the growing transparency of companies, who are willing to engage more regularly and effectively in information exchange and knowledge to back up their environmental and social responsibilities.

7.6. Institutional changes in the worldwide dissemination of industrial ecology concepts and procedures

As regards participating actors, changes have also taken place, for instance during the exploration of industrial ecology concepts in new and old industrial areas (respectively *green* *field* and *brown field*) under the name of Eco-Industrial Parks (U.S.A.) or Sustainable Industrial Areas (the Netherlands). An eco-industrial park or a sustainable industrial area is a community of manufacturing and service businesses that work together to improve their environmental and economic performance. The concept – that mimicks Kalundborg's Industrial Symbiosis – has been disseminated all over the world, for instance in the Burnside industrial area in Halifax, Canada, the Humberside region in the United Kingdom, the Trondheim's industrial region in Norway, the South Central Business District Eco-Industrial Park in Chattanooga and the Stonyfield Eco-Industrial Park in Londonderry, New Hampshire in the USA, an industrial area in Cape Town in the Republic of South Africa (Beers, 1999), Tirupuu in India (Ramaswamy & Erkman, 2003), the Kawasaki Zero Emission Industrial Park in Japan (UN University, 1998), the `original and reclaimed' off-shore Jurong island project in Singapore (Sharma, 2001), the Guigang eco-industrial city in China (Duan, 2001, Zhu & Côté, 2004) and the PRIME[138] project in Makati City in the Philippines (Chiu, 2001). According to Erkman (2000) industrial ecology in Japan is more or less circular economy.

In the overview below, some eco-industrial park approaches are described in order to illustrate the fact that in the case of the industrial ecology concept, a real occurrence (Kalundborg) has also provided the basis for a mediating organisation and/or a key person to organise the dissemination of the concept.

The Burnside industrial ecology project dates from the early 1990s. The project followed a similar path as the STIMULAR cleaner production dissemination project (see Chapter 4): it started as a project, and later became institutionalised as an intermediary association. Businesses in the Halifax Regional Municipality now have an arms-length and responsive service to assist them in addressing integrated environmental and economic issues. The Eco-Efficiency Centre in Burnside is a non-profit centre supported by a team of public and private partners who all share a commitment to improve the ecological effectiveness and economic efficiency of Burnside businesses, of the Halifax Regional Municipality and of Nova Scotia as a whole (web site of the Eco-Efficiency Centre).

The mandate of the Centre is to move the environmental agenda forward by demonstrating that the right environmental choices can help businesses reduce costs and/or generate new revenue. The Centre is focused on the Burnside Industrial Park, however, it is expected that the Eco-Efficiency Centre will be a prototype for application to the broader Nova Scotia business community.

The goals of the Eco-Efficiency Centre include directing new attention to the areas of energy and water conservation, and renewed attention to pollution prevention and source reduction issues. Some specific functions of the Eco-Efficiency Centre include:

- To assist companies, primarily small and medium sized businesses, from all sectors in the Burnside Industrial Park, and as resources allow, in other industrial parks in Halifax Regional Municipality;
- To respond to requests for information, and to provide relevant information on pollution prevention and resource conservation opportunities for business throughout the Halifax Regional Municipality;
- To conduct preliminary environmental reviews of company facilities in the Burnside Industrial Park with the objective of identifying source control, energy and water conservation opportunities;

[138] PRIME is the acronym for Private Sector Participation in Managing the Environment.

- To produce and distribute fact sheets to relevant businesses in Burnside Industrial Park and as resources allow, to businesses elsewhere in the Halifax Regional Municipality;
- To organise and co-operate in offering training sessions and workshops in facilities and for groups of businesses;
- To promote success stories to encourage other businesses to become similarly involved in the industrial ecology activities;
- To encourage co-operative efforts among businesses within and between sectors.

The UNEP report – *The Environmental Management of Industrial Estates* (1997) – does not provide a definition of ecologically-induced industrial estates.[139] In the report is stated that the incremental extension of the industrial estates with advanced environmental management issues should lead to unique *green* industrial estates. Leading principles such as the precautionary principle, integrated approaches to environmental management, environmental planning, ecological design, total quality management, cleaner production, resource recovery and industrial ecology should be involved. The existing industrial estate should organise this development, assisted by the establishment of an operations and information centre to co-ordinate the management of environmental services.

With this approach (an incremental development from *no management* to *industrial ecosystem*), the UNEP report bases its plan on the division between general management and environmental services. Referring to industrial estates worldwide, the strong institutional influence of pollution control can be detected. On the one hand it can be said that UNEP, as an international organisation, has had to compromise with existing situations that can only be changed marginally. On the other hand, if a new concept is translated at that level, it will hardly stand a chance to break through.

In the U.S.A., several new developments have translated the industrial ecology concept within the eco-industrial park approach. This approach followed the two definitions of the U.S. President's Council on Sustainable Development (1996): "..A community of businesses that cooperate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat), leading to economic gains, gains in environmental quality, and equitable enhancement of human resources for the business and local community..", and "..An industrial system of planned materials and energy exchanges that seeks to minimize energy and raw materials use, minimize waste, and build sustainable economic, ecological and social relationships..". Although the last definition stresses the physical resources and energy flows, both definitions involve social responsibility, with attempts to develop links with the local community.

Until now the development of cleaner production and industrial ecology concepts has been described as a phenomenon originating inside the companies. With the development of eco-industrial parks, new actors outside the cleaner production and industrial ecology concepts have entered the field. For instance Lowe (1996) noticed, in meetings for the development of an industrial park network in Brownsville (U.S.A.), the presence of representatives of private developers, public development agencies, economic development corporations, an urban land institute and the Cornell University.

[139] The simple definition of Peddle (1993) is used: `A large tract of land, sub-divided, and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and close proximity of firms'.

Allenby and Graedel (1995) distinguished three types of industrial ecology systems as a development path. The first type requires a high throughput of energy and materials to function and exhibits little or no resource recovery; the second type represents a transitional stage where resource recovery becomes more integral to the working of the system but does not satisfy its requirements for resources; the third type re??cycles all of the material outputs of production, while relying on external energy inputs.

Wernick and Ausubel (1997) suggest three analytical methods to discover and measure progress in finding influence. The first maps the flow of a material (such as lead) through the nation's industry, a sector, and even within an individual firm. This mapping resembles the analysis of the money or energy in an economy. The second follows a product through its whole life, from assembly to *end of life* management (and beyond), and encompasses all the materials in the products. The third examines the course of, say, iron per unit of GDP, to find out whether a society is approaching or retreating from the industrial ecology's goal of lightening the environmental impact per person per unit of net income generated by that activity. Chertow (1999) concluded, after a U.S. National Science Foundation industrial ecology workshop[140] in April 1998, that there exists a continuum of industrial symbiosis: through waste exchanges; within a facility, firm, or organisation; among firms co-located in an eco-industrial park; among local firms that are not co-located; and virtual eco-industrial parks. This continuum offers a broad range of approaches to sharing resources. Chertow prefers the 'anchor tenant' approach in which one company anchors a network of other companies for the supply of energy and materials and for the re-use of residues.

The Cornell Center for the Environment (1999) has developed a handbook on ways to revisit conventional zoning and regulatory approaches as well as private agreements that lead to environmentally responsible community development providing positive incentives to attract businesses and jobs. One of the motivations is to help planning bodies, legislative groups, regulators, community activists and developers to encourage eco-industrial development in their communities by creating a win-win situation (p.7). However, they were frequently unsure how to do that. Codes[141] and covenants are seen as providing helpful means because they often set parameters for development. Many eco-industrial park covenants have an association with a board of directors that supervise the park's management.

Eco-industrial development can take one of two forms: co-located (one place) or virtual (links more co-locations). In two EIDP meetings (Cape Charles, VA, Albuquerque, NM) it was agreed on the following minimum goals: to strive for continuous business and environmental improvement, to establish networks to accomplish objectives and links to the local community and the eco-system, and to achieve beyond compliance levels with federal, state, and local regulations. In the handbook, an illustration of the Vision Statement of Londonderry, NH (1996) is provided, covering the following issues:

- *sharing a common mission through long-term partnerships*: looking for long-term connections and synergies between eco-park occupants;
- *accountability*: including land stewardship and ecological performance assessment;

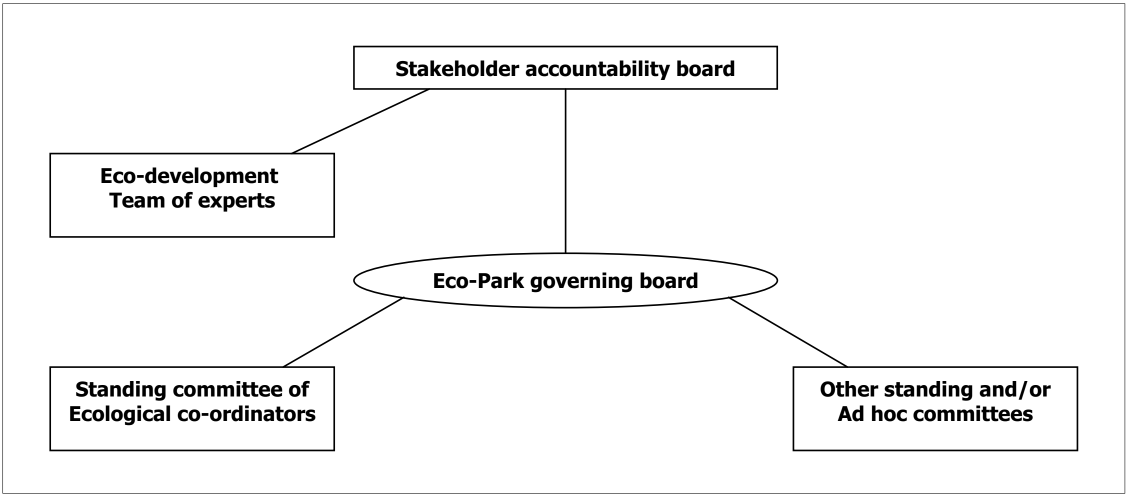
[140] The U.S. National Science Foundation organised a workshop in Washington D.C on `Linking Industrial Ecology to Public Policy' in April 1998.

[141] Codes are regulations established by state and local governments pursuant to their authority to ensure public health and safety, e.g. zoning and environmental regulations.

- *striving for continuous improvement and innovation*: involving business competitiveness and environmental performance;
- *land stewardship*: focusing on ecological integrity and biological diversity;
- *serving the local community*: for economic benefit as well as educational and outreach programs;
- *serving one another*: including eco-park business, employees, and members of the community.

An illustration of the eco-park management structure in Londonderry, NH (1998) is presented in Figure 7.6.

Figure 7.6 **The eco-park management structure in Londonderry, NH (1998)**



The handbook describes eco-industrial parks as a promising type of alternative economic development. Business and community do not have to be in conflict, they can flourish together. Both have a stake in directing economic growth in a sustainable manner. Businesses benefit from an invested, satisfied and interested labour force and supportive community. The community benefits from having good jobs and a healthy economy. Both have a role in ensuring sustainable economic development through the development of codes, covenants and restrictions. However, it is also stated that too often, industrial ecology does not fully consider the community in which they are locating, thus, creating a gap between community and business interests. The eco-industrial park approach attempts to bridge this gap by fostering community-oriented development.

All industrial parks have some form of management for the daily activities of the park: professional management companies privately manage some, others are tenant-run or managed through private/public partnerships. Performance management of eco-industrial parks requires effective indicators that help the group make progress in the direction of sustainability. An overview by Hart (1999) provides an operationalisation of such indicators in the handbook, as Table 7.15 shows.

Table 7.15 An overview of economic, environmental and social indicators in the mode of traditional and sustainability indicators

Traditional indicators	Sustainability indicators	Emphasis of sustainability indicators
Economic Indicators		
* Median income * Per capital income relative to U.S. average	* Number of hours of paid employment at the average wage required to support basic needs	* What the wages can buy * Need to define basic needs in terms of sustainable consumption
Environmental Indicators		
* Ambient level of pollution in air and water, generally measured in parts per million of specific pollutants	* Biodiversity * Number of individuals of key species, such as salmon in a stream or birds in a given area	* Ability of the ecosystem to process and assimilate pollutants
Social Indicators		
* System Approach to training and other standardized test scores	* Number of students trained for jobs that are available in the local community * Number of students who go to college and come back to the community	* Matching job skills and training to needs of the local society

One of the primary goals of eco-industrial parks development is continuous environmental improvement. As such, the codes and covenants should be flexible enough to adapt to changes in the connections that are formed. This flexibility should fall under an established review process ensuring input by all stakeholders. By creating new codes, communities take responsibility for fostering an economic development climate in their communities that draws sustainable industry practices. By creating eco-industrial codes and covenants regulation, developers ensure the character of the industrial development in a particular industrial park over the long term. Both are essential for effective, long-lasting eco-industrial development.

The covered subjects also changed, as is illustrated in an eco-industrial development roundtable organised by the North West Louisiana Commerce Centre at the end of February 2001. The following topics were discussed for bio-regional orientation: the background of permaculture design, emergency aid, industrial ecology and sustainable development. Open space topics were: infrastructure, national security and emergency aid, regional materials flow, agricultural re-use and natural capital. As regards dissemination policy, other sessions were organised, such as strategies for stakeholder involvement and infrastructure development. The results of the discussions were also to also serve as valuable inputs for preparation of the U.S. National Centre's online resource manuals for communities and developers considering eco-industrial park development

7.7. Global institutionalisation in industrial ecology

The institutionalisation of new concepts is characterised by a number of professional developments, such as being the subject of training, journals, policy instruments, handbooks, development funds, associations and conferences. In the case of industrial ecology, all these characteristics are being put into practice in a relatively short time. The handbook on industrial ecology (mentioned in Section 7.6) and the eco-industrial park dissemination funds of the Dutch government (discussed in Section 7.8) are an illustration of this. Another example is the initiation in 1997 of a scientific Journal on Industrial Ecology, jointly published by Massachusetts Institute of Technology (M.I.T., Boston) and Yale University. Industrial ecology has been the subject of sessions in cleaner production and pollution prevention roundtables worldwide since 1995 (2nd ERCP). Large-scale conferences on industrial ecology were first organised at the end of the 20th century.[142]

Additionally, new industrial ecology organisations have been established in Canada and the United States. In January 2000, Natural Resources Canada, Environment Canada, Dalhousie University and The Cardinal Group Inc. launched the Canadian Eco-Industrial Network (CEIN, 2000). The CEIN is an association of public and private organisations designed to serve as an information clearing house on eco-industrial networking and related approaches for developers and practitioners of eco-industrial networking and for sustainable business leaders in Canada.

The Industrial Ecology Institute (IEI) was established in Washington D.C. as a not-for-profit educational enterprise to promote the principles and practices of industrial ecology in the rapidly industrialising emerging countries (IEI, 2000). In June 2000, The International Student Committee on Industrial Ecology was established to promote communication among industrial ecology students throughout the world (ISCIE, 2001).

Finally, the University of Southern California (Los Angeles) and the Cornell University jointly initiated the U.S.A. National Center for Eco-Industrial Development[143] in 2000. The mission of this centre is to facilitate job creation and sustainable industrial expansion in distressed communities around the nation by applying the principles of industrial ecology, establishing eco-industrial parks, and expanding the use of environmentally benign manufacturing processes and techniques.

Overall it can be concluded that the industrial ecology concept is becoming increasingly widely accepted, although the industrial ecology concept is sometimes used as a catch-all label. For instance at the ISIE conference, speakers seemed to believe that everything related to the environment can be accommodated under the umbrella of industrial ecology, from social frameworks, entropy, material flow analysis, spatial economics until traditional

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[142] Such as the Global Futures Organisation in California (the Future 500 summit organised an Industrial Ecology conference in April 1998, April/May 1999, October 2000 and November 2001), US-EPA conferences (among others in Louisville), an Eco-Industrial Development Roundtable jointly organised by `The Symbiosis Institute' and `Cornell University's Work and Environment Initiative' in Kalundborg in September 2001, and the inaugural conference of the International Society for Industrial Ecology (ISIE) conference in Noordwijkerhout, The Netherlands, 12-14 November 2001. The ISIE is supporting research and applications related to the emerging field of industrial ecology. The Gordon Research Centre at Colby-Sawyer College, New London, NH, organised an Industrial Ecology conference on 9-14 June 2002. A Joint SETAC Europe and ISIE meeting was organised under the title *Industrial Ecology: from theory to practice* in Barcelona, 3-4 December 2002. The second ISIE conference was held in Ann Arbor, USA, in the period 29 June – 2 July 2003; the 3rd one in Stockholm, Sweden, in the period 12 – 15 June 2005.

[143] After the death of the managing professor of the industrial ecology programme at Cornell University, the programme was stopped at Cornell University and the U.S.A. National Center for Eco-Industrial Development was continued in California.

policies of re-use, recycling, separation of waste and separation after the collection of waste. The dominant focus is a techno-economic focus on material flows including the statement that Life-Cycle Assessment is the methodology for the new scientific discipline of industrial ecology (Udo de Haes, 2001). By paying no attention to the social sciences, one neglects the process issues that involve changing routines within the current industry structure.

7.8. **Industrial ecology developments in the Netherlands**

In the Netherlands, the Zeeuwse Milieufederatie organised a study meeting[144] for politicians, policy-makers, industry associations, labour unions, consulting and engineering firms, chambers of commerce, and experts from knowledge institutes, with input from the INES –project, on 30 May 1996. Drawing on the Dutch public policy document *The Economy and the Ecology* (1997), two environmental organisations in Noord-Holland (the Netherlands) organised a meeting about the application of industrial ecology concepts to the development of new, and the renovation of old, industrial harbour areas near Amsterdam (Milieufederatie Noord-Holland, 1998).[145] The environmental organisations organised the discussion meeting so that they could express their wishes for a holistic approach to sustainable development in the North Sea canal region. The basis for industrial activities was the development of eco-industrial parks with maximal modal shift for traffic. It was concluded that government should facilitate loans for an integrated approach of emissions reduction, employment increase and added value progress within an industrial ecology framework.

As a consequence of the Dutch public policy document *The Economy and the Ecology* (1997), the Dutch government subsidised many eco-industrial park projects. Several local authorities were stimulated to set up successful eco-industrial parks through a deliberate policy-making process; the involved consulting firms developed various planning methods with several functions. However, the vision of sustainability was not explicitly defined, the categories *symbiosis* and *utility sharing* were not sufficiently considered, the companies were not sufficiently involved in the development process, and the steering instruments could only enforce options with a limited environmental benefit (Leeuwen *et al*., 2003). NOVEM[146] (1999) published an overview of 62 eco-industrial park projects throughout the country, both in industrial and market garden areas. These projects were mostly in the initiation phase at the time of the report. This was the reason for the city region of Haaglanden (The Hague and surrounding communities) to establish a *Knowledge Platform for Eco-Industrial Parks* together with the province of Zuid-Holland in 2001, in order to integrate the scarce knowledge about eco-industrial parks (Provincie Zuid-Holland, April 2001).

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144 Under the title: *Naar een duurzame Zeeuwse Industrie* (Towards a sustainable Zeeland industry).

145 Here too, participants had a variety of backgrounds. There were representatives from politics, ministries of economics and water management, environmental, economic and physical planning departments of municipalities, regulatory agencies, private development organisations, environmental and citizens organisations, industry associations, labour unions, consulting and engineering firms, chambers of commerce, and experts from knowledge institutes and universities.

146 NOVEM is an intermediary organisation for the awarding of research funds from the Dutch government.

7.9. **Sustainability and industrial ecology issues in the Rijnmond area**

Towards the end of the 20th century and the beginning of the 21st century, the sustainability discussion was strongly influenced by the need for new land in the Rotterdam harbour and industry area. The different interpretations of that need led to a decision at the national level to start the PMR project (Project Mainport development Rotterdam). This project started in 1997 to explore the need for a new industrial area, to be developed in the North Sea, and defined by environmental criteria. Several ministries, the municipalities in the Rotterdam region and the province Zuid-Holland are co-operating on this project. Against this background, many other discussions and multi-stakeholder initiatives were elaborated during the 1990s.

The *ROM-Rijnmond project* (Physical Planning and Environment in the Rijnmond area, Dil *et al*., 1993) is based on a policy covenant, signed by all the government bodies and industry involved in the Rijnmond area on 9 December 1993. The project (which runs until 2010) aims to strengthen the Rotterdam harbour and industrial area as international gateway and to improve the living quality of the residential areas by integrating the environment in the physical planning of the Rijnmond region. Industry representatives are members of the different working groups. It can be observed that on the whole the initial institutional framework of the ROM Rijnmond project was traditional. In the period until 2003, no new actors at higher levels became involved.

Another forum was provided by the *RDC project* (Rotterdam Sustainability Club), a joint initiative from the Erasmus University Board and the Municipality of Rotterdam in 1996. This Club started a sustainability dialogue platform with members from government, industry, expertise centres, an art policy centre and an environmental advocacy organisation. The informal structure should stimulate new ideas and initiatives for a sustainable Rotterdam region. There were strong personal environmental motives for participation. However, the participants' interest declined after the club reached a mature phase in 2001.

Furthermore, the *INES Mainport Project 1999-2002* started as the follow-up to the INES project. The industrial association took the initiative in 1998 of establishing a small professional organisation to function as an intermediary in the performance of the defined activities in the INES project and to explore further possibilities. A high-level strategic platform, with members coming from government, industry (plant directors and industrial association), expertise centres and an environmental advocacy organisation, discussed the different projects and their contributions to a sustainable region. The INES Mainport project was explored under the umbrella of the ROM-Rijnmond project and had a positive self-evaluation, but it was hardly known to ROM-Rijnmond management (Baas, 2002).

All three projects developed in separate circuits. There were a few people who were members of several groups but they were not in the position to provide synergy between the projects. Another project under the umbrella of the ROM-Rijnmond project was *Energy 2010*. Because of several similarities with the INES Mainport project, a merger was proposed in 2000, but did not succeed. As part of the national policy on transition management, the Ministry of Economic Affairs started a `Sustainable Rijnmond' project in the Rijnmond area that was nominated as one of the experimental regions at the beginning of the 21st century. In 2002, many actors in the different projects saw the potential synergy to be gained from a merger of the separate circuits (Baas, 2002). Under the umbrella of the ROM-Rijnmond project, a new project in addition to the preceding ones started under the name of *R3: Sustainability in the Rotterdam Harbour and Industry Complex*. This project – which includes a strategic discussion platform made up of relevant stakeholders – should be part of the driving mechanisms towards a sustainable region.

The specific aspects of the development of industrial ecology in the Rotterdam Harbour and Industry Complex are recapitulated in Table 7.16.

Table 7.16 Overview of the various aspects of industrial ecology in the Rijnmond area in the period 1990 - 2003

Period/ Issue	1990 - 1993	1994 – 1997	1999 – 2002	2003 - ongoing
Theme	Development of company's environmental management systems	INES project: exploration of industrial ecology	INES Mainport project: implementation of industrial ecology projects	R3 – Sustainability in the Rotterdam Harbour & Industry Complex: exploration of transitions
Actors	Deltalinqs, environmental co-ordinators, consulting firm (project facilitator)	Deltalinqs, environmental co-ordinators, consulting firm (project facilitator), academic researchers	Deltalinqs (project manager), representatives of industry, government (national, regional EPA, provincial, port management), academia, environmental advocacy organisation	ROM-Rijnmond Programme (including project management), representatives of industry, government (national, regional EPA, provincial), port management, academia, environm. advocacy org.
Relation-ship	Industry partners	Industry + academic researchers	Industry lead + all stakeholders	Government lead + all stakeholders
Process	Knowledge dissemination, quarterly information exchange	Academic research, Decision-making in INES platform led by board member of Deltalinqs	Feasibility research + implementation of INES projects, accountable to a stakeholders platform	Energy transition research, Considerations by a strategy platform of stakeholders
Financing	Subsidy from government	Subsidy from government	50% government subsidy + 50% time input by industry	Subsidy from government
Type of learning	Learning by doing, information exchange by partners	Traditional research projects + feasibility study, start of learning by learning	Learning by doing and by learning within the perspective of stakeholders, information in strategic platform	Reflexive learning through evaluation of projects in strategy platform of high-level stakeholders
Institutio-nalisation	Development of network of environmental co-ordinators for EMS development	Representatives of industry and academics in a garbage can model of industrial ecology development	Strategic decision-making stakeholder approach to industrial ecology development	Strategy platform of stakeholders for sustainability transition policy development

7.10. Provisional conclusions on the development of the industrial ecology concept

With respect to the questions `..What were the origins and the characteristics of the cleaner production and industrial ecology concepts and the intervention processes leading to the application of these concepts and accommodation with their implementation..? and `..How and under what conditions was the concept of industrial ecology translated into action by companies and how were learning processes concerning implementation dealt with?..', the following preliminary conclusions can be drawn.

It can be concluded that the industrial ecology concept is increasingly becoming widely accepted. Also, institutionalisation – as with the initiation of a scientific Journal on Industrial Ecology in 1997 and the start of the *International Society on Industrial Ecology* in 2001 – draws attention to the issue of industrial ecology. It is obvious that the Kalundborg Industrial Symbiosis experience is used as the only example worldwide. It has often been observed that there is no other known example of mature industrial ecology in practice.

The complex system involving different companies and actors (including their different activities and targets) that is required for the existence of industrial ecology in a region is an important, but time-consuming variable. In the Netherlands, several local authorities were encouraged to set up successful eco-industrial parks through a deliberate policy-making process; the consulting firms involved developed various planning methods with several functions. However, the vision of sustainability was scarcely explicitly defined, the categories *symbiosis* and *utility sharing* were not sufficiently considered, the companies were not sufficiently involved in the development process, and the steering instruments could only enforce options with a limited environmental benefit.

In the Rotterdam Harbour and Industry Complex, two sustainability programmes were developed in the 1990s, namely the ROM Rijnmond project (with a balanced economic and ecological objective for the region) and the INES project (with its focus on industrial ecology).

The ROM Rijnmond project dealt initially, on the most optimistic view, with indicators of cleaner production. Furthermore, ongoing developments with new approaches within industry were facilitated. However, the institutional framework was traditional and no new actors at higher levels were involved. The merger (together with the INES Mainport project) with a transition programme of the Ministry of Economic Affairs in 2003 changed that situation.

The INES Mainport Rotterdam project had the potential of constituting a new step in industrial ecology. The initial INES project had a traditional approach, in which stakeholders were kept at a distance. Although in the INES Mainport project the economy dominated the bottom line, space was created for new activities such as the establishment of an intermediary organisation for the management of the project, new actors from the highest levels of industry, government, academia and NGOs, and the start of a dialogue about regional developments in a sustainability perspective.

In the INES project, new ways of thinking and co-operation were found to be essential but they took time to be developed and implemented. However, in a mature situation of traditional regulation, this social process has to ripen. The first phase of the industrial ecology project in the Rotterdam harbour area was not spectacular in its physical results, but worked as a consciousness-raising and new mind setting for key actors in regional industry. This formed the basis for the design of the INES Mainport project, in which the industrial ecology perspectives were explored in new, more finely-tuned projects. The results of the projects were the basis for strategic discussions between new partners at higher levels in industry and society.

The INES projects were influenced by general trends, such as public services liberalisation, outsourcing of non-core business activities, and the emergence of cluster and co-siting management that strengthened the focus on dialogue and growing transparency of companies to engage more regularly and effectively in information exchange and knowledge to back up their environmental and social responsibilities.

The long-term growth and sustainable development of the region ask for new institutional arrangements in which industrial ecology can play a role. Beyond the INES Mainport project results, initiatives for sustainability developments, such as organisational research, information, conferences, think tanks, vocational training providers, specialised training and general education (Hart, 1996) should be facilitated. In that way, industrial ecology is the concept of mutual responsibility as part of the holistic sustainability concept. In relation to Selman's observations on sustainability (2000), a choice for the sustainability concept requires radical innovations.

Because so many actors and organisations are involved, the development of industrial ecosystems is site-specific. An important distinction can be made between existing and new industrial areas. The design of an industrial ecosystem must take into account the characteristics of the local and regional *ecosystem* but its development must also match the resources and needs of the local and regional *economy*. These dual requirements reinforce the need for working in an inquiry mode (Lowe *et al*., 1996). In combination with learning processes involving the experiences of other communities, developing industrial ecosystems in an interactive dialogue with stakeholders is a practical route towards the implementation of sustainability projects in a long-term perspective.

8 About Learning, System Boundaries, Perception and Cluster Alliances in the Perspective of the INES and INES Mainport Projects

This chapter deals with the actors and organisations actively involved in industrial ecology projects in the Rotterdam Harbour and Industry Complex. The analytical framework used provides an understanding of these activities by focusing on three phases of (regional) industrial ecology and governance mechanisms in which perception, learning processes, trust, cluster alliances and system boundaries – as part of a socio-technical system – play an important role. Significant elements that need to be considered when investigating regional types of eco-industrial parks are selected on the basis of this analysis.

Like most other eco-industrial park projects in the world, the INES (1994 – 1997) and INES Mainport (1999 – 2002) projects find their significant other model in the Kalundborg Industrial Symbiosis project. The success stories of three decades of evolution in the Kalundborg industrial area have been mimicked on the basis of a techno-economic approach by ongoing empirical research. The results of industrial ecology projects function as examples of their economic and environmental potency. During the course of the INES projects, explicit learning was organised by discussing economic and environmental results, for instance during workshops. Much implicit learning was accomplished by translating the industrial ecology concept into new applications such as multi-utility provisions and co-siting. On the whole, it was (implicitly) learned that the translation of the Kalundborg model is site-specific and time-consuming. One of the reasons for this is that regional industrial ecological systems meet with both *static* and *dynamic* challenges as a result of their specific system boundary.

This chapter begins by discussing insights into system boundaries and the relationship of these with diverse knowledge bases (Section 8.1), linking them to an analytical framework in Section 8.2. The analytical framework is used to shed light on the learning processes of the INES project (Section 8.3). The evolution of governance mechanisms in relation to the INES projects and industrial clusters are then analysed (Section 8.4). Section 8.5 describes the observations in the INES Mainport project concerning the *object and subject system boundaries*, while Section 8.6 analyses the stage of evolution reached by industrial ecology initiatives. Section 8.7 reflects on industrial ecology life cycles and the INES projects. Finally, Section 8.8 contains conclusions providing food for thought in relation to the sustainability content of approaches towards regional industrial ecology.

8.1. System boundaries

This section tackles system boundaries and their consequences on regional industrial developments. System boundaries exist both in relation to organisations and activities. Dietz (1992) makes a distinction between systems that cover the topics of the activities of actors (*object systems*), and systems as the totality of active actors grouped in systems that we call organisations (*subject systems*). Another distinction can be made between the static and dynamic dimensions of system boundaries. Because industrial ecology focuses on change, it is necessary to deal with dynamics, especially those that influence the nature of the system.

8.1.1. *System boundaries: static issues*

Boons and Baas (1997) have argued that it is useful to look at the system boundary of industrial ecology. The ecological system is an analytical construct, and the processes and outcomes it contains depend upon its precise boundaries. Three such boundaries were discussed: the industry sector, the product chain, and the regional industrial system. As regards regional industrial systems it was concluded that they often consist of actors that are not automatically dependent on one another for their core activities (in contrast with a product chain, where i.e. suppliers and producers have such a dependency relation). Usually, authoritative co-ordination institutions are available that may be used to develop the system.

Also, there usually is a separation between the production system and the actors that consume the products. This is a complication in making a regional system more sustainable, because without some common problems or goals (which create dependency), the actors in the system deal with each other only on matters that are not strategic to their survival. To the extent that co-ordination mechanisms are present, they are not designed to deal with such problems. In fact, many actors in the Rijnmond area are tied up in other networks that have that function (such as being part of a multinational firm, or global product chains). When making such systems more sustainable in the Rijnmond area, the construction has not only to be built upon relatively weak foundations, but also has to deal with other structures that are seen by actors as being more important.

As the focus is on a regional industrial ecosystem, it is interesting to look at relevant insights under the heading of clusters and external efficiencies. Cluster management (as management of joined interests of companies in a certain area) is rooted both in economic and materials flows. Porter (1998) observes that `..Clusters dominate today's economic map of the world: they form critical masses – in one place – of unusual competitive success in particular fields..' Porter defines clusters as geographic concentrations of interconnected companies and institutions in a particular field. He states that `.. Clusters are not unique, however; they are very typical – and therein lies a paradox: the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, motivation – that distant rivals cannot match. Competitive advantage rests on making more productive use of inputs, which requires continuous innovation...'.

Also according the Dutch Ministry of Economic Affairs (2002), the clustering of activities is an emerging issue. Innovation is necessary in order to remain competitive, but it is not a matter for a single company anymore. The technological developments go too fast, the risks are too high and the markets have become too complex. The answer is co-operation, with suppliers, customers, competitors on specific issues, and with expert institutes (because knowledge is the condition for innovation).

Gnyawali & Madhavan (2001) adopt an embeddedness perspective, which suggests that competitors, far from being atomistic entities free to undertake any competitive action within their own resource constraints, are embedded in a network of relationships that influences their competitive behaviour. The structure of the network to which they belong influences the flow of assets, information, and status among the network members. Network-based resource advantages vary across firms, resulting in varied levels of motivation and ability to undertake action or respond to actions of others. According to some American reports, more than 50% of new alliances are between competitors (Harbison & Pekar Jr., 1998). Gnyawali & Madhavan (2001) detect the existence of co-operation and competition in a network too: companies can work together by sharing resources and committing themselves to common task goals in certain domains; at the same time partners also compete by taking independent positions in other domains. Further, they state that the density of a network is important for facilitating flows of information and other resources, for developing trust, shared norms and common behavioural patterns as “closed” system, and for sanctions.

Porter (1998) does not pay any attention to the co-ordination of such clusters and to the fact that there are only a few examples in the world that illustrate his thinking (but lack the attractiveness of Kalundborg). However, without mentioning industrial ecology as a concept, Porter refers to relevant aspects of the INES Mainport Rotterdam project. He states that: `..Clusters promote both competition and co-operation. Competition can coexist with co-operation because they occur on different dimensions and among different players. Modern competition depends on productivity, not on access to inputs or the scale of individual enterprises. Productivity rests on *how* companies compete, not on the particular fields they compete in. Being part of a cluster allows companies to operate more productively in sourcing inputs; accessing information, technology and needed institutions; co-ordinating with related companies; and measuring and motivating improvement..’.

Boons and Baas (1997) focused their attention on the co-ordination of activities carried out by different economic actors within an industrial ecology application. Such co-ordination can be given shape via the product or material life cycle, a geographical area, a sector or miscellaneous relationships such as bilateral constructions. Best (1990) reflects on a mix of co-operation and competition (within new organisational formats beyond single companies) in his book *The New Competition*. Co-ordination does not automatically mean co-operation; a market of competing firms is also a co-ordinating mechanism, allocating resources in a relatively efficient way. Best (1990) discusses the important role of sectoral organisations and government agencies in bringing about this mix.

Also, Porter (1998) observes that `..many clusters include governmental and other institutions, such as universities, standard-setting agencies, think tanks, vocational training providers, and trade associations that provide specialised training, education, information, research, and technical support. A cluster allows each member to benefit *as if* it had greater scale or *as if* it had joined with others without sacrificing its flexibility. Advantages are, better access to employees and suppliers, access to specialised information, complementarities, and access to institutions and public goods, and better motivation and measurement. Also suppliers, for example, proliferate within a cluster because a concentrated customer base lowers their risks and makes it easier for them to spot market opportunities..’.

8.1.2. *System boundaries: dynamic issues*

As the metaphor of industrial ecology is connected to change processes in nature, it is important to deal with the dynamics of the ecosystem, i.e. the processes that are part of the system, and the way in which the system changes over time. The focus of this section is on a number of processes that are especially relevant, making a major distinction between the dynamics of maintaining the status quo and those of change. The first type of dynamics deals with processes that serve to keep the system operating as it is, while the second category deals with processes that are related to the system going through a number of phases. There have been attempts to stimulate such processes of collective learning in local communities in connection to the issue of sustainable development (Carley and Christie, 2000, Selman, 2000). An important element is the acceptation and use of collective learning as a process of reflection and action. The action concerns projects that involve local partners and, in addition to this concrete aim, serve to develop and reaffirm the trust between local parties. The reflection is needed in order to link projects to the larger strategic objective of developing the local community, and critically assess whether these aims are still relevant, and whether all the parties are included in the effort to work towards these aims.

Community development starts with simple projects with visible results. These serve to build up the trust that is needed to reach for aims that carry a more distant reward. Trust is also needed to make it possible to implement projects that are useful for some partners, but costly to others. The latter will only participate if they can trust the others to do the same in the future. If a regional system is striving for sustainability, and its goals become more strategic and long term, it may be forced to grow in terms of the number of activities and the diversity of actors it contains. In other words, the system becomes larger.

8.1.2.1 Institutionalisation: the life cycle

A useful metaphor in this context is the life cycle of an industrial system. It highlights the fact that organisations involved in industrial ecology initiatives often have a history in dealing with one another. Rather than establishing a completely new network of connections, industrial ecology initiatives build on - and are thus influenced by - the existing connections between the organisations involved (Boons and Berends, 2001). In the literature on how groups of organisations evolve, there have been several suggestions that they go through different phases that can be conceptualised as a life cycle. Shearman and Burrell (1987) provide a model with four phases:

- *Community*: this first phase is the industry in its embryonic state. There is a strong sense of common fate but this is more shared by individuals than by organisations. Typically, these individuals work in close geographical proximity, and frequently change their organisational affiliation. The level of trust is high, and competition is low. Silicon Valley in its first stage is a good example;
- *Informal network*: this stage is demarcated by the development of a distinct set of products and technologies. As a result, the bonding to a limited geographical area is less important, allowing geographical distribution. This implies that organisational boundaries become more important. Specialisation between organisations develops;
- *Formal network*: this phase is the industry in its maturity. It displays a high level of competition, low level of trust, and the distinction between core and periphery in the network;
- *Club*: eventually, an industry meets with a crisis. Due to engrained ways of perceiving and acting, adaptation to environmental changes becomes more difficult. This results in defensive behaviour, coupled to a social structure that resembles a club with exclusive membership.

The concept of life cycle has links with the literature on institutionalisation, where due to processes of isomorphism, the members of an “organisational field” develop similar ways of thinking and acting (DiMaggio and Powell, 1993).

8.1.2.2 Networks as contexts for learning

Complementing these insights, some literature treats networks of organisations (of which industrial ecosystems are an example) as a vehicle for processes of collective learning. Compared with the relatively common culture and routines within organisations, the loose ties between organisations can be the channels through which new ideas are developed. This of course depends upon the density of the network, and the diversity in the set of organisations of which the network consists. Bruce identifies four critical phases as requirements for network information flow: *creation* - new management practices are developed at local plants; *identification* - requires that advances at local plants are recognised; *transfer* - disseminates the created and identified practices to other sites in such a way that they can be usefully applied; and *application* - managers at other sites must be willing and able to apply the innovation to their local operations. As communication of ideas always involves individuals, it is implied that individuals who are capable and skilled in making use of the potential for collective learning must occupy the ties between organisations (Clarke and Roome, 1999).

8.1.2.3 Incrementalism

Incrementalism – the adoption of changes in small steps – accommodates the general attitude of uncertainty reduction. In industrial ecology projects, the conditions required to achieve good results at the meso level are influenced by uncertainty about the results at the micro level of the separate companies. As a result participation in industrial ecology projects usually starts with small steps in non-core activities. Das and Teng (2001: 252) argue that risk is often conceptualised as variances in outcomes of importance to the risk-taking subject, more often associated with potential losses than potential gains.

Perceived risk however, usually relates to the estimated probabilities of several outcomes. In starting strategic alliances in industrial ecology networks, the associated gain perspective is the incentive. In the elaboration of such networks relational risk arises because of the potential of opportunistic behaviour of some actors and possible conflicts when some companies' own individual interests are not congruent with those of other partners. This means that the network must perform in such a way that it achieves the perceived gain perspective. In relation to this, Goodin's (1982) three forms of incrementalism[147] are important dimensions to consider. Furthermore, two well-known forms of bias in decision-making (Lammerts van Bueren, 1999)[148] strengthen the incrementalism approach: the *confirmation trap* - the obstinate search for the confirmation of a certain opinion or a taken position – and the *regression-to-the-mean* phenomenon. This phenomenon means in statistical terms that when totally mutually or partially independent events happen, extreme situations tend to return to normal practice.

8.1.2.4 Phases of industrial ecology

Following up ideas about incremental steps that might trigger radical steps, Boons and Berends (2001) came up with three different stages in the evolution of industrial ecology initiatives (Figure 8.1). For *brownfield* sites, these are the following:

1) *Regional efficiency*: autonomous decision-making by firms; co-ordination with local firms to decrease inefficiencies (i.e. utility sharing). Such activities may be facilitated by local government authorities, and existing co-operative arrangements between entrepreneurs, in short: local social networks. This phase is characterised by identifying and making use of existing win-win situations.
2) *Regional learning*: on the basis of mutual recognition and trust, firms and other partners exchange knowledge, and broaden the definition of sustainability on which they act. In

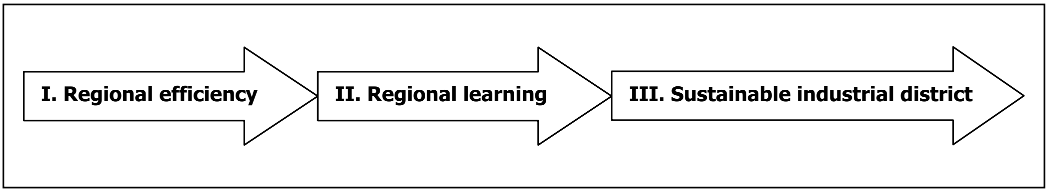
[147] See Section 2.5: strategy of decision, epistemic rationale, and adaptation rationale.
[148] See Section 2.4.2.

this phase, other stakeholders (local citizens, grassroots movements) may become involved as well. Thus, both the goal and range of membership broaden.

3) *Sustainable industrial district*: actors develop an - evolving - strategic vision on sustainability and base their activities on this vision.

For greenfield sites, there is also the phase of *selection* that precedes these three phases. In the selection phase, the actors that will form the core of the socio-technical system are selected. This selection can involve criteria related to the process of sustainable development.

Figure 8.1 From regional efficiency to a sustainable industrial district



8.2. Important elements of an analytical industrial symbiosis framework

The above considerations provide important elements of an analytical framework that can answer the research questions with respect to the origin and characteristics of the industrial ecology concept, the intervention processes, the conditions for the application of industrial ecology, and the accommodation of its implementation. The following preliminary conclusions can help to analyse the INES projects and may serve as a basis for stimulating such systems (see Section 10.1) that are engaged in a process of sustainable development.

8.2.1. *Analysing regional industrial systems and sustainable development*

The analysis from a social science perspective should centre on the collective competitive activities. This is more or less identical with what is termed the problem of co-ordination (Boons and Baas, 1997). Taking these activities as a starting point is useful, because it links to regional economics and general processes of cluster development. There are three focal points in the analysis, which are discussed below.

a) *Types of collective competitive activities*
Which activities in the system contribute to sustainable development? This can range from activities such as technological innovation, utility sharing, training facilities for environmental and human resource managers, to young children care centres and marketing strategies for the system as a whole.

b) *The governance mechanism through which these activities develop*
Developing these activities requires some form of co-ordination among the actors in the system. The forms of co-ordination range from pure market mechanisms, via (industry or industrial park) associations, to formal government arrangements. It is typical for a regional industrial system that is able to develop such activities to combine several of these mechanisms, making use of existing mechanisms (such as: government bodies that are already installed, an industrial club) and to build on them. The history and evolution

of these mechanisms is an important issue to assess, as it provides clues on possible further developments and causes of current inertia.

c) *The learning process of the system*
Until now, industrial ecology developments in industrial areas have tended to work on a *learning by doing* basis. The success stories of the Kalundborg example are usually translated into projects in their own industrial region. There is talk of explicit learning when the results of the projects are given as feedback to all stakeholders via workshops, publications, dialogues and education. Also follow-up developments based on the evaluation of the projects can develop explicit knowledge. There is talk of implicit learning when actors are not aware of (or do not realise) such effects as being one of the outcomes of the industrial ecology dissemination process. Nevertheless, some actors can learn from their participation and translate the learning into new developments as incentive for their own organisation and also distribute it to the network. If the three phases of sustainable development in regional industrial systems are taken as a point of departure, it is possible to predict which goods are typically produced in which phase of the learning process, and which governance mechanisms are effective in producing them in a given situation.

8.2.2. *Stimulating sustainable development in regional industrial systems*

From the literature on industrial districts it was learned that it is in fact difficult to stimulate such developments, as they are rooted in local factors, institutional contexts, and idiosyncratic events. This implies that even though general patterns and developments (such as the three phases in Figure 8.1) are recognised, they are shaped by unique factors of each particular case. This also means that stimulating such developments must incorporate sensitivity to these unique actors. A useful way to summarise the above is to combine these phases with the life cycle of a group of organisations.

8.3. **Learning from the INES project**

Because of a lack of knowledge, the first INES project (1994 – 1997) was an implicit learning process for all the organisations involved. The sharing of resources across firms - symbiotic linkages to use the language of industrial ecology - was new in the region, although several bilateral arrangements, what we now call industrial ecology, already existed. Notably, the INES project was introduced to both environmental managers and co-ordinators, and local plant managers (building on the lessons from earlier projects that their commitment is essential for the success of the project as well as to ensure that the changes will continue beyond the project). The INES project was performed in co-operation with the environmental co-ordinators of the companies.

Co-operation between industry and universities on developing and experimenting with applied science for environmental purposes was a new experience. At that stage, an existing communication network of environmental managers provided the personal contacts for the necessary information exchange and realisation of connections. That existing infrastructure helped facilitate the acceptance of the INES project as a useful, new approach in environmental management (Boons, 1998).

In relation to variables that could strengthen or weaken the dissemination of the industrial ecology concept in the INES projects, it is obvious that instrumentally the focus was on regional efficiency projects. Although the university research team assumed that organisational learning processes at the meso level would be important for the development of industrial ecosystems, no explicit learning processes were designed. Also, and the findings in industrial ecology projects mimic the findings in cleaner production projects (Section 5.6.4), the lack of feedback to plant managers during the INES project resulted in their lacking or losing commitment to the industrial ecology concepts.

Nevertheless, *doing* things gave rise to *learning* things at a level beyond single companies: the INES projects provided the basis for learning by doing by the Deltalinqs board. They saw that the compressed air case resulted from contacts between a supplier and users in a model that some have labelled learning by interaction (Vickers and Cordey-Hayes, 1999). This showed that although the initial INES project was not spectacular in physical results, the social and learning processes concerning environmental cluster management[149] were very important.

The Deltalinqs board members learned that the exploration by the INES project only generated projects concerned with operational optimisation. But other discussion topics in the region, such as `The future of fossil fuels' and `What is a sustainable industrial district?' needed to go beyond a technical-analytical approach. In order to pursue environmental objectives that go further than waste recycling, reflection, strategic decision-making and the involvement of more stakeholders are required. Within the industrial ecology organisation development they learned that "crossing the company boundaries" was critical for industrial ecology projects, and that this relied on such factors as infrastructural aspects, the size of companies, external sources of knowledge, the level of trust, the recognition of key actors, the assurance of future support, the role of external co-ordinators and the flexibility of the industrial ecology network (Baas, 1998).

Organisational researchers (Vickers and Cordey-Hayes, 1999) describe a more advanced *learning by learning* process where organisations develop the ability to be *reflexive* (i.e., self-conscious of the motivations and consequences of their own actions) – which in this case would be institutionalised industrial ecology monitoring becoming an embedded characteristic of the system. Put more simply, the insights from the first INES project and the learning process that arose from it, and the institutional context of the ROM-Rijnmond programme, led to a second INES project, called the INES Mainport project 1999 – 2002.

However, the learning processes for industrial ecology dissemination projects had a limited scope. The focus was mainly on the use of other companies' waste and utility sharing, which belongs to the stage of regional efficiency. The level of network-learning at the plant management level was low, especially in relation to network development or strategic alliances that are developed in technology-intensive sectors such as biotechnology and information and communication sectors: rapidly developing technologies and markets ask for the synergy derived from connecting and sharing information and expertise. The level of learning was also low within single companies, because a limited number of employees were dealing with the concept or were informed about it. It also meant that industry saw the industrial ecology network as an innovation and presented it to external stakeholders as such. At the same time hardly any new incentives for internal learning and innovation in environmental management were generated.

[149] In this thesis, environmental cluster management is defined as the linkage of three companies or more in an ecologically induced collaboration.

When the INES project was tested according to the learning processes model of Nooteboom (1999), the results were found to be limited. Nooteboom provides a model for the correspondence between different phases of exploitation and exploration in learning processes about strategic alliances. The phase of exploration starts with the radical innovation of the novel practice. Then a process of trial and error must generate a phase of consolidation that becomes a dominant domain. Because this innovation process is not based on a single project, the model is fed by an internal need to cope with disintegration elements in core-business activities. Nooteboom (1999) explains that `..disintegration is dynamically efficient to generate exploration, while integration into tighter intra-firm networks is needed to achieve productive efficiency in exploitation..'.

This model was not present in the INES project. There was no issue of disintegration in core-business activities in the Deltalinqs member organisations, leaving eventual difficulties in the normal practice of single organisations out of consideration. The INES projects were designed outside the companies, and participation in a project was on a voluntary basis without any consequence in case of failure or withdrawal. The single industrial ecology project can therefore be characterised as a *one-hit intervention* in the shape of a feasibility study. Further exploration and dissemination belong to another decision-making process. In that way the INES project can be characterised as acting without any engagement (not taking into account the fact that the directly involved actors were very committed themselves).

The overall conclusion from the INES project 1994 - 1997 is that a learning process concerning industrial ecology as a phase in sustainable development needs the involvement of higher levels of systems in which industry operates.

8.4. The evolution of governance mechanisms: INES and cluster ideas

The Deltalinqs industrial association played the role of provider of collective services and promoter of new methods such as industrial ecology initiatives in the INES projects. Their status as an important representative of the Rotterdam region that is dominated by multinational chemical corporations, provided both sectoral and geographic area characteristics. In a taxonomy of organisational implications of a combined sectoral and geographic area type of industrial ecology, the following characteristics of the INES projects can be listed: an organisation for co-ordination was available (Deltalinqs with the INES Mainport management), the competitive dependency precluded extensive co-operation and had to be based solely on non-core business industrial ecology, although there was limited interrelatedness (as is aimed for in industrial ecology), and finally, the approach was interdependent. A new development in the INES Mainport project was that the project included stakeholders from government, academia and an environmental advocacy organisation.

A comparison of clusters in Porter's analysis and in the INES Mainport Rotterdam project has to take into account the fact that the Europoort/Botlek region is not geographically easy for industrial ecology systems connecting all companies. The area is located on both sides of the river Rhine and Nieuwe Waterweg canal, and spreads out on approximately 40 kilometres of land.

Projects with a holistic potential involving demand for, and supply of, steam in a compact industrial park are economically less feasible in long-drawn industrial areas because of the logistics and loss of energy. In the INES Mainport Rotterdam project, smaller cluster constructions were used as an alternative. Criticism of these small independent clusters was related to the fact that the synergy of scale would be lost if the clusters could not be connected in the future.

An overview of Porter's findings and of examples drawn from the INES Mainport project, that reveals a number of differences and similarities, is presented in Table 8.1.

Table 8.1 Comparison of Porter's cluster analysis with the INES Mainport cluster development

Porter's cluster analysis	INES Mainport Rotterdam cluster development
Peer pressure, pride and the desire to look good in the community spur executives to outdo one another	The character of the large-scale chemical industry and the distance of Europoort/Botlek region from the community hardly involves these issues
Clusters *require a decade or more* to develop depth and real competitive advantage	After a decade of development this effect is starting to be felt in some specific projects, such as district heating and co-siting
Clusters are at least as vulnerable to internal rigidities as they are to external threats.	*Internal rigidity*: the traditional economic requirements at the company level threaten INES development. *External rigidity*: the traditional economic dominance in INES decision-making leads to continued use of traditional regulatory approaches
Regulatory inflexibility slows productivity improvement	There is an imbalance between `what is legally possible for industrial ecology' according to government officials and the `experienced impossibility' by industry
Group think (Janis, 1969) among cluster participants can be another powerful form of rigidity	The lack of internalised visions and targets for the region strengthen tendencies to group think (Janis, 1969) development

The INES Mainport project struggled with a complexity of organisations and actors with divergent objectives, which was a counterproductive threat to new developments. Although the different partners wanted to go beyond that threat, a breakthrough beyond single entity level was difficult. The Demand & Supply of Steam project illustrates the different positions taken by stakeholders. In 2000 approximately 2200 MW was emitted into the air and between 4000 and 6000 MW was emitted into the surface water. Originally the project was defined in a holistic way involving many companies in the area. The size of the project was not viable in economic terms. Also, a subsequent phase of eight smaller projects under the Demand & Supply of Steam project's umbrella was not successful (see Section 7.3.1). Finally, the project's approach was considered in small clusters that might interest the commercial market, e.g. two waste treatment corporations. The cascade development in the elaboration of the Demand & Supply of Steam project raises the question of whether smaller clusters block or stimulate the interconnection of the clusters into a bigger system. A debate in 2000 about this question revealed the positions presented in Table 8.2).

Table 8.2 Stakeholders and their attitude to the question: `Do smaller clusters block or stimulate the interconnection of the clusters into a bigger system?'

Organisation	Position
Industry association	The necessity to more connections is pointed out in the Utilities workgroup. Companies are looking at this point.
Municipal port management	Refers to the complexity for different actors and systems to organise bigger cluster systems
Waste treatment and air sharing facilities	Are making efforts to cluster companies
Plant manager	Refers to the workload and scarcity of human resources for INES activities. Meeting requirements such as the Seveso guidelines eats up time allotted to INES activities. At the micro level of companies small clusters are manageable. Connecting to bigger systems is beyond the scope of the micro level. This is why companies can go off track. Many activities are related to infrastructure.
Regional environmental authority	Has the impression that decision-makers in many companies say: it is too difficult and it is financially unfeasible
Regional water management authority	Considers that the project is on the verge of being accepted. They will not sign any permits for more emissions of waste heat. Currently there is a wasted discharge of 4000 - 6000 MW into the water. Do we want this to continue?
Ministry of Environment	Refers to the situation due the liberalisation of the energy system. The liberalisation means that officials cannot spontaneously take new initiatives, such as a new infrastructure. Industry should bring such issues to the table
Regional environmental advocacy organisation	Wants to discuss solutions, not a fall-back to traditional approaches
Knowledge institute	Observes that the contours of a conflict between general acceptance at a macro level and the difficulty of operationalisation at the micro level are becoming visible. The learning process from earlier experiences is being neglected. A knowledge connection of several stakeholders is required.

The following issues were expressed as an illustration of industrial practice. The question from a plant manager emerged whether companies have to take the initiative to develop bigger clusters. There was commitment, although economic viability was often lacking. Who would organise this exploration of bigger clusters beyond the economic level? If officials keep sitting behind their desks, and companies are faced with economic constraints, a serious threat to further developments arises.

There were many activities in the region: cluster talks – between an incinerator and a compressed air company, the Existing Rotterdam Area[150] project of the Rotterdam Port Authority and the Ministry of Environment – about the implementation of industrial ecology

[150] In Dutch: Bestaand Rotterdams Gebied (BRG) project.

in the structural re-engineering of the Botlek area. There was also much overlap: a streamlining of communication was wished for. Within Deltalinqs much discussion was going on about INES; the fifty companies considered industrial ecology to be a good concept and were also willing to pay, e.g. eight companies joined the BIR project (Utilisation of industrial rest warmth) and paid € 11360 each. As regards experience in the field of communication, it was noticed that only the same eight companies were involved in information-sharing. The other 42 companies thought that the project had stopped. That did not contribute to the general acceptance of industrial ecology.

Porter (1998) points out to four issues on the strategic agenda for a breakthrough of cluster management: the choice of location, local commitment, the upgrading of a cluster, and working collectively. For the Rotterdam area, the following observations are relevant:

1) *The choice of location*: in the second half of the 20th century the location became prosperous. Crude oil refining was the basis for the dominance of chemical industry in the region. Nearly all large chemical multinational corporations have production facilities there, although many headquarters are situated abroad. This situation can generate a barrier when the local management is not supported in its industrial ecology initiatives by the corporation's management.
2) *Local commitment*: the social glue that binds clusters together also facilitates access to important resources and information. Tapping into the competitively valuable assets within a cluster requires personal relationships, face-to-face contact, a sense of common interest, and `insider' status. Deltalinqs and the INES strategic decision-making platform could strongly facilitate this social glue.
3) *Upgrading the cluster*: upgrading the cluster should be part of the regional management's agenda. The issue is: Who plays a role in regional management?
4) *Working collectivity*: the ways clusters operate suggest a new agenda for collective action in the private sector. Cluster thinking clearly demonstrates how companies benefit from local assets and institutions. Government, working with the private sector, should reinforce and build upon existing and emerging clusters rather than attempt to create entirely new ones. Successful new industries and clusters often grow out of established ones. In fact, most clusters form independently of government action – and sometimes in spite of it. They form where a foundation of local advantages exists.

In Section 8.5, an overview of experienced system boundaries will be described, and in Section 8.6 the governance positions of industry and government will be discussed in relation to the most powerful stakeholders in the region, industry and government.

8.5. **Experienced system boundaries**

The actor's perspective and system boundary determine the scope and intensity of changes. Managers often have an economic/rational management approach (Burrell and Morgan, 1979) of operational production organisations and have learned to optimise their production activities within their own plant boundary. In case of the INES Mainport project, nearly all managers of large plants had, despite the enormous steam surplus, reasons to prefer their own conveniences for economic (the costs of the required infrastructure) or strategic (perceived loss of independence) reasons. Furthermore, within the production facilities in the Rotterdam harbour and industry complex, hardly any specialists for new projects were involved beyond their daily activities. New corporate developments were covered at other levels in their corporation and the regional industry association covered regional developments. Apart from this, plant managers did not have the breadth of perspective required to consider the possibility of bigger clusters; they also were not in the position to explore this for competitive reasons.

Even if the plant manager was committed, s/he was dependent on the exploration of industrial ecology through an intermediary organisation and the commitment of the division or corporate management. That commitment at higher management levels could be induced, but things are more complex when headquarters are physically far away and/or are part of another culture. Also at the operational level, the system boundary within which industrial ecology may be explored is limited.

In the research on system boundaries in the INES Mainport project (Baas, 2003), several interviewees mentioned that because the individual company was able to keep its distance, there was no concept owner. So many organisations and actors were involved, who were only small parts of the total and also had no demand articulation, that a passive attitude was not surprising. The participating organisations tended to perceive a new dependency (one of the defence mechanisms of Oliver, 1991) and thinking about new developments slowed down. The range and intensity of changes played a determining role in the perspective and system boundaries of the different actors. Dependence on the voluntary participation of companies implied a system boundary for Deltalinqs. The association could mobilise its members around joint environmental, economic and social themes, but it could not force members to act on certain things. Co-ordination of information, awareness raising, communication and the performance of projects were all needed in order to change this situation. Such complex projects required the following skills and assets from the intermediary organisation: time, patience, sometimes pressing on with projects, and anticipating set-backs.

This goes against the attitude of government officials (and industrial area project developers), who view the industrial ecology and sustainability concepts as business-fit concepts. This means that they expect industrial initiatives on dissemination. They are willing to facilitate but not to enforce such initiatives. The industry itself is hesitant, not about the issues as such, but because the dominance of operational core business activities does not create the right atmosphere for time-consuming, new, non-core business activities. It is obvious that government expectations about the business-fitness of the concepts are the same as the expectations of the promoters of cleaner production at the start of the concept's dissemination.

Although good housekeeping and eco-industrial parks have become well-known terms, it does not mean that simple interventions on the basis of a win-win situation are easily realised. Factors such as the lack of a demand articulation, being tied in cleaning routines, the need for uncertainty reduction, the absence of clarity about results, the organisational culture, as well as the fact that cost savings and financial aspects play a secondary role as criterion during the design of environmental management, generate a complex amount of obstacles for the dissemination of the concept. If there are no changes in the surroundings, then there is no pressure from outside on those working with a new concept. (Dieleman, 1999).

Baas (2003) reports about several types of object and subject system boundaries. Object system boundaries include a number of features:

- *System boundary and perception in historical perspective*: the traditional difference between `We care for employment and wealth' (industry) versus `We care for the environment' (government) is still characteristic.
- *System boundary and the position of the activity*: the object systems differ in daily practice; for regulatory agencies it is core business, for companies it is non-core business. This means that the complexity of industrial ecology and different priorities have an effect on the related expertise.
- *Rules and regulation*: the institutionalisation of environmental policy has led to a complex maze of regulations applying to individual companies. This situation can be counter-productive for industrial ecology, for the waste of one company may be a resource for another (Frosch and Gallopoulos, 1989).
- *The geographic area as system boundary*: the Europoort/Botlek area is geographically not easy for industrial ecology constructions because of the ribbon-like development of the industrial area along the borders of the river Rhine for some 40 kilometres. This raises the question whether it is better to design smaller cluster management for water and compressed air to stimulate a bigger system.
- *Liberalisation and infrastructure as system boundary*: industry has always seen environmental investments as efficiency improvements with an expected return on investment of two to three years. After environmental policy was integrated into general policy, an expected return on investment of six years became commonplace. With the liberalisation of public facilities – such as energy – it is the other way around. The privatised energy companies expect a lower rate of return on their investments than industry, but not the traditional rate of return over a period of thirty years when they were public energy companies.[151] This generates a different time frame between industry and energy companies that often hinders industrial ecology initiatives.
- *Continuity as system boundary*: participation in medium and long-term sustainability projects show both an increase and a decrease in commitment. Once a vision and a mission statement have been formulated, and responsibilities are settled, daily operations have priority.
- *Company boundaries as subject system boundary*: different types of organisations (such as production, energy and service companies) belong to the industrial sector of the economy. Within these types of organisation the companies are either independent facilities or subsidiaries of a national or international corporation. The background of the companies with different nationalities and visions is difficult to rationalise for the separate headquarters.

Furthermore, there are differences in organisational structure, from *hands-on* steering by the management of a division to a *footloose* construction. There exist large differences in targets, vision, culture, and the sense of urgency with regard to environmental and safety risks. For instance, a large corporation's subsidiary will first look inside their own group to consider CO_2 emissions reduction. Another system boundary is that new company

[151] Some experts state that in the decision-making process for the unification of the European Union market, for which obstacles to the optimal operation of the free market had to be taken away, it was forgotten that from an economic perspective the free market does not always provide the best solution. Sometimes a monopoly works better, for instance in the case of the electricity supply. This is because with natural monopolies, the owner needs to have long-term investment perspectives.

developments are generated at other corporation levels and can cross over with regional initiatives.

8.6. INES Mainport and the stage of evolution of industrial ecology initiatives

In the case of the INES Mainport project, both the industrial association and government organisations functioned at the meso and macro levels. This means that the dimensions of structure – such as the existing infrastructure (market), management, power and stakeholders – and the dimensions of change processes – such as policy strategy, rationality, learning processes, mimicking and dissemination – interplayed within a complex context. The characteristics of the positions of industry and government – as major stakeholders in the change process – are analysed below.

Position of the Deltalinqs industry association

1) *Its scope is both national and regional*: national because Deltalinqs represents large chemical multinational corporations, regional because it was founded in a specific region and currently still mainly representing regional member-corporations;
2) *It represents the regional corporations in the Europoort/Botlek area*: although Deltalinqs is not an industrial sector organisation (though it does represent a majority of the large member-organisations of the Dutch Chemical Industry association), they occupy a strong power position towards the national government;
3) *Its intermediary position entails both strengths and weaknesses*: Deltalinqs can mobilise its members on joint environmental, economic and social issues, but cannot force individual members to do specific things.

Position of the government

1) *Environmental regulation*: two regulatory organisations, the local environmental authority (representing the province in the area) and the regional water management authority, perform their tasks in accordance with legal requirements and voluntary agreements between government and industry;
2) *Economic development*: at a national level, decision-making on land reclamation from the sea in order to further develop the industrial park, and specific economic stimulation of the Rotterdam Mainport, are important issues; at a regional level, the port authority is responsible for the economic development of the harbour. Environmental aspects are still weakly integrated in their activities.
3) *Facilitation*: government – both at the national and local levels – has new roles to play. It must ensure the supply of high-quality inputs such as educated citizens and physical infrastructure. It should promote cluster information and upgrading and the build-up of public or quasi-public goods that have a significant impact on many linked businesses. The aim of cluster policy is to reinforce the development of *all* clusters. Every cluster not only contributes directly to national productivity but also affects the productivity of *other* clusters. Cluster development initiatives should embrace the pursuit of competitive advantage and specialisation rather than simply imitate successful clusters in other locations.

Phases of industrial ecology

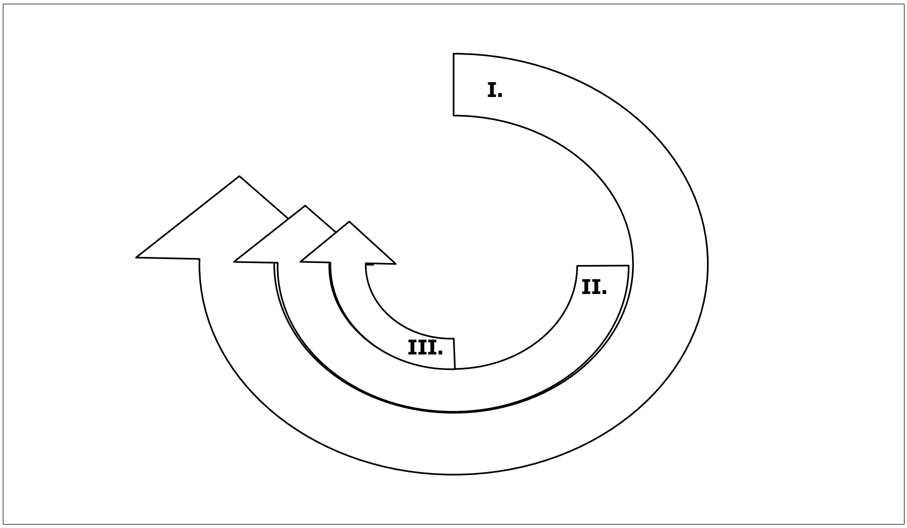
Regional efficiency was developed in the Industrial Ecosystem project (INES project 1994 - 1997) in the Rotterdam harbour area (Baas, 1998). Fifteen sub-projects concerned with utility-sharing, waste exchange and joint treatment, were defined. Some sub-projects have been implemented; several sub-projects are in the fine-tuning phase before implementation. The INES project demonstrated the need to go beyond a technical-analytical approach. The management of regional efficiency needs the involvement of key-actors and organisations. The area management, the instruments, trust, flexibility and assurance of support for the network are important elements.

The INES project introduced the need for stage II, the *learning region* phase. The core management of the follow-up programme, the INES Mainport project 1999 - 2002, involved a strategic decision-making platform with representatives from industry, government, a university and an environmental advocacy organisation. Thus, both the goal and range of membership were expanded.

According to Nonaka and Takeuchi (1995), a learning region is open, information-scanning, sensitising, monitoring, and evaluating. Parto (2001) argued that the literature on learning regions has thus far paid insufficient attention to (national or local) employment, labour and capital markets, and changes in the larger economy. Together with the development of a longer-term vision and mission statement,[152] and their operationalisation, these are possible elements of the development of stage III, the sustainable industrial district (see Figure 8.1 for a linear perspective, Section 8.1.2.5). However, these are isolated elements of stages II and III. The basis of the *trinity* of the single company, the industrial park and the sustainable industrial district, is still regional efficiency with a technical-economic perspective. Nevertheless in a system theory perspective, the emergence of elements at other stages might provide a scattered pathway to a sustainable industrial district.

[152] INES Mainport Visie op een duurzame ontwikkeling van de Mainport (Vision on the sustainable development of the Mainport), August 2002.

Figure 8.2 **From regional efficiency to a sustainable industrial district from a system theory perspective**



The regional context of the INES network

Owing to the absence of government interference and waste exchange markets, the need for co-ordination and intermediary activities concerning industrial ecology dissemination emerged. The network development process is an ongoing chain of partnerships of different types that is influenced by three factors: scope, phase and stage (Baas and Boons, 2000).

In the INES project, the scope of the industrial ecology initiative was originally limited to the Deltalinqs firms; government stakeholders were scarcely informed about the results of the projects. In the INES Mainport project, the scope was broadened to other stakeholders with the creation of a strategic decision-making platform, which enabled the confrontation of expertise of various actors, such as representatives from government, industry, environmental advocacy organisations and expertise centres. These, with their different knowledge and perspectives, could discuss a subject and develop new solutions. This created the foundation for the development of partnerships towards a sustainable region, under the condition that more strategic issues were discussed and led to related decisions.

The Europoort/Botlek region provides an example of industrial symbiosis being inserted into a long-standing group of organisations (Baas, 1998a). It has been concluded that the group of organisations is in the maturity phase as a formal network (Shearman & Burrell, 1987). Although there is a high level of competition, the actors within the Deltalinqs working groups have established a reasonable level of trust through information exchange and discussions about new developments. Their participation in INES sub-projects illustrates this well. In the INES sub-projects, Deltalinqs has been a focal actor occupying a strategic position in the network. It has been involved in many significant links as an intermediary organisation. Its position has given it easier access to external assets, information and status. At the same time there has been a distinction between core and periphery in the network; less centrally-positioned companies find it more difficult and costly to syndicate assets and interpret information.

It was also found that an existing group of organisations that are worldwide competitors implied that they have different perspectives on implementing new regional ideas. This meant that the strategy needed to focus on how to break open these different perspectives. The character of large-scale chemical industry and the physical distance of Europoort/ Botlek region from the Rotterdam community hardly made a place for peer pressure, pride and the desire to look good in the community. Moreover, the type of risks inherent to the chemical industry strongly determines its technical process management and encoded learning (Baas, 2001). This meant that on the pathway to sustainable development, *regional learning* in the Europoort/Botlek area had to involve the start of co-operation on non-core and holistic issues.

The emphasis on regional efficiency projects such as utility sharing can be explained in this way.

System boundaries and trust

From the perspective of institutionally steered processes, the following observations can be made. Goodin's (1987) concern that we cannot anticipate the real effects of social interventions prior to actually experiencing them already provides difficulties in multi-layer decision-making processes about participating in interventions. In industry, the main actors are the industry association, the plant management and employees at the operational level. The Chief Executive Officer (CEO) abroad can add an extra level to decision-making processes. Industrial actors often have an economic/rational management approach (Burrell and Morgan, 1976) to operational organisations. Their approach determines the economic conditions for environmental projects and outcomes. Their function is described within the system boundary of their organisation. Their position (responsibility for decision-making), scope (compliance and mandate), perspective (value of the project or concept), commitment and the authority that the actors draw from this, influence the outcomes and the intensity of changes at the aggregated level of industrial ecology.

At the operational level, plant managers experience limitations of the industrial symbiosis system boundaries (see Section 8.5). When the environmental awareness that many people have cannot be deployed in the work environment, an external compensation will be sought, for instance through membership of an environmental advocacy organisation (Baas, 2002). However, as sound industrial ecology is based on devising optimal cleaner production within companies, the tacit knowledge within the system boundary of the operational level can be explored as part of the overall approach.

The task of the industry association is to bring the (inter)dependencies together by developing legitimacy for new institutional arrangements. This situation requires more attention to mutual trust, the development of joint values and ethics of the concept, a communication infrastructure and new responsibility sharing in the region. Trust that exists at the personal, organisational and inter-organisational levels is effective in industrial ecology networks through lessening concerns about opportunistic behaviour, and a better integration of the partners. Das and Teng (2001: 255) treat trust as a subjective state of positive expectations within the dimensions of goodwill trust and competence trust.

Goodwill trust is about one's good faith, good intentions and integrity in dealing fairly and caring for other partners in the network. Goodwill trust reduces the potential perceived relational risk of the network and must be elaborated by competence and expertise (competence trust). Goodwill trust in Deltalinqs (in the case of environmental projects) was mostly developed at the operational level of environmental management. Environmental co-ordinators knew each other and shared intentions and commitment to a good environmental performance. Goodwill trust in Deltalinqs was also present at the level of plant managers, although it seemed to be more instrumental and political.

In the case of the INES Mainport project the plant managers were working at the edge of their system boundary. They had responsibility for activities within their plant (in most cases in the Europoort/Botlek area there was a hierarchic line to their corporation outside the region) and they took part in the industrial symbiosis project. This meant dealing with trust at all levels in a position where economic and organisational constraints (a lean organisation with a limited staff) and other political preferences (such as safety organisation in 2001) were dominant. The dependency on links with CEOs around the world was a weak part of the concept development. It is part of the discussion whether product lines provide better system boundaries than regions for industrial ecology co-ordination. But the chemical industry is not easy to cover in terms of products: it produces compounds that are partly the basis for other industries, can be totally modified and cannot be traced back.

Uncertainty reduction

Goodin's second concern is that even when we can anticipate the outcomes we cannot anticipate our evaluative response prior to actually experiencing those outcomes. And here uncertainty comes in. When starting the implemention of industrial ecology concepts, the outcomes are not definite, despite growing experience elsewhere, which is providing information on the economic/ rational perspective of waste exchange and utility sharing more frequently. Even then the various options have to be researched empirically; the evaluative response prior to actual results cannot be anticipated. It is also required that the plant managers be committed to certain outcomes (as stated before, continuous feedback on project results is one of the conditions for success).

The Compressed Air sub-project (part of the INES project) in Box 8.1 is representative of situations in which curiosity and interest are present, but full commitment is not expressed at the beginning of the sub-project. However, it is obvious that a certain commercial potential, in this case the outsourcing of a utility independently from the INES sub-project described in Section 7.2.5, provides an incentive to another company to realise that potential as their core business.

Box 8.1 *Compressed air*

A compressed air pilot study in the INES project presented instructive challenges. In Section 7.2.5 is described that the measurement in the feasibility study showed that the usage of compressed air was lower than expected (7,000 Nm^3/hr instead of the presumed 12,000 –15,000 Nm^3/hr). The results meant that the economy of scale needed for cost reduction was insufficient. Compounding the problem of diminished economies of scale, the supplier was very busy with the installation of a larger system for the delivery of compressed air to the largest refinery in the region. As a result, they gave less priority to the INES compressed air sub-project. In addition, not all of the potential users were enthusiastic about the INES sub-project, although they did not reject participation completely.

The commercialisation should have been started in 1998, the period between the first INES and second INES Mainport project; that period was a hiatus, lacking the active participation of an intermediary organisation. As a result of these factors, both the supplier and the companies using compressed air decided implicitly to avoid the risks of a new system.

Another compressed air supplier, however, learned about this sub-project. This company was able to start a new project by building the trust required for the exchange of knowledge with four other firms and by reducing the scale of the investment needed for the installation. The supplier invested in the installation and the pipelines, and now runs the process, maintains the system and is responsible for a continuous supply. This central installation for four companies has been in operation since January 2000.

Preliminary results show savings of 20% in both costs and energy, and a reduction of CO_2 emissions (as a result of the reduction in energy use) of 4,150 metric tons each year. In 2002 another three plants, and in 2003 seven plants more, joined that system. This construction provided new business opportunities for the utility provider. They designed a new utility infrastructure for compressed air and nitrogen for 10 companies in the Delfzijl industrial park in the north of the Netherlands (aluminium, chemical and metal-working companies) that opened under the management of the utility provider in 2004 (Voermans, 2004). In addition, the utility provider is exploring the concept in several countries in Europe.

Working on uncertainty reduction with the help of three forms of incrementalism discussed in Section 2.5 (Goodin, 1982), each with its distinctive goals, strategic imperatives and rationales, provides certain results, which are detailed below.

1) A *Strategy of decision*

This means calling to continue with the type of incremental intervention that is perceived to have yielded desirable results previously: people decide to repeat what is reinforced (slow, small changes, but `sleeper effects' mislead by appearing late).

As regards the development of the INES Mainport project, the weak link to the CEOs abroad might be strengthened by involving them in an action of the board of the industry association, namely communicating about the joint vision and mission statement in the Rotterdam area. Without involving that level, the step towards *regional learning* in the Europoort/Botlek area will be limited to small clusters of co-operation in specific operations dictated by short-term economics. The great potential for CO_2 reduction and the prevention of energy loss and the economic constraints in the Steam project need an in-depth evaluation.

2) The *Epistemic rationale*

The claim to be able to get by without any theoretical understanding whatsoever of the system into which we intervene is a research strategy using the policy arena as a laboratory.

The practitioner approach has a limited economic/rational focus. In fact this approach is not a new research strategy, but a traditional project approach within a new `industrial ecology' concept name. The short-term dimension "looking for technological/economic advantages to environmental priorities" dominates the projects. Even learning by doing has hardly been evaluated. The suggestion for an e-mail Waste Exchange facility in the INES Mainport project in 2000 demonstrated the lack of knowledge about such a sub-project feature in the INES project in 1995.

3) The *Adaption rationale*

By proceeding slowly and cautiously, we can correct mistakes and adapt future moves in the light of past experiences. In fact, the overall synergy of the project is limited by the adaption rationale of the single entities. It only allows a slow and cautious course of action by the intermediary organisation. Even a modest push by the intermediary organisation in the direction of certain industrial ecology options was perceived as coercive. In such a situation learning from past experiences will not go beyond the level of finding and promoting single projects.

8.7. **Reflections on industrial ecology life cycles and the INES project**

As regards recovering materials, Wernick and Ausubel (1997, 37) state that `..Technology making recovery cheap and assuring high quality input streams must be followed by encouraging regulations and easy informational access. A ready market must appear. Technologies are inseparable from institutional and social strategies. We need to learn why industrial ecology is not already the rule in industry and remove the impediments..'.

This observation is analogous to the following issue in cleaner production: why is the cleaner production win-win concept not getting disseminated more routinely? Changing the institutional context at the micro and macro levels of organisations is not only a far-reaching and complex process it is also often underestimated (Dieleman, 1999). And firms do not consider the natural environment to be a competitive item (de Groene, 1995). Against this background, institutional dimensions, such as perception, the power positions of organisations and the life-cycle position, are discussed below in relation to the development of the INES projects.

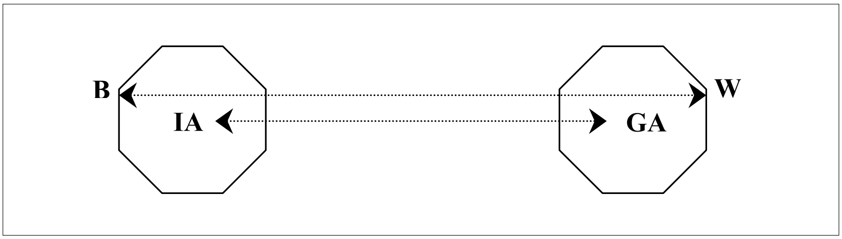
Perception in practice

During the INES project (1994-97) the experience concerning the mutual perception of industry and regulatory public bodies shows a dramatic similarity with `the Established and the Outsiders model' of Elias and Scotson (1972), as well as Kline's (1985) considerations about perceptions. Although there were frequent contacts between them, varying from strict regulation to the stimulation of cleaner production, their own familiar worldview was seen as superior: on the industrial side the idea of *bringing prosperity*, on the government side the idea of *saving the environment*. It was very difficult to go beyond the technological approach in the INES projects.[153] The external relation focus was still traditional. It was more institutionally oriented than contingency oriented.

Also, in the evaluation of the INES Mainport project Baas (2002) found a greater difference in the mutual perception of industry and government representatives than expected. The different worldviews mentioned above, along with decision-making structures and time frames, are important variables for the explanation of this finding. The differences in perception influenced the appreciation of the INES Mainport project. If the view of a government agency is far away from the option consisting of stimulating self-regulation by industry, their appreciation is closer to the conclusion that `the results of the INES Mainport project are disappointing' or, `the companies only think about themselves'. This does not imply a fall-back to strict regulations, because from the past it has been learned that laborious processes of regulation come into place that are difficult to uphold. Nevertheless, the dilemma of prejudice and distrust – an underlying part of the mindset – continues to influence attitudes and decisions in practice.

In analogy to Elias and Scotson's *The Established and the Outsiders* (1972) the following *worst case* model can be constructed. Suppose that one octagon represents the objective or inter-subjective perception of the variance in mindsets of industry with the medium **IA** (Industry Average). When they profile themselves according to their **B**est individual example, while they orient themselves towards government according to their **W**orst individual example instead of the medium **GA** (Government Average), than the difference between B and W is bigger than between the **A**verage differences in perception of the two categories, as Figure 8.3A shows.

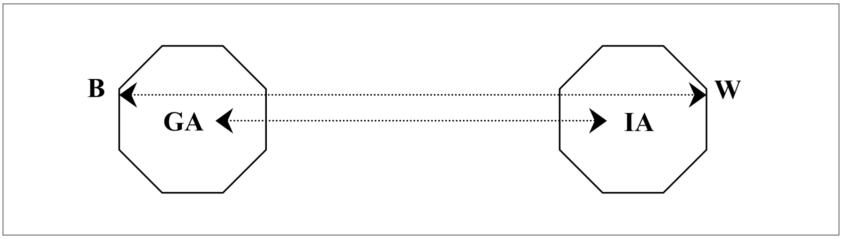
Figure 8.3A **Model: Differences in perception between two categories of organisations (perception of government by industry)**



The same construction is valid the other way round for the perception of government organisations by industry.

153 Citation of the Chairman of the INES Mainport Rotterdam project in an evaluation of the first year of the project.

Figure 8.3B **Model: Differences in perception between two categories of organisations (perception of industry by government)**



In the worst case scenario, in which one category is dominated by the best individual practice in contrast to the worst illustration of practice of the other category, a platform for joint actions will function insufficiently and the differences in perception will hardly change.

Along this line of thinking, different positions can be analysed within the INES Mainport project. A latent position of consent is a basic element when government organisations show good will by saying that *it is good when the industry itself takes initiatives*. In this context government officials participated passively in the Strategic Platform of the INES Mainport project. But at the same time, Deltalinqs' interpretation, namely that the seven parties involved in the Strategic Platform of the INES Mainport project were driving force, was not recognised by the involved parties. The practice of two meetings per year in 2001 and 2002 with changing actors did not lead to a realisation of this responsibility. This constituted a handicap in bridging the viewpoints through successful dialogue.

The market and the life cycle metaphor

According to Wernick and Ausubel (1997) one impediment is the absence of government intervention, that will ultimately make the markets for waste materials rise or fall on the basis of their economic vitality. One option is to start a waste exchange brokerage, such as that presented in a US EPA report (1994) and the INES project 1994-1997, and planned in the INES Mainport project in a feasibility study in 2001. The risk of civil liability connected to handling industrial waste is also a barrier to how much can be recycled. Another impediment is that the private firm is the basic economic unit and until now is also the unit for regulatory purposes. Pelletiere (1999) highlights the need for serious attention to be given to the issue of transportation. Due to improvements in transport technology and infrastructure, and the increasing efficiency of the production process, the value of goods has been rising relative to the costs of transport. However, industrial ecosystems will utilise what are currently considered wastes due to deficiencies as regards either their quantity or the quality in which they are available. This will raise either the costs of processing the material or transporting them or both. When transport costs are high relative to the value of the goods being transported, the minimisation of transport costs becomes increasingly important for company decisions in an industrial ecosystem.

As stated earlier in this chapter, according to Boons and Baas (1997) the co-ordination of activities conducted by different economic actors in an industrial ecology context can be given shape via the product or material life cycle, a geographical area, a sector or miscellaneous relationships such as bilateral constructions. Best (1995) reflects on a mix of co-operation and competition within new organisational formats beyond single companies and discusses the important role of sectoral organisations and government agencies in bringing about this mix.

Two main pathways in developing industrial ecology activities are important: the organisation of those activities, and the activities that are being aspired to. As market incentives are important drivers for industry, the involvement of industry representatives is required. That can be different for existing industrial sites (*brown field*) and newly designed industrial sites (*green field*). In the first case industry almost everywhere has developed a form of industrial association. That form can be weak or strong, but it constitutes a basis for industrial ecology exploration. In the case of a new industrial site, government officials – whose task it is to formulate and shape a political decision – are strongly involved. They can either carry out their task in isolation, or seek commitment from, and involvement with, other stakeholders, especially industry representatives. Many issues have to be covered with respect to the organisation of industrial ecology (Boons and Lambert, 2000). A comparison between the stages of industrial ecology and the life-cycle phases of an industrial district is provided in Table 8.3. The table shows that, on the one hand, the stages of industrial ecology may more or less naturally combine with similar phases of the life cycle, such as the *birth* phase with regional efficiency and the *growth* phase with regional learning. The other cells show that the industrial ecology phases in some way go against the natural tendency, either because they precede the natural tendency, or because they lag behind this tendency.

Table 8.3 Stages of industrial ecology versus life-cycle phases of an industrial district (modification of the Table by Baas and Boons, 2000)

Stage/ Life cycle	Birth	Growth	Maturity	Decline/Restructuring/ Rebirth
Regional efficiency	Easily inserted into development	Possibilities for win-win	Narrow search for win-win	No incentive to search for eco-efficiency; if induced, search might lead to restructuring
Regional learning	Difficult due to the absence of established networks	Learning coincides with natural tendency of the group	Need to countervail inertia	Restructuring through going beyond the existing infrastructure and culture
Sustainable district	-	-	Need to pass system boundaries	Rebirth through new institutional arrangements

The concept in the INES projects was developed out of environmental management systems and cleaner production concepts towards industrial ecology primarily from an environmental perspective. Seen in the perspective of Table 8.3, the INES Mainport project covered a mature industrial area that is characterised by chemical plants owned by multinational corporations, completed with service companies in order to maintain the *go with the flow* practice though a regional efficiency approach. The area has newcomers both at old industrial sites, more frequently on a co-siting basis, and on reclaimed land areas. The industry association Deltalinqs started to put into practice the industrial ecology concept in the field of regional efficiency. This strategy made use of the evolution in a group of organisations, inserting ideas on industrial ecology into the more general development of the group.

The power position of Deltalinqs

Because Deltalinqs faced inertia in developing industrial ecology, two basic approaches to control have to be reflected upon (Das and Teng, 2001: 259). The first approach is external, measure-based control, emphasising the establishment and utilisation of formal rules, procedures and policies to monitor and reward desirable behaviour (also called: formal control, objective control). The other approach is internal, value-based control, relying on the establishment of organisational norms, values, culture and the internalisation of desirable behaviour and outcome (also called: clan control, informal control, social control).

Although the intermediary position of Deltalinqs did not allow the association to coerce individual members into doing certain things, the social control position was powerful. Nevertheless, some form of objective control was needed. On the one hand, environmental and economic results had to strengthen the industrial ecology project; on the other hand, those results had to strengthen the trust of government organisations in the competence of Deltalinqs. Deltalinqs had a strong position in the relationship with the government, but had to show that the INES Mainport Rotterdam project would go futher than a few bilateral environmental projects.

That put Deltalinqs in the following position: the association stimulated a positive feeling and good will trust. This had to be confirmed in competence trust. Deltalinqs had a low degree of behavioural control of their member companies, which increased relational risk. But Deltalinqs had a high degree of social control, which decreased performance risk. In general, the social control position of Deltalinqs needs to be explored further and the formal control on the performance has to be strengthened both for internal and for external reasons.

Another strategy that can be adopted, taking into account the inertia in developing industrial ecology, is to temporise. This is useful in situations where the group of organisations is in the early phases of the life cycle of a new concept, while some of its members, or stakeholders outside the group, want to go ahead with industrial ecology. Here it is important to keep such ambitions in place, while slowing down the initiatives in order to keep in touch with the more general evolution of the group. Newcomers have to be selected according to their industrial ecology commitment and potential contributions to countervail the temporary inertia.

Finally, there is the strategy, for a group of organisations in the mature phase of its life cycle that involves growing into a sustainable industrial district. For this breaking down system boundaries is needed. At the early stage of regional efficiency building, it might be relatively easy to implement, as the actors within the group have established a level of trust, and have developed the networks through which such activities can be discussed and monitored. On the other hand, this approach implies that they are more reluctant to implement more, far reaching new ideas. Here the strategy should focus on how to break open this reluctance. In that way, industrial ecology can be a way of renewing a mature or declining group of organisations.

Apart from the above considerations about the best strategy in the INES Mainport project, it can be added that the development of a vision and mission statement in 2000 was too much engineering oriented. There was a lack of attention to what sustainable enterprises in a sustainable industrial district are. Also, in the case of information processing, communication was an underestimated issue until then. As information is an important basis for raising awareness about the concept further, the feeling of urgency, understanding and responsibility for sustainability must be developed during discussions and decision-making. The traditional power positions were blocking progress, which could take advantage of the opportunities within the political structure that could support the building of new capacity and capability for change.

8.8. Conclusions about the INES projects and some food for thought on regional sustainability development

According to the analytical framework used in this thesis, the INES Mainport project kept being in the first phase of regional efficiency improvement. The members of the INES decision-making platform were aware of this and were increasingly discussing and seeking ways to move to the next level of regional learning. Despite a position paper and a workshop about this situation in June 2001, limited attention has been given to such developments and there is even, because economic pressures were stronger than ecological ones, less attention to the INES sub-projects. The industrial ecology experts' argument that the INES sub-projects were win-win projects did not provide incentives to the search for improved eco-efficiency. This is a finding similar to Dieleman's conclusion on cleaner production (1999) that cost savings and financial aspects derived from environmental measures play a minor role as criteria for the design of environmental management systems in single organisations.

With respect to the governance mechanisms it is clear that there initially was a productive situation in which an existing, representative organisation picked up the idea of regional industrial ecology. This meant that routines could be used for co-ordination (decision-making and monitoring). However, after a number of projects it became clear that these routines were not always suited to the demands placed upon the evolution of the industrial system. This led to a discussion on the introduction of smaller clusters.

It is concluded that the INES Mainport approach can be described as an efficiency improvement approach within specific clusters under the heading of industrial ecology. Of course the Europoort/Botlek area always has been a sort of global village: a complexity of multinational organisations and actors with their own objectives, which makes a breakthrough beyond single entity levels very difficult.

Because commitment to the concept was present in the recent past, Deltalinqs has a *social control* status regarding the possible re-birth of the commitment and the dissemination of the concept. However, the operationalisation beyond technical cluster projects needs a renewed attention to the vision and mission statement of the industrial ecology programme in the region. Government, working with the private sector, should reinforce and build on existing and emerging clusters rather than attempt to create entirely new ones. Successful new industries and clusters often grow out of established ones. In fact, most clusters form independently of government action – and sometimes in spite of it. They form where a foundation of local advantages exists.

Long-term growth and sustainable development in the region require new institutional arrangements in which industrial ecology can play a role. These must go beyond the current INES Mainport project initiatives for sustainable development, such as research, information, conferences, think tanks, vocational training, specialised training and general education (Hart, 1996). In that way, industrial ecology can be the concept underlying mutual responsibility that can be part of the holistic sustainability approach in the region. According to Selman

(2000), choosing sustainability requires radical innovation. It can be concluded that the INES Mainport project has been operating mainly in the *very weak* dimension in the continuum of modes, characteristic features and canons of sustainability (see Table 3.4), where dimensions such as `problems of including businesses in dialogues, departmental silos are still strong, and the implications that the Local Agenda 21 fosters *business as usual* despite the rhetoric', continue to dominate.

Industrial ecology is a complex conceptual framework designed to facilitate new systems of material flows. The new systems require the linking of many different organisations and actors. For instance, in the INES Mainport network, industry is present – with producers, energy providers, services organisations and related consulting firms. Within these types of organisations, independent companies and subsidiaries of a national or international corporation are to be found. Besides, there are differences in organisational structures, such as *hands-on* steering by the management of headquarters or a division, or managing in a *footloose* construction. Furthermore, there are differences in vision, targets, culture, environment and risk effects.

Within government there exist differences at the national, provincial and regional/municipal levels, and also in the types of activities – such as environmental regulation, stimulation and facilitation. In short, you cannot speak only about **the** government or **the** industry.

Actors and their organisations face their system boundaries at different levels, such as: individual, organisational, institutional and societal. Given the limits of system boundaries for the organisations and key actors, the `branching off point' in the trajectory of technological and institutional change, where a choice between several future paths can be made (Piore and Sabel, 1984), might be absent. The introduction of industrial ecology is going beyond single organisations, which means that facilitators outside the companies will manage the overall process in a dependent position in relation to the single company managers; the translation within a single organisation can be instrumental without change in routines.

The complexity of the field – stemming from the many interactions and numerous actors involved – makes predictions hardly possible. The general solution to complexity is often command and control, and reducing complexity through simplification. In industrial ecology processes, the physical interactions of individuals around waste exchange are still the main focus. Weick (1979) argues that either organisations do not learn, or that organisations do learn, but in non-linear ways. Organisations are built for certain activities; learning by interaction happens at a low level of incrementalism (Weick and Quinn, 1999). Besides, the economic market has been the strongest variable in industrial ecology development until now. However, when one force in the `triple bottom line' is too strong, the system does not move.

The (perceived) company's interests go beyond the collective interests. In general, in order to avoid that barrier, higher levels of decision-making must be involved. In the case of the INES Mainport project, this level was, for many companies, the CEOs who have their offices in foreign countries. Nevertheless, this was not seen as crucial in the region. Interaction and learning processes within the framework of experiments and projects using a multi-stakeholder approach (such as the strategic platform in the INES Mainport project) is currently perceived as the optimal pathway to sustainable innovations.

However, for the chemical industry as a whole, the emerging challenge is to integrate the Responsible Care Programme with industrial ecology and sustainability specifications beyond their individual member-companies. VNCI, the Dutch sectoral organisation,[154] could initiate a national and international[155] discussion about this.

It can be concluded that the life cycle of the group of organisations in the Rotterdam harbour and industry complex is in the phase of a formal network (Shearman and Burrell, 1987). It is characterised by both a crisis (the lower value-added structure of the economy in comparison with other harbours in the Western-European region) and the challenge of innovation (the INES sub-projects and the emergence of a new sector of service providers). For this challenge of innovation, Baas and Boons (2000) consider it necessary to guide industrial ecology as a process of network development: a) the type of partnerships in which the different actors find themselves, b) the scope of the industrial ecology initiative: only firms, or including other stakeholders as well, and c) the stages through which an industrial ecology initiative evolves.

Ad a): The type of partnership can be classified according to two criteria: the extent to which the partnership deals with core activities of the actors involved, and the extent to which partners have conflicting interests (Long & Arnold, 1998). The type of partnership can be qualified as *exploration*: partnerships that score moderately low on both criteria. Typically, this is the situation where actors are involved in a partnership for the first time. The co-operative effort mainly serves to develop the trust necessary for subsequent rounds. The type of partnership is stronger than *leverage,* which qualification is used for the partnership that scores low on both criteria.

Ad b): The scope of the industrial ecology initiative is adequate: it includes stakeholders from industry, government, an environmental advocacy organisation and academia.

Ad c): As regards this dimension it can concluded that the INES projects are characterised as having a regional efficiency improvement focus. However, elements of a learning region are also present, according to the criteria of Nonaka and Takeuchi (1995). They say that a learning region is open, information-scanning, sensitising, monitoring, and evaluating. Also, following the analysis of Parto (2001), who argues that the literature on learning regions has thus far paid insufficient attention to (national or local) employment, labour and capital markets, and changes in the larger economy, it can be argued that these issues are somewhat touched upon in this regional approach.

If these issues are being discussed in a regional, multi-stakeholder strategic platform, we may conclude that the potential to grow towards a sustainable region is present. When single industrial ecology projects are the basis for a future strategic vision on sustainability for the region, choices have to be made. Although this strategic partnership situation runs the risk of coming into conflict (Boons, 1999), it generates the challenge of the correspondence between the different phases of exploitation and exploration during learning processes within strategic alliances (Nooteboom, 1999). The linking of knowledge, relationships and motivation, generates the dimensions for continuous innovation (Porter, 1998).

Several lines of action to influence sustainable network transition processes come together in linking the change processes within, between and among stakeholders at the micro, meso and macro levels:

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154 VNCI is the acronym for *Verenigde Nederlandse Chemische Industrie* (Dutch Chemical Manufacturers Association).

155 Such as the regaugement of the Responsible Care Programme on the initiative of the Canadian Chemical Manufacturing Association in 1991.

- From the perspective of institutionally steered processes, Goodin's (1987) concern that we cannot anticipate the real effects of social interventions prior to actually experiencing them already provides difficulties in multi-layer decision-making processes to participate in interventions.
- From the perspective of processes of modification and resistance to change (Oliver, 1991) and translation (Czarniawski & Sevon, 1996) of new concepts, we can learn that a specific type of incentive management is needed to bridge the gap between theory and real-life practices.
- From the perspective of the co-ordination of the transition processes, market mechanisms (Porter, 1998) embedded and facilitated in learning networks (Baas, 2003) are strong.
- From the perspective of system boundaries theory, it is clear that an array of static and dynamic systems can support, interlink, disturb or phase out regional sustainability developments (Baas & Boons, 2003).
- From the perspective of the life cycles of institutional arrangements (Shearman and Burrell, 1987), knowledge can be built on the interaction of incremental steps in operational projects and strategic network learning processes (Nooteboom, 1999, Baas, 2002).

These are the major building blocks for the development of transition processes to a sustainable region. The practical situation in the Rijnmond area[156] of continuity between industrial ecology and sustainability networks reveals two important conditions:

a) The funding for continuity of projects: the implementation of the Compressed Air sub-project and the Waste Heat sub-project are the result of time-consuming processes;
b) The strategic platform for fundamental dialogue on the basis of interaction between sustainability projects in practice and strategic network learning processes.

The analysis shows that the Rotterdam harbour and industry complex is at the beginning of a sustainable development process. The region is characterised by static system boundaries in which organisations and actors are currently linked. Given these characteristics, it may seem surprising that it has even attempted to make regional systems more sustainable. One purpose of analysing case studies is to find out how these problems can be overcome. The assumption is that a change at the object system level is followed by a modification at the subject system level. When the object and subject systems are crossed over with static and dynamic system boundaries approaches, the conditions stated in Table 8.4 may be produced.

156 The ROM-Rijnmond funded projects Energy Rijnmond and INES Mainport merged with the Sustainable Rijnmond project funded by the Dutch Ministry of Economic Affairs from 1 January 2003.

Table 8.4 Static and dynamic dimensions of system boundaries

System	Static	Dynamic
Subject	Incremental changes of existing structures	Multi-stakeholder approaches with an innovation perspective on the basis of ecological streams
Object	Regional efficiency improvements	Material life cycle approach as a co-ordination mechanism

More dynamic approaches are possible on the basis of experiments and projects that mainly put object systems in an innovative perspective. These innovative perspectives have to be presented as challenging for the purpose of discussion in a multi-stakeholder strategic platform and to avoid business-as-usual, routine choices. Strategic choices can be made by members of a multi-stakeholder strategic platform on the basis of learning processes around the experiments and projects. Those choices can lead to innovations in the subject systems.

Finally, in the long run, it is important to consider the core business material life cycle as a co-ordination mechanism in combination with the issue of organising a sustainable industrial district, as the basis for a strategic alliance of Deltalinqs, the government, environmental advocacy organisations and academia in a new institutional setting, paying attention to integrated social, economic, ecological and technological developments as sustainability innovations.

9 Cleaner Production, Industrial Ecology and Sustainability: Conclusions

In this chapter, the empirical data and secondary analysis of the results of various studies are tested against the images of change in organisations and the cultures of different categories of companies. We also consider the implications of these data as regards answering the third set of research questions:

`What can be concluded about the processes of change leading to the implementation of the concepts of cleaner production and industrial ecology? Do the developments provide evidence of a practical paradigm shift in concept innovation?'

In this chapter, the author starts by reflecting on the processes involved in learning and applying new concepts within industry in Section 9.1. Section 9.2 contains insights into developments towards sustainable regions. This section is followed by conclusions about environmentally-induced change processes (Section 9.3), conclusions about the dissemination (Section 9.4) and credibility (Section 9.5) of cleaner production and industrial ecology concepts. The author then positions cleaner production and industrial ecology in future applications (Section 9.6), and closes with final considerations (Section 9.7) and the main conclusions about the dissemination of cleaner production and industrial ecology concepts in practice (Section 9.8).

9.1. Reflections on processes involved in learning and applying new concepts within industry

The scientific relevance of concept dissemination is, in the case of cleaner production, the coupling with environmental performance as a secondary process and the role of social dilemmas. The social dilemma of a potential conflict between the manager as an industrial leader and her/his role as a citizen, underlines how essential it is to provide a business-fit environmental approach. One can speak of cognitive dissonance when a manager strongly argues that he is already doing so much for the environment whilst in reality the reverse is true (`The Myth of Doing Environmentally Well'). One can also speak of a paradigm shift when the philosophy and organisation are based on a new worldview. The assumption is that the more in-depth the learning processes of new concepts are, the more radical the innovation process within the existing institutional context will be. This conceptual relationship is presented in Table 9.1:

Table 9.1 Cleaner production application as result of the type of cleaner production learning processes and their elaboration in organisational change

Learning process		Organisational change: Incremental change	Organisational change: Radical change
	One-loop learning process	Cleaner production assessment in demonstration project	Cleaner production innovation
	Continuous learning process	Cleaner production assessment implementation and continuous improvement	Cleaner production re-designing

An interesting lesson was learnt within the Rotterdam public transport organisation towards the end of the PRISMA project. There was a disagreement between the management and the project team stemming from the priorities of the management, who preferred the top-down approach entailed by a starting environmental management project, which had been launched by the Rotterdam municipality for their operational public organisations. Whether the public transport organisation's management was unwilling or unable to protect and finalise the PRISMA project was not clear. Anyhow, this provides another lesson about the need for continuous top management commitment. When the top management of the public transport organisation was faced with a proposal by the municipality (the owner of the public transport organisation) to join the development of a top–down environmental management system, they chose that prescriptive line (Volberda, 1998) and phased out the other line – bottom–up cleaner production.

Maybe the cleaner production concept was too isolated and unsystematic to be implemented into the existing management culture. It is inherent for people who promote new concepts to think at the level of radical, innovative changes. The existing routines were challenged, and in case of cleaner production the expectation was that these routines could be modified relatively easily because of the ethical (better for the environment) and economic (better for business economics) benefits. However, during the launch of new concepts in a democratic context we faced existing institutional constraints, which support, at best, only incremental changes. On the other hand it has to be remembered that a more strict, top–down command and control context does not provide the conditions for dialogue, reflexivity, openness to innovation and trust that are essential for testing, disseminating and implementating new concepts within the organisation or between several organisations.

These experiences demonstrated clearly that the *cleaner production concepts need a broader approach in order to be accepted*: cleaner production involved a radical new perspective, but progress within organisations and their surroundings only took place in small, incremental steps. From this it is clear that various levels of management and the crucial professional educational backgrounds in organisations have different `personal and social clocks' as regards the recognition, acknowledgement and acceptance of new approaches.

At the level of the subject boundary the question can be raised whether cleaner production is limited to a system's perspective? As an analogy, the example of a car can be used: one can study the development of cleaner cars, but this does not say much about the sustainability of transportation systems in general. This does not mean that cleaner production concepts are irrelevant, but in a sustainability hierarchy, a holistic approach such as a *Cleaner production system* is needed. On the one hand you can debate whether this is a radical technological process change or a product change; at least it is a breakthrough concerning material substitution, a change that may play a longer-term catalytic role. On the other hand one can debate whether there are ups and downs in continuous improvement. That is to say that continuous improvement is not a straight-line evolutionary process and that sometimes companies seem to move backwards.

In the Kalundborg industrial area, company managers developed bilateral links for the shared use of waste and energy; these agreements evolved over several decades. They performed this intentionally in an open economic system of modification and survival. One can say – without labelling this with the metaphor of an industrial ecosystem – that they mimicked elements of the ecosystem. Once environmental problems had been thrust upon the political agenda, it was realised at one point that all the different links could be labelled an Industrial Symbiosis – for which Kalundborg is now world famous. However, the human activity system cannot fully mimic an eco-system, because one has to take into account the fact that the various actors in the system have targets and intentions that may not be known to each other. Those targets and intentions can be conflicting and without any knowledge of this, the foundations of an industrial ecology system can be weak from the start. If industrial ecology is viewed as a process, this is the first phase to elaborate. The further dimensions of this type of change can also be applied in the industrial ecology concept, as portrayed in Table 9.2.

Table 9.2 Industrial ecology application as result of the type of industrial ecology learning processes and their elaboration in organisational change

		Organisational change	
		Incremental change	Radical change
Learning process	One-loop intervention: single lesson given from outside	Industrial ecology assessment in demonstration projects	Industrial ecology innovation
	Continuous intervention: learning within a region, as a routine	Industrial ecology implementation	Industrial ecology re-design

At *the meso level*, there was a cleaner production learning process within sectoral organisations and several governmental organisations. These organisations translated new knowledge into encoded knowledge in manuals and assessment assistance. Thanks to waste minimisation assessments, good-housekeeping knowledge and practices were fostered. It is worth noting that individual projects often stopped at this point.

At *the macro level*, funding programmes were designed to support cleaner production dissemination. As the objective was dissemination on a wide scale, cleaner production quick scans (based on the assumption that the concept was known) were promoted. In summary it can be said that the dissemination of the cleaner production concept has increased knowledge about the concept, but has inhibited further learning processes and has not deepened the concept in more integrative developments.

In relation to industrial ecology, a similar development can be observed. Despite the fact that industrial ecology is perceived as a normal business practice (waste exchange and energy sharing), the industrial ecology assessments in demonstration projects generated mainly 1st order changes of knowledge about the concept. But the implementation of that knowledge in practice was time-consuming and difficult; only a few incremental 1st order changes were made – as illustrated by the INES Compressed Air project. At the meso level, many organisations, both private and public, oriented themselves towards the concept of industrial ecology in the Netherlands at the end of the 20th century (NOVEM, 1999). At the macro level, the national policy paper on the economy and the environment (1997) generated appreciation for the concept of industrial ecology and became the basis for funding designed to facilitate learning about the concept. The concept was found to be attractive but its operationalisation was strongly path-dependent on the originator of the plan. Also, until now, the industrial ecology concept has had a strong engineering focus. The social conditions and organisation of the concept have scarcely been explored.

The lack of awareness about, and the utilisation of, the concepts of change management within both cleaner production and industrial ecology assessments led most of the assessments to be limited technical approaches that usually did not include the social and psychological dimensions of organisational change. Existing experience and implicit knowledge were almost never utilised in the process of exploration and development of the new cleaner production and industrial ecology pathways. Based on this situation the development of the cleaner production and industrial ecology concepts did not generate any radical changes and together with the development of environmental management systems, resulted in the following situation in 2000 (See Table 9.3, mainly based on the environmental performance of large companies).

Table 9.3 The initial situation at four organisational levels in 2000 in companies in the Netherlands

Organisational level	Situation in 2000
Conceptual level	- Implementation of an environmental management approach, including a good-housekeeping concept and an end-of-pipe environmental technology approach - Engaged in voluntary agreements with government
Operational level	- Meeting the environmental requirements - Good-housekeeping
Coalition level	- Development of environmental management systems - Incorporation of environment within separate management functions - Integration of environmental issues into company management
Value level	- Publication of environmental performance reports - Publication of corporate social responsibility reports

In relation to sustainability it can be said that the emerging triple bottom line approach recognised the increasing interdependence of three dimensions: corporate economy, ecology and social responsibility. As a result, environmental issues could become more integrated inside company management. However, the performance of the environmental management systems is still often little more than just meeting the requirements. Managers usually base the validation of performance on an encoded instrumental approach. They are eager to consider new subjects within an emerging societal context such as sustainable enterprises and corporate social responsibility, but seem to neglect innovation related to more pro-active approaches of the `old' environmental component.

The intention of the Dutch Ministry of the Environment to spearhead their policy with the concept of sustainable enterprises (NMP-4, 2001), has been primarily translated according to the belief that multi-national corporations would participate actively in such projects. However, as was found by an inquiry of the regional EPA into the Europoort/Botlek area in 2002, knowledge about the sustainable enterprise concept is almost lacking in international subsidiaries of multi-national corporations that only have a production function in the Netherlands. Their managers are oriented towards instruments and concept standardisation. For those purposes, in case of local (environmental, political or social) requirements, they can receive the consent from higher corporate levels to allocate time and budget to environmental measures. In practice, there is less attention to organisational (learning) processes; an important variable is that the production organisations are not equipped for this. They lack knowledge about this discipline, have limited management capacity, and have very limited decision-making space within the corporation.

At the CEO level of multi-national corporations, market thinking provides a legitimacy for entering new markets. Whereas previously environmental reasons may have prevented companies from entering new markets, several multinational corporations are now translating the social responsibility component of the sustainability concept into entering new markets in order to bridge the gap between the rich and poor in the world. Environmental management systems do not play a crucial role in these decisions; neither do improvements based on cleaner production and industrial ecology, because these concepts are considered to be non-core business. In contrast, some multinational corporations are translating the concept of sustainability as a part of their core business. Thereby they are beginning to take the lead as agents of change in defining the sustainability agenda (Rossi *et al*., 2000).

It is interesting to note that such companies have not been followed by the world financial organisations IMF and World Bank. These two organisations have taken a long time to integrate cleaner production in their projects. In fact, they are at the beginning of a transition period away from the traditional environmental protection approach, and are also more focused on instruments and standardisation. Within the same context, unfortunately most global institutions are not yet ready for sustainable development. Much needs to be done to help them make a rapid transition in their policies, procedures and instruments so that they promote sustainable development rather than the outmoded pollution standards and pollution control approaches.

The question is whether the four conditions of Karsten and Van Veen (1998)[157] are exhaustive for the acknowledgement of cleaner production. Here again the discussion is about the nature of cleaner production as a general concept within organisations or as a specialised concept within professional disciplines. The conditions of Karsten and Van Veen are fulfilled for the cleaner production at the basic level of good-housekeeping. As regards professional development in relation to cleaner production, additional conditions such as knowledge about organisational change are needed. Within the state-of-the-art of specialised knowledge, shifts towards insight into, and professional commitment to, new concepts also play a role.

In the case of the dissemination of the cleaner production concept, the commitment of CEOs was thought of as the main pre-condition for obtaining the support for, and permission to perform, cleaner production demonstration projects. However, it is experienced many times that more is needed. There is, for example, the need to retain clear evidence of the manager's ongoing commitment via feedback loops. This ensures better progress and a more complete acceptance of the results of an ongoing implementation of cleaner production changes. This level of integrated and ongoing support was scarcely observed in the test companies, in spite of the fact that the potential for good results was clear. The corporate practice usually remained 'normal', or went to `back to normal'. But in those cases where company managers participated actively in the project, they found that the waste minimisation assessments were not easy because they required data that was dispersed in all departments of the organisation, or might be partly based on assumptions. Also the amount of time needed to collect data for the assessments was far greater than initially expected. These findings show underscores that continuous feedback is needed to familiarize company managers with obstacles that otherwise should be unknown and might lead to disapproval.

9.1.1. *Learning processes and environmental management*

Maurice *et al*. (1986) wrote about the degree of professionalism, the relative importance of formal knowledge – as opposed to mastery or practical (tacit) skills – and the formal recognition of qualifications. Their study underlines the importance of education and training as a key institutional factor shaping the knowledge configurations and patterns of social interaction within firms. In industrial ecology applications, there is a link to the knowledge configurations and patterns of social interaction *between* firms. When the concept of industrial ecology is narrowly confined to separate technical projects, then specialists in waste treatment or utility sharing are involved. They, and others in the organisation, require hardly any learning and training. But when the industrial ecology concept goes beyond single projects, then change management and education are required at different levels.

The assumption is that the scope of the formal education and qualification system of an organisation are closely related to the nature of their environmental management. For the analysis of the development of cleaner production concepts, two dimensions may be contrasted:

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[157] The four conditions are: a label (not a crystallised theoretical framework), such as *prevention*, a problem analysis such as *cleaner production assessments*, a solution such as *cleaner production options*, and the application of successful solutions (see Section 2.1).

1) Externally based Environmental Requirements Focus (EERF): the focus is on meeting the external requirements placed on the organisation's environmental performance.
2) Internal Environmental Integration Focus (IEIF): the focus is on the integration of environmental issues in the organisation's activities. Environmental performance is an indicator of the success of this integration.

When the relations between the reactive and pro-active management styles are contrasted with regard to management focus and environmental regulation four specific environmental performance models as portrayed in Table 9.4 are observed.

Table 9.4 The environmental management model as result of the type of management focus and its elaboration of environmental regulation

Management focus	Environmental regulation: Internal	Environmental regulation: External
Reactive	Pollution control model	Environmental regulation model
Pro-active	Pollution prevention model	Stakeholder model

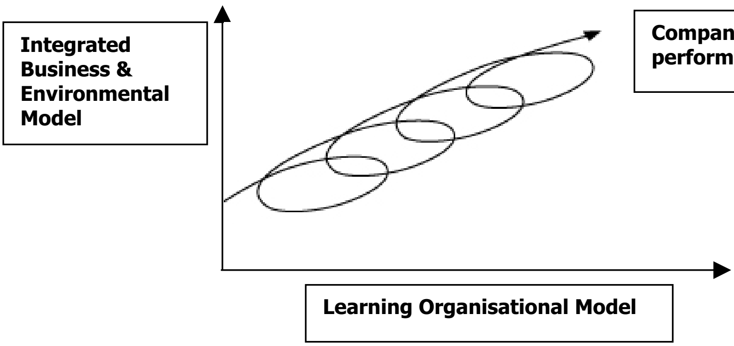
With the environmental regulations, one dimension of the societal model comes into the picture. Besides the traditional relationship between industry on the one hand, and the EPA's environmental regulations on the other hand, sustainability enters the playing field as a new dimension. The scope of environmental regulations might be enlarged; both through economic and voluntary instruments such as clean technology tax reductions and covenants, and through new partnerships, even with an environmental advocacy organisation. This change requires that companies develop or hire in new areas of expertise. The degree of formalisation of expertise, and the individual and organisational learning system influence the knowledge configuration within firms and as a consequence, the nature of the organisation of their environmental management. To go beyond the traditional environmental focus, and even beyond the pollution prevention focus, the management focus has to be broadened by awareness raising, organising learning processes and change management to integrate the new concept in the organisation's activities. Two dimensions – environment and learning – define the configuration portrayed in Table 9.5.

Table 9.5 The environmental management model as result of the strength of the organisational learning focus and its elaboration in environmental focus and performance

		Environmental focus and performance	
		Internal	External
Organisational learning focus	Low	Environmental management model	Pollution control model
	High	Professional business & environment integration model	Enlightened environmental management model

As companies progress along this journey, their development towards sustainability unfolds toward a better integration of pollution prevention and learning dynamics within the organisation and this can lead to even higher levels of enlightened environmental management. As this situation is part of the professional business and internal environment integration model, better performance of the company can be expected. Such a process is visualised as a corkscrew curl development line in Figure 9.1.

Figure 9.1 **The environmental performance of an organisation as a result of implementation of an integrated business and environmental model within a learning organisation**



Until the 21st century, there were not many organisations that were exploring this pathway. In summary it is clear that the scope of environmental management for the major societal stakeholders is changing:

a) *At government level*: from regulatory to combined regulation and stakeholder policies;

b) *At industry level*: from filling environmental management positions with on-the-job trained personnel to filling them with recently-educated graduates; from end-of-pipe approaches to including pollution prevention policies and practices;
from a closed, environmental, internal focus to open approaches that include stakeholder and social responsibility policies;

c) *At the environmental advocacy level*: from protesting to a combination of action, dialogue and facilitating development and implementation of proactive policies.

9.1.2. *Beyond individual organisations*

In the 1990s, the concepts of sustainable development and industrial ecology emerged at the level beyond firms. Also, it became clear that for these concepts to be implemented, different learning phases are required, such as the shift from only technical to socio-technical approaches (Côté and Cohen-Rosenthal, 1998), or from regional efficiency to regional learning to sustainable districts (Boons and Berends, 2001).

One element that is often left out of the equation is the fact that the organisations involved in industrial ecology initiatives often have a history in dealing with one another. Rather than establishing a completely new network of connections, industrial ecology initiatives build on - and are thus influenced by - the existing connections between the organisations involved (Boons, 1998). The Industrial Ecosystem project (INES project 1994 - 1997) in the Rotterdam harbour and industry area illustrates some of these aspects (Baas, 1998). The results of fifteen INES projects for utility-sharing, waste exchange and joint waste treatment projects can be categorisized as improving regional efficiency. In this phase an existing communication network of environmental managers provided the personal contacts for the necessary information exchange and for connecting actors and organisations with a view to the implementation of projects.

Such regional efficiency developments need the involvement of key actors and organisations. Regional management, instruments, trust, flexibility and assurance of support for the industrial ecology network are important elements in this process (Baas, 1998). The first INES project taught the industrial board members in the region that sustainability innovation must proceed beyond a technical-analytical approach. That insight led to the second INES programme.

The core management of the follow-up programme – INES Mainport project (1999-2002) – involved a strategic decision-making platform with representatives from industry, government, a knowledge institute, and an environmental advocacy organisation. The acceptance of a longer-term vision and mission introduced elements belonging to the third stage of a sustainable industrial district. The level of operationalisation of that stage will reveal the real strength of industrial ecology development in the region.

One of the items to investigate is how existing system boundaries can be overcome. It is learned that in the current situation individual organisations weigh their own interests against the synergetic possibilities of the region. Several industrial examples illustrate the fact that this routine approach has blocked the fulfilment of the potential for greater use of steam that is currently wasted. Although the industrial organisation plays a stimulating intermediary role, power is vested at the level of the individual entities (within the limited playing field in which they are active when they are a member of a multi-national corporation).

In the INES and INES Mainport projects, the intermediary organisation probed the industrial ecology projects and gave orders for the performance of feasibility studies. It is learned that the implementation of the results of the feasibility studies required much communication and dialogue, both within as well as between companies. In the case of multinational corporations, that implementation process can be accepted, allowed for social reasons, or not accepted at the headquarters' level. The overall policy of the multinational corporation can also intervene and/or overrule the local facility. The probing of all possibilities can be a barrier for exploration at the individual company level. The multinational corporation's policy can also get stuck within the individual company when the multinational corporation's policy is more obsolete than the policies in the individual daughter company's surroundings. Characteristically, new ideas such as industrial ecology hardly have a chance to be implemented due to the existence of corporation-wide rules and procedures, an internal orientation with much management energy dedicated to control, and the fact that other organisations give the signal that they will not join in industrial ecology partnerships and, finally, owing to references to many external environmental regulatory requirements – which are currently frustrating many employees. According to Roobeek (2001), the transformation of such traditional situations from being an isolated and internally-focused organisation into a network-focused organisation helps such organisations to move out of their rigidity.

The translation process covers the reshaping of an outside idea (the concepts and routines that fit with existing practices); the introduction of new concepts can lead to piecemeal organisational changes, no changes at all, the start of a dissemination process or comprehensive changes. Differences in the translation process do not seem to be determined by the technologies employed by an organisation, but by the organisational culture. That means that a higher level of industrial ecology networking needs a performance that goes beyond technical efficiency.

Most of the company's translation processes of a cleaner production intervention consisted of allowing a single-loop assessment (and single loop learning) of a production process, after which the good-housekeeping concept was accommodated. The good-housekeeping element of cleaner production was also taken over from outside: from other companies, literature, sector organisations, and dissemination programmes. It constituted an improvement on operational practices rather than the integration of the cleaner production concept. For integration to take place, the involvement of other professional sectors within an organisation (such as managers, accountants, researchers) is needed, so as to provide a further reflection basis for starting double-loop learning processes.

The strategic responses of those professionals to institutional pressure principally followed system approaches, such as an environmental management system, an ISO 14000 system or total cost accounting. Industrial designers were eager for a more fundamental change through exploring the concept of eco-design.

The connection between these translation processes is that they grew incrementally and were often disconnected. As a consequence the learning process was limited to an application of encoded knowledge. To go beyond that level, embrained learning processes are essential. This was a lesson for entrepreneurs (the first INES project is only based on waste management and technology, according to a Deltalinqs board member) and for researchers and intermediary organisations in the role of change-agents who learned that organisation theory is important to bring about change. Although the dissemination of cleaner production was sometimes beyond cases both nationally and internationally, they remained within the existing paradigm.

9.2. **Towards sustainable regions**

Cleaner production and industrial ecology use an engineering approach (focus on physical and material processes). Cleaner production has a single focus; industrial ecology has a system approach. Sustainable development also uses a system approach, but is mainly a social process, based on a common perspective on how to deal with social, economic and environmental criteria in an integrated way. The following sections present the results of the analyses of sustainability development at the meso and micro levels, presented in earlier chapters.

9.2.1. *Regional activities and industrial ecology*

It can be said that new perspectives are being explored in the starting dialogues between new partners at high levels in industry and government. The initial INES project was not spectacular as regards its physical results, but the social processes linked to environmental cluster management (the involvement of more than two companies in an environmentally-induced construction) must not be underestimated. It takes time to convince other industry management members of such a new approach.

At the level of an industrial association, the situation sometimes resembles the prisoner's dilemma (Hardin, 1968). If no new initiatives are taken, the industry becomes vulnerable to direct regulatory pressure. The development of internal environmental management systems and 4-year environmental plans in the Dutch chemical sector received backing from the government. The government regarded the first round of these 4-year environmental plans as a learning process for all partners. It was accepted that the plans were not spectacular. However, if the contents of the second round did not improve, criticism from the regulators could be expected, especially a call for stricter regulation. As a result, the industry is captured in being an active partner in a new industrial relationship. This is not bad, because a stimulating context such as the question of involving *captains of industry* in the INES Mainport Strategy platform, can give synergy to the projects. On the other hand, what can be expected in the coming years? New technologies? New products? Maybe in a longer time frame, but the usual 4-year environmental plans have a limited scope at the level of emission reduction in the traditional investment system cycles. There is no coupling with the social processes of re-developing the organisations into new patterns in product design and production installation development. This kind of social development could increase the receptivity to a radical breakthrough.

In the INES project, new ways of thinking and co-operation were found to be necessary but took time to develop. However, in a situation of mature traditional regulation, this social process has to ripen. The first phase of the industrial ecology project in the Rotterdam harbour and industry area did not produce spectacular physical results, but worked as consciousness-raising and mind-setting for key actors in the regional industrial sector. This formed the basis for the design of the second phase, in which the industrial ecology perspectives are being explored with new projects and further dialogue between new partners at high levels in industry and society.

The INES Mainport project industrial ecology has proved to be a complex system linking many different organisations and actors. The actors and their organisations have faced their system boundaries at different levels, such as: the individual, organisational, institutional and societal level. The complexity – due to the high number of interactions and actors – made predictions hardly possible. The original general solution to complexity has been `command and control' and reducing complexity through simplification. In industrial ecology processes, the physical interactions between individuals about waste exchange are still dominant. Learning by interaction happens on a low level of incrementalism (Weick, 1984). Besides that the economic market has been the strongest variable in industrial ecology until now. When one of the three forces in the triple bottom line is too strong, the system does not change.

Maybe industrialists can integrate their knowledge with that of other stakeholders within industrial innovation processes over a longer time frame. This kind of new practice could foster the sensitivity for a sustainability break-through. Regional learning is thus a prerequisite for developments such as those experienced by the INES strategic decision-making group. Mutual recognition and trust in the exchange of knowledge between firms and other stakeholders requires multi-loop learning processes within and between organisations. This situation hardly arises in the world. Perhaps also here, a balanced approach of stimulation and pressure (the traditional *carrot, preach and stick* approach) exercised by societal stakeholders in a region can help this process.

As we see the concept of industrial ecology as the operationalisation of sustainability, we can conclude that the design of eco-industrial parks – compared with cleaner production – involves many new disciplines and actors, for instance for physical planning: regional planners, developers, ground owners, and financial partners. The renovation of industrial parks in accordance to eco-industrial park designs is influenced by different characteristics of joining organisations. There are organisers from inside looking out and from outside looking in. Also the type of industry is an important variable for linking activities. At the level of organisational policy not only the individual company, but also the industrial park's management must be based on sustainability management as "the integration of economic, environmental and social policy in careful use of resources for the production of environmentally responsible products and services, satisfying societal needs, respecting the local culture, and sustaining the functions of the environment for present and future generations".[158]

Although the focus is on the region, this must not lead to closed systems. Under a closed system situation, there may be international trade issues and ecological footprints that might be ignored for political reasons. However, in the case of multinational corporations, sustainability management may include the commitment of a CEO that might be located in another region or another country. At the level of cleaner production and industrial ecology, this issue already emerges, although commitment at high management levels is sometimes only needed for specific situations carried out by local managers. Anyhow, the higher the value level of a concept, the higher the hierarchical levels in organisations that are or must be involved, as is shown in Table 9.6.

Although it seems easier for environmental managers to sell waste than to make cultural changes in their company, building industrial ecology constructions on unsound foundations – that do not really involve improved efficiency and being effective in a wider sense – will fail in the long run. Cleaner production constitutes one of the foundations of industrial ecology and can be fully utilised and implemented within industrial ecology networks. The back-and-forth process between cleaner production optimisation and industrial ecology application in the companies taking part in the network optimisation process in the *Compressed air project* in the INES project provides a good illustration of this. It is also concluded that industrial ecology can reinforce the implementation of cleaner production. When industrial ecology is elaborated at the strategic management level, the continuity

[158] My definition of the sustainable enterprise is presented in Section 2.1.

required for cleaner production implementation can be more fully secured. This means that cleaner production is part of the industrial ecology system.

Table 9.6 The type of concept and the involvement of actors and the main characteristics of focus and perspective in business management

Issue \ Concept	End-of-pipe technology	Cleaner production	Industrial ecology	Sustainability
Actors	Environmental co-ordinators; Environmental technology specialists	Environmental managers; Plant managers	Eco-industrial park management; Plant managers; Physical planners	CEO; Division Managers; Plant managers
Focus	Pollution control	Pollution prevention	Pollution prevention, Recycling and Utility sharing	Production for needs in balance with socio-economical and eco-system
Perspective	Waste	Production process, Products, Services	Production process, product chain and energy carriers	Re-engineering and Innovation of production, products and energy carriers

The next question is whether industrial ecology is part of the sustainability system. The number of companies, their diversity in size and type, and the intensity of their interactions are major variables in the system. Here the links between individual companies and the links between companies and society are to be tested according to the criteria of sustainability. This system demands a holistic approach based on new worldviews. The production process is an element at the level of individual companies (at the micro level) but the output of by-products is also the function of *servant of the network* (Wallner, 1999) at the meso level. The interconnected-ness of cleaner production and industrial ecology to sustainable regional development can be linked to regional education and innovation institutes. Also, new employment for the region and informational, social and cultural contributions complete the holistic worldview at the macro level.

On the one hand, industrial ecology is seen as providing a new perspective at different stages towards sustainability. Even the functions of a production process company can vary: the delivery of warmth from one company to another is adding a *service* output next to the products.

On the other hand, many critics fear a false perspective and a blockage of creativity to further sustainability steps. It seems that the scope of industrial ecology is an important variable. When the focus is only on the recycling of waste (in other terms), then industrial ecology is not a new sustainability driver. When the focus is the *Science of Sustainability*, new pathways to sustainability can be explored.

9.2.2. *The interconnection between the different levels*

Table 9.7 presents an overview of the levels of concept dissemination, the context of the structure, the process of change and the analysed results as a basis for reflection in Ragin's research model.

At *the macro level* rational processes in the existing power structure of the market of stakeholders have led to industry and government giving preference to the emergence of environmental management systems. The acknowledged need for environmental management, with enough room for the own responsibility of organisations, could be translated in an incremental way.

At *the meso and micro levels* the mimicking of environmental management systems was strongly influenced by subsidised dissemination programmes via industrial sector organisations. Industrial sector organisations also played a role in cleaner production projects, which lead to a number of radical results (for instance the shift to water-based inks and paints, Schoner Produceren, 1995). However, cleaner production dissemination kept being stand-alone projects; in the policy of industrial sector organisations environmental management systems were preferred at fulfilling the demand for settling non-core issues. In order to stimulate industrial ecology concepts the term of *external* environmental management systems (EMS) was even used.

Table 9.7 Outcomes of environmental management in `the market of transition processes of new concepts' (Figure 2.1) at the macro, meso and micro level

Concept, Structure & Process/ Level	Concept	Structure	Process	Outcome
Macro	Sustainability	Market	Rationality	Self-regulation of industry is favoured; Development of eco-tools and instruments
		Power	Policy strategy	Ministry of Environment favours EMS
		Stakeholder	Dissemination	EMS dissemination programme was large; CP dissemination programme is marginal
Meso	Industrial ecology	Management	Mimicking	The Kalundborg case as external EMS is favoured
		Stakeholder	Dissemination	EMS as internal programme is institutionalised externally
Micro	Cleaner production	Perception	Translation/ Learning	Industry sees CP as environmental issue
		Information		Expert background is one-dimensional
		Decision-making		Industry is reluctant and condones expertise approach

Selman's statements (2000) reflect the spectrum from a weak to a strong interpretation of a concept. Translated into the concepts of cleaner production (internal at company level), industrial ecology (industrial park level) and sustainable development (local community level), sustainability has to be rooted in the concepts of cleaner production and industrial ecology. This so-called *Three Concepts Challenge for Sustainability* is constructed between two dimensions: weak and strong (see Table 9.8):

Table 9.8 The Three Concepts Challenge for Sustainability: from Weak to Strong

Three Concepts Challenge	From WEAK to	STRONG
Cleaner production	*One hit* intervention in EMS	Integration in decision-making
Industrial ecology	Waste exchange	Material flow, logistic & social industrial park management
Sustainable development	Lip service to policy integration; Faint social awareness and little media coverage	`Triple Bottom Line' performance of all relevant stakeholders

In this triple bottom line approach, governmental agencies and relations between companies and regulating agencies must also be changed. The integration of environmental management within companies means more self-regulatory responsibility for the companies and as a result, important changes have to take place in the relations between industry and regulatory agencies.

The level of changes that is required – incremental or radical – gives rise to very different arguments. Hirschhorn (1997) states that regulatory authorities have a good instrument in pollution prevention for promoting radical changes in perspective and approaches for change. Somewhat differently, the Aspen Institute's "Alternative Path" (1996) supplements the current regulatory system rather than replacing it: the current system is needed to serve as a performance benchmark whilst new methods are being tested. However, when this view does not include innovative methods (such as cleaner production) within the regulatory framework, the threat of failure (especially in the case of permission to temporarily exceed the maximum emission loads because of the weak competitive position of companies in the world) is large (Vroegop, 1996).

A sustainable enterprise displays the following basic characteristics: it has developed a vision and mission statement on the use of renewable energy, toxic use reduction, dematerialisation, production stewardship (including external organisations that contribute to production processes), product stewardship (including leasing products) on the basis of cleaner production, industrial ecology, social responsibility, and respect for the local culture.

Individual companies are interconnected via industrial ecology systems located in sustainable regions. The industrial ecology concept involves the concept of cleaner production at the company level, including life cycle assessments, total cost/benefit accounting and material flow management; beyond the individual company level life cycle assessments, total cost/benefit accounting and material flow assessments are included in industrial park management.

Eco-industrial park arrangements face the challenge of maintaining the flexibility of their involved partners. This can be at the level of materials and energy or it can also be at the level of business economics decisions of MNCs, at a more global level. It can also mean that when a company decides to decrease the activities on their industrial site, the available infrastructure of the other parts of the site could be interesting for other companies. This potential problem of closing the whole industrial site in the case of lower production activities has resulted in a new industry approach: *Co-siting*. In the co-sting concept, the industrial site-owner is responsible for the infrastructure and the environmental permits for the site. As such it is a type of cluster management that is attractive for all partners.

The cleaner production concept involves giving attention to the following major aspects:

1. *Environmental aspects*: from cleaner production demonstration projects to quick scans/mainstreaming of cleaner production in all companies and from individual companies to cleaner regions;
2. *Functional aspects*: these functions go beyond pollution control and involve business economics, innovation, product policy, education and consumer relations;
3. *Temporal aspects*: the tension between short term and long term developments has to be taken into account ("We need to make profits now! Cleaner production is for the future");
4. *Institutional aspects*: what formal and informal roles are institutions playing? How do they react to cleaner production?

The conclusion we can draw from the INES project (1994-97) is that the mutual perception of the industry and the regulator shows a dramatic similarity with the Established and Outsiders model (Elias, 1976) and Kline's considerations (1995) about the perception of disciplines. Although there are frequent contacts between industry and regulator, varying from strict regulation to the stimulation of cleaner production, their own familiar world is seen as better: on the industry side the idea of *bringing prosperity*, on the government side the idea of *saving the environment*. It was very difficult to go beyond the technological approach in the project.[159] The external relation focus was still traditional. The focus was more institutionally-oriented than contingency-oriented.

9.3. **The characteristics of the cleaner production efforts towards change**

In general, the findings in practice (as discussed in Chapter 4) stress that although environmental technology has developed integrated circular flow techniques, end-of-pipe technology still plays a dominant role in the industry. At an organisational level environmental management systems have emerged (based on the existing practice of end-of-pipe and clean technology approaches, and with the implementation of good housekeeping practices). Briefly summarised, these only constituted first order change: small improvements and adaptations that do not change the core of the system (Levy and Mery, 1986).

It can be concluded that is was often believed that if suitable answers were found in the pioneering companies, and if these were written up in operational manuals, that similar companies could also solve their problems by following the examples and approaches set out

[159] Citation of the Chairman of the INES Mainport project in an evaluation of the first year of the project.

in the manuals. It was believed that positive economic and ecological results would stimulate the dissemination of cleaner production concepts to other companies.

During the early phases of the introduction of cleaner production research, it was often assumed, and found, that savings of resources and energy were four to ten times as great as the avoided waste treatment costs. Such approaches were thought to be more fundamental and business-fit for company managers and it was anticipated that many business leaders would get on the cleaner production bandwagon. However, this has not happened to a large extent, partly owing to the mental barriers to perceiving these new approaches as core-business instead of environmental management, and partly owing to the lack of incentives linked to environmental measures (Gunningham and Burritt, 1997, Dieleman, 1999, Cleaner Production Earth Summit Round Table, 2000).

A few other reasons may include that the first test cases were performed under special conditions, such as: the use of special funds, the presence of an assessment team with professional assistance or supervision, and consent to a special intervention in daily practice. But if there was no follow-up within the company, over time the influence of the demonstration project often faded away (at the micro level). Traditional business economics accounting and the judgement of managers in a cleaner production perspective were other important factors that contributed to this decline in involvement with cleaner production as a continuous process.

At a macro level, the institutional configuration was often neglected. Without any changes in the regulatory system, which is based on pollution control and hardly touches on the business innovation field, it has been found that self-regulation does not generate breakthroughs to sustainability, but rather is doomed to failure.

9.3.1. *The characteristics of performed cleaner production reviews*

Cleaner production assessments were largely characterised by an engineering approach seeking to promote a paradigm change (from pollution control to pollution prevention), and was based on the assumption that managers should cognitively apply business-fit concepts. But during the dissemination process, most of the cleaner production projects had a limited scope. The intermediary organisation offered cleaner production expertise, an instrument - the cleaner production assessment - and specialised knowledge, and/or assessment supervision. The company often expected the intermediary organisation to perform an assessment, to formulate the problem and to advise on how to solve the problem.

However, this approach was found to be fundamentally inappropriate to create permanent changes. Whitley (2000) concluded that codified knowledge could not be accessed easily and used productively without appropriately trained staff. And innovations, in this case cleaner production concepts, drawing on complex knowledge bases, are unlikely to be developed by firms lacking the ability to obtain and integrate a variety of information of different sources.

As has been found in work designed to foster the dissemination of other concepts, the dissemination of the cleaner production concept has not been self-sustainable: only critical actors become the people who discover, apply and transfer the new ideas (Bruce *et al*., 1994). Also as regards sustainability indicators it is clear that it is easier to collect physical data and find a standard, such as `carbon equivalent per turnover'. Sustainability data are made up of physical data such as the (re)use of resources and renewable energy; they can also include qualitative indicators such as education level, labour conditions, individual development possibilities, equity and rate of self-esteem. Rondinelli and Berry (2000) remark that nowadays externally-oriented corporate environmental citizenship activities often include:

incentives for employee collaboration with community groups on natural resource conservation and protection projects, *strategic alliances* with environmental groups and communities, and *philanthropic support* for environmental activities. They also include contributions to environmental infrastructure, sponsoring education and training programmes for teachers, funding community-initiated environmental initiatives, and creating formal stakeholder relationships with environmental interest groups, non-profit organizations, and local government bodies to prevent or solve crucial environmental problems.

In order to fulfil these social and sometimes non-quantifiable objectives, other organisations than environmental institutions must be involved. Elements of such institutionalisation trends are discussed in the next section.

9.3.2. *The dissemination and implementation of the cleaner production concept within organisations*

The study of dissemination and implementation processes has been dominated by the analysis of production or product design processes. Hage and Hollingsworth (2000) found that idea innovation networks contain six arenas of research: basic research, applied research, product development research, production research, quality control research, and marketing/ commercialisation research. They state that the greater the diversity of competencies or knowledge that is connected with frequent and intense communication within an arena and the greater the size of the arena, the greater the likelihood that radical innovations will emerge. New knowledge need not occur in all six arenas, but the radically new knowledge (regardless of the arena) must be integrated with knowledge changes in other arenas if radically innovative products or processes are to occur. Radical research solutions in one arena usually involve tacit knowledge and to be effectively communicated to another arena, both tacit knowledge and codified knowledge must be communicated across diverse disciplinary boundaries and barriers.

These findings are related to research activities concerning products and manufacturing processes, i.e. innovation research related to the core business. It is not related to social and management processes, i.e. steering instruments of knowledge and the organisation. Van Strien's social science practical paradigm shift can be the framework for important changes of social and management processes, namely basic and applied science, environmental and general management, product development and innovation, and environmental management accounting. Basic science is conceived as without any particular application or use in view. In case of cleaner production, there is talk of a the following modification: in a multi-disciplinary approach the theoretical knowledge about process technology, the economy and ecology acquired new expertise about the underlying foundations of phenomena and observable facts in order to solve environmental problems. It is the realm between the basic science of disciplines integration and applied science by which the concept of cleaner production was tested in order to acquire new knowledge. It was directly undertaken for the solution of environmental problems within a business-fit framework. The new knowledge was the basis for theory development that would be tested in new applied research.

General management formulated a (implicit or explicit) vision and policy for the organisation. Environmental management supervised and performed the environmental policy and had links with the organisation's surroundings. The first link of the cleaner production concept to an organisation is to the employee who is responsible for environmental issues. Dissemination is dependent on the type of environmental management used and its integration and specialisation in the organisation.

In the arena of product development and innovation, the science of industrial design developed research on the integration of the cleaner production concept into existing knowledge. In the arena of financial accounting the total cost/benefit accounting concept emerged. The accounting science developed research on the integration of the concept of cleaner production into existing knowledge.

These arenas were made up of large organisations and, in the minds of one or two persons (the manager and/or knowledgeable person on the issue), of small organisations. New concepts will mostly reach the organisation via the arena that is closest to the concept. Whether the concept reflects an awareness leading to a demand depends on the scope and connectedness to that developed demand. Eckert (1989) argued that information travels differently within different socio-economic groups. Organisational assumptions – namely that given the `right' medium people will exchange information freely – overlook the way in which certain socio-economic groups, organisations, and corporations implicitly treat information as a commodity to be hoarded and exchanged. As is discussed in Section 8.6, the decision on how to disseminate knowledge can have a limited horizontal spread in case of a voluntary approach in the arena, nearest to the concept. If this is feasible, knowledge dissemination is enforced more effectively through vertical spreading in the organisation (Whitley, 2000). Dutton *et al*. (2001) found that when employees perceive the inherent intersection of micro and macro forces is determining change patterns in their organisation they can start an (*issue selling*) process by which they affect other's attention to, and understanding of the events, developments and trends that have implications for organisational performance. All these findings are important issues in an organisational analysis of the optimal approach to cleaner production dissemination.

9.4. Conclusions about the cleaner production and industrial ecology concepts dissemination and implementation until now

As a general line until now we saw that cleaner production dissemination and implementation has been slow. The concept has hardly succeeded in gaining admittance to the core business perspective. In contrast to this, the industrial ecology concept dissemination quickly became a hype. The issue of waste exchange was soon viewed as a core issue.

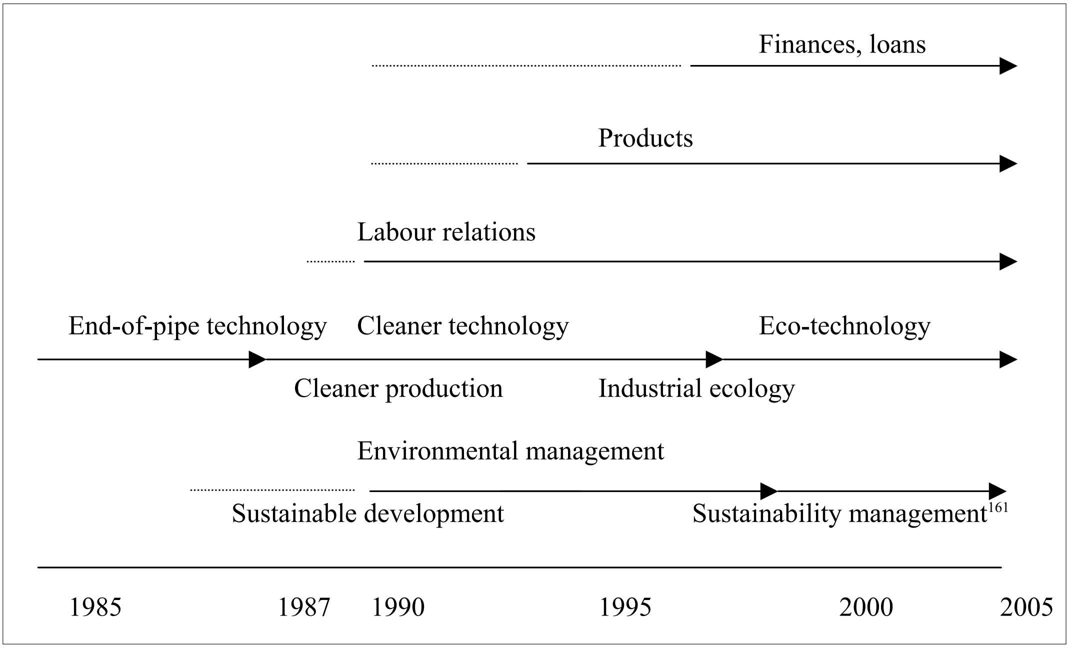
Based on the consideration of needing a learning perspective for the dissemination of pollution prevention, secondary analysis of cleaner production demonstration projects brought knowledge about the human dimensions in sustainability company management. They provide insight into social processes that influence the use of materials. Power structures, cultural norms and values, and social relations are important variables. The generalisation of demonstration projects can be promoted via new cleaner production projects, both at the local and international levels. The integration of cleaner production projects and models is complicated and is seldom done. The framework of this study is built around the interplay of interactive research and theory forming. This interplay involves the analysis of illustration material (cleaner production projects in the North) and developments elsewhere (continental Cleaner Production Roundtables, Cleaner production policy – dissemination projects: UNIDO/UNEP, Zimbabwe, Mexico).

The acknowledgement that the NCPCs were dominantly designed and equipped against an engineering background grew at the end of the 1990s. Some NCPCs started to recruit staff with other disciplines for this task. The Mexican NCPC recruited an economist and a lawyer with policy-making experience for marketing the concept and lobbying in the policy-making circuit.

A complementary approach is frequently required for sustainability company management. In cleaner production demonstration projects in the metal industry, the possibility of reducing the use of coolants has often been demonstrated. This possibility can be quantitatively studied in other companies, and can be the basis for modelling in the direction of sustainability company management. Nevertheless, such research will also mainly deal with the benchmarking of qualitative data pertaining to company management. In the last decades, the discussion has involved a range of issues, starting from the researcher's position to the optimal aggregation level.

At the macro level in the cleaner production approach, an overview of the emerging dissemination and diversification of new issues – such as cleaner technology, eco-design (products) and *green* loans (banks) (Louche, 2004) – showed the diverse trends in the time frame 1985 – 2005 (see Figure 9.2).

Figure 9.2 **Overview of the emergence of environmental (and related) issues in the period 1985 - 2005**[160]



This overview also raises the question of whether a paradigm shift has occurred or whether we are still in a conversion period. This question can be answered at different levels.

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[160] The dotted lines means that the issue was already being noticed by stakeholders but did not make a breakthrough in operational plans (a Dutch bank was already busy with environmental funds in 1990).

[161] Corporate Social Responsibility and Sustainable Enterprises are translated terms of sustainability management.

Firstly, there is the issue of the concept itself, which can be located at the value level. Cleaner production is split into several paradigms (organisation, technology, policy) without an integrating theoretical framework. Each of the paradigms themselves is limited and flawed (Donaldson, 1995). Then there is the professional level: the experts dealing with the disciplinary background as a part of the concept, the technologist working with cleaner technologies, the financial specialists working with cleaner production cost/benefit accounting and the designers, working with life-cycle assessments. The growing pluralism of the new concepts can provide increasing richness, but also implies the threat that it is too rich to digest (Donaldson, 1995). The overview of upcoming environmental and related issues in their time frame (as presented in Figure 9.2) reflects the different points in time at which the various professionals started to become involved with the new concept. The emergence of environmental issues often posed problems of integration into the existing routines. The belief in the win-win concept (ecology and economy can go together) neglects the risk that pollution treatment suppliers might lose out.

Another point is that by bringing ecology and the economy to the same position, it looks like the validation of ecology is being boosted. But in the win-win concept one of the two notions provides the setting; and as the economy must at least have a neutral outcome in the short-term, there is not so much difference with the ecological dimension, especially not in terms of long-term structural changes.

At the operational level, the number of employees involved (breadth of the organisational learning, Huber 1991, or critical mass) and the embeddedness of the new concept, the inclusion of environmental issues in decision-making processes and the involvement of stakeholders are several criteria needed for a reflection on a cleaner production paradigm shift. Berkel (1996) formulated nine criteria[162] in a “Plan - Do – Check, and Correct” cycle designed to evaluate the implementation of cleaner production in an organisation. Berkel (1996) also assessed the practical value of cleaner production assessment according to three criteria: implementation, economic impact and environmental impact (with three possible scores: low, significant and large). However, the dairy manager of a company that got the highest score according to this system was far from acknowledging this conclusion (Dieleman, 1999).

The overall conclusion is that the cleaner production dimension of good-housekeeping is the most well-known within Dutch industry and has passed through a partial, practical paradigm shift. This does not mean that the dimension is so substantial that it makes a good substitute for all other approaches. One might say that the basis of the cleaner production concept - good housekeeping - is intervening, but not displacing the previous paradigm – i.e. the end-of-pipe approach. In relation to the development of cleaner production in the professional disciplines, the conclusion is that innovators and early adopters are going through a practical paradigm shift, but they are in the margin of the mainstream approaches. Concepts such as eco-efficiency and green productivity, that often lead to diffuse discussions, might be part of Donaldson’s overload for digestion.

[162] The criteria are as follows: environmental policy, environmental goals, leadership, production management, environmental reporting and communication, employee involvement, cleaner production assessment, materials accounting, and cost accounting.

9.5. Conclusions about the credibility of cleaner production and industrial ecology

Boons *et al*. (2000) have formulated four criteria for institutional change. When the shift in concepts is approached with the same framework, the following criteria can be formulated:

1) *The concept level* (application): are the concepts far-reaching and radical enough to depart from the traditional mode of operationalisation of the organisation?
2) *Is the concept itself a form of institutional change*? Are the concepts developed at different levels (operational, model, coalition and value levels) simultaneously?
3) *Is the concept widespread within the sector and society*? How well known are the concepts and how widespread is their application within organisations?
4) *Do the concepts change inter-organisational relationships/modes/regimes of governance*?

In the 1990s the concepts of cleaner production became known all over the world via intermediary organisations (such as the National Cleaner Production Centres of UNEP and UNIDO). Everywhere the concept has – at best – been applied at the operational and plant management levels. Key –actors, such as academics in the case of cleaner production and industrial engineers in the case of industrial ecology, have disseminated the concepts through presentations and demonstration projects (Boons *et al*., 2000).

The concepts were presented as being attractive and part of a win-win approach. However, consulting firms and environmental technology providers put up strong resistance in the organisational and institutional context of environmental regulation. The threat of losing national markets was countered by supporting sharper international pollution control and international agreements that provided openings to international markets for environmental technology. It was beyond the scope of their understanding of the cleaner production and industrial ecology researchers and promoters that the learning processes in organisations often were one-loop processes (the assessment and feasibility research on, and implementation of, options) and ended in *back-to-normal* routines.

At this point, the issue of fads and fashions in the diffusion and rejection of new concepts provides an insight into their state-of-the-art (Abrahamson, 1991, Karsten & van Veen, 1998). According to Karsten and Van Veen, success factors for a new management concept display the following characteristics: a label acronym, provisions of an "Aha-erlebnis"[163] and success stories, and illustration by large international organisations. These characteristics are present in the case of the cleaner production and industrial ecology concepts:

- *Label acronym*: Pollution prevention (P2), cleaner production (CP) and industrial ecology (IE) are established labels;
- The problem analysis and the solution should provide an "*Aha-erlebnis*": the preventive approach has affected many organisations in this way;
- *Success stories* have to be grand and attractive: many cleaner production demonstration projects illustrate the results of cleaner production; the Kalundborg industrial area is evidence for industrial symbiosis.
- *The illustration by large international organisations that set the example*: various industrial multinationals have adopted cleaner production programmes: the 3M Corporation (P3 programme – Pollution Prevention Pays); DOW (WRAP programme

[163] A German term for a "sudden breakthrough of awareness".

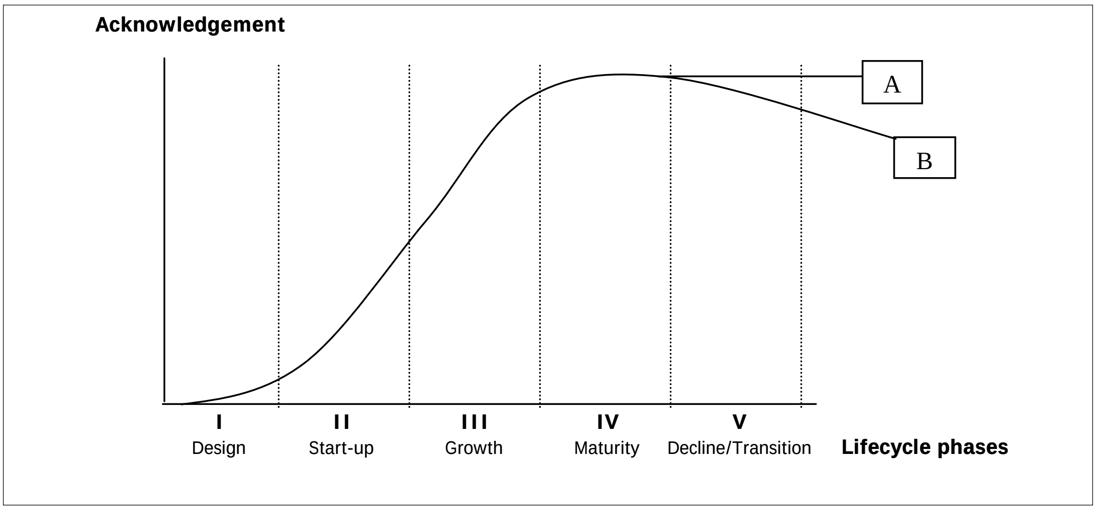
– Waste Reduction Always Pays). The UN organisations UNEP and UNIDO have formulated a cleaner production policy and launched the National Cleaner Production Centres programmes all over the world.

With reference to these characteristics, cleaner production should make a definitive breakthrough. However, with respect to the life cycle of concepts (birth/origin; growth/dissemination, application; disappearance/death/revival), the introduction of cleaner production demonstration projects has hardly influenced individual firms; it has not made much difference in firms where cleaner production assessments were performed, or in firms that could have mimicked the results of other firms. In general, the life cycle of a concept will resemble the life cycle of products and organisations (market approach). One can identify phases of start-up, emerging growth, maturity and decline or revival. Also one can draw on the findings of Downs (1972) who distinguishes the following phases in the life cycle of environmental problem-solving:

- *Pre-problem phase*: the problem is there, but is recognised only by a few people (experts, well-informed laypersons);
- *Recognition & Acknowledgement and Excessive Enthusiasm phase*: an incident and/or threat leads to a breakthrough as regards the will to attack the problem (for example, on a local scale, the soil contamination problem was viewed as a serious threat for public health because of the leaking of benzene into drinking water pipes in Lekkerkerk, a Dutch village; and on a global scale, the thinning of the ozone layer);
- *The problem-is–bigger-and-more-expensive-to-solve-than-expected phase*: upon further enquiry, environmental problems are often found to be bigger and more complex than originally expected, especially in their consequences on society;
- *Diminishing attention phase*: solving the problem takes too much time and the costs are too high, so people lose interest in it;
- *Marginalising phase*: a process of institutionalisation of standard policy takes place.

The life cycle of a concept includes elements of the market and problem-solving approaches, involving five phases (see Figure 9.3):

Figure 9.3 **The life cycle of cleaner production concepts**



In the *concept-design* phase (I) of a new concept, the founder of the Pollution Prevention Pays Programme, Dr J.T. Ling, CEO of the 3M Corporation in 1976 – had to improve an existing situation that was not optimally functional and satisfying in practice. Many new management concepts are designed and developed for the same reason. In the case of 3M, it was a reaction to the company's persistently bad environmental performance, which caused many clashes with the regulatory authorities. The new concept had to prove itself on a small scale, before the relevant stakeholders could recognise its value and become convinced of the benefits of more widespread implementation throughout the company.

In the *start-up* phase (II) of the dissemination of a new concept, the major actors are the concept advocates and messengers, innovative or growing organisations that adopt the concept, and research funds for demonstration projects. Their emphasis lies on information, awareness raising, acknowledgement, learning and acceptance in practice. Stakeholders such as funding organisations and companies that participate in demonstration projects are actively approached.

In the *emerging growth* phase (III), the new concept becomes acknowledged to a certain extent. There is an expansion of activities and geographical spread; other organisations (public and private) and more persons are involved. Also, fine-tuning specialisation is starting. New stakeholders such as provincial and municipal waste prevention teams and some consulting firms accommodate the concept. The start of an institutionalisation phase can be perceived.

In the *mature* phase (IV), cleaner production activities are expanding. There are processes of professionalisation at the individual, organisational and networking levels. Also new journals and educational modules are generated. The relevant stakeholders are now organisations involved with both international and national programmes for cleaner production dissemination, public/ private intermediary organisations, private consulting firms, and cleaner production fora.

In the *decline* (V-B) or *transition* (V-A) phase, the concept can be phased out, accommodated, translated or reassessed by other concepts. In the case of cleaner production the state-of-the-art of the concept is discussed. It can be accommodated at the good-housekeeping level, translated into concepts such as eco-efficiency, and reassessed and embedded in concepts such as industrial ecology, sustainable development and, at the beginning of the 21st century, sustainable enterprises and corporate social responsibility. The international stakeholders for the cleaner production concept are UNIDO and UNEP; they have been stimulating cleaner production policy in the sector through the 1998 Cleaner Production declaration and the reporting for the Rio+10 evaluation conference in the Republic of South Africa in September 2002, and by facilitating cleaner production experts in consulting firms, intermediary organisations (especially the UNIDO NCPC activities) and academia.

An additional characteristic of concluding about success or failure that has to be kept in mind is that cleaner production and industrial ecology are *perceived as non-core business concepts* by the industry and as such they are maintained at another level than the more direct management concepts. This also means that even with a positive answer to the four conditions of Karsten and Van Veen (1998), the time frame for dissemination will be more time-consuming. As the implementation of new concepts is dependent on the subjective interpretation of the user, the cleaner production concept was also elaborated at other levels within organisations. Mechanisms such as the publication of results in specialised literature, and the stimulation by governmental and industrial sector organisations convinced many managers to apply cleaner production elements such as good housekeeping in daily practice. This process supported interventions at the micro level of individual organisations that were reinforced at the macro level of governmental and industrial sector organisations. The result was that the cleaner production concept has been recognised as a dominant design (Anderson & Tushman, 1990 in Boons, 1995: 29) and has reached a critical mass in the Netherlands. For more radical breakthroughs, however, these mechanisms are not sufficient.

Three considerations about the acceptance and appreciation of cleaner production lead us further into the discussion:

1) The first consideration is whether the diffusion of cleaner production was mainly limited to good housekeeping, because single-loop interventions only affected learning processes at the level of 1st order changes. When cleaner production assessments only lead to the implementation of selected options and no follow-up takes place, the learning process is limited to tactical, individual, and single-loop learning by doing (Dodgson, 1993, Snell and Chak, 1998, Bateson, 1973, Vickers and Cordey-Hayes, 1999);
2) New knowledge needed vertical support within organisations (Schulz, 2001). Schulz's finding is related to top-down processes taken on the management's initiative. Cleaner production projects were often allowed and elaborated in assessment teams that lacked the commitment of the manager at the end of the assessment loop and did not mix with the old knowledge. Also, the breadth of organisational learning (Huber, 1991) was limited. And the way knowledge about cleaner production was distributed (or not) did not connect with horizontal spreading and translation of the new knowledge. The translation of environmental management systems was in general regarded as appropriate for the

company. The top management supported its dissemination and knowledge was spread as routine (incremental knowledge horizontally).

3) At the same time, far-reaching and radical transitions need the involvement of other levels and professional disciplines in organisations. Moreover, deeper involvement is or can be very time-consuming if an organisation really starts and sustains such processes of change. Taking this into account, the question of which time frame is suitable to analyse the acceptance of cleaner production is a difficult one. Until now, it can be concluded that the good-housekeeping part of the concept is well known at the level of companies; it is widespread within the sector and society, but it is not yet radical enough at the inter-organisational modes of governance. The necessary role of a multi-loop learning dissemination policy to encourage wider social learning related to cleaner production (beyond the learning agendas of industrial organisations) also affects other stakeholders and the education system.

When discussing change and learning processes in institutionalised systems, we also have to take the past into account (Jones, 1999). This is because the past matters as a *lesson* (what can we learn from it), as a *constraint* (which capabilities have already been developed and cannot be changed easily) and as a *resource* (knowledge and competence embedded in distinctive routines and practices). Much of the knowledge is tacit and not easily transferable. Besides that, the balance of often piecemeal or allowing approaches both within government and industry does not provide a sound, supportive foundation for large changes. Key persons who are influential in decision-making processes feel the need for much support for their sustainability efforts.

With respect to the criticism that industrial ecology generates a closed system and therefore inhibits innovation, conditions to prevent this from happening have to be created. Although companies are respected as individual entities having their own identity and dynamics, they integrate resources and co-operation from outside into their organisation. There is always a variety of views within an organisation; rather than seeking to impose a dominant culture, the healthier response is to build on diversity. This means that management systems must be sensitive and in constant interaction with their surroundings to make renewal in an open system possible. The question: `How can one develop and manage an overall system that is designed to encourage and support breakthroughs in order to broaden the definition of, and support for, sustainability as a guiding principle?' is answered in the Sections 9.5 and 9.6 of this thesis.

Are the concepts of cleaner production and industrial ecology receiving sufficiently credibility and do they get enough support to be implemented optimally? The answer to this question is related to the depth of the learning processes that are supported and experienced during implementation. The cleaner production and industrial ecology concepts must compete with the routines of traditional environmental management, which is partly based on externalities and neglects to some extent hidden environmental costs and benefits, with its application of economic theories. The cleaner production and industrial ecology concepts are being promoted for the common good of economics and ecology. They portray the relationship between the costs of environmental pollution and the efficiency of the production process as a preventive, win-win concept. By doing so, business economics becomes the essential variable for decision-making, especially by using the general rule of thumb that environmental investments should have a return within a maximum of three years. This approach will never be able to trigger an innovative response within industry.

At the level of single-loop learning, incremental steps such as good-housekeeping and regional efficiency improvements have received credibility as parts of the concept. If we wish to achieve a radical breakthrough towards sustainability the answer to the above question is different. Regional learning is seen as a prerequisite for a breakthrough. Mutual recognition and trust in the exchange of knowledge between firms and other stakeholders requires that all engage in double and multi-loop learning processes within and between organisations. In 2004, such a situation was seldom in evidence in the world.

9.6. Positioning of cleaner production and industrial ecology

Many observations made in the demonstration projects showed that cleaner production and industrial ecology awareness-raising and implementation activities are time-consuming within companies, service organisations (such as hospitals and eco-tourism), governmental organisations, regions and educational institutes. The substance of the concepts requires a modification and/or translation process in relation to the conditions for change towards tailor-made sustainability pathways, both internally and externally.

In the INES Compressed Air project project, cleaner production optimisation within the companies and industrial ecology application with other companies needed several feed-back loops. The results of that iterative process became the basis for the most effective compressed air network between the involved companies. It proved the link between cleaner production and industrial ecology. The industrial ecology concept reinforced the implementation of cleaner production and prevented the collapse of an industrial ecology construction on a weak foundation.

When industrial ecology is elaborated at the *strategic management level*, the continuity that is required for cleaner production implementation is secured more effectively. This means that cleaner production is part of the industrial ecology system. The step from cleaner production to industrial ecology increases the complexity of the sustainability system. The number of companies, their diversity in size and type, and the intensity of their interactions are major variables in the system. Here the links between individual companies and their links with society are to be tested according to the sustainability criteria. This system requires a holistic approach based on a new worldview.

At the *level of individual companies* (micro level), the production process is a major element. However, in the perspective of industrial ecology at the meso level, the output of by-products functions as 'servant of the network' (Wallner, 1999). The interconnectedness with sustainable regional development can be attributed to regional education and innovation institutes. Also new employment for the region and informative, social and cultural contributions complete the holistic worldview at the macro level.

At a *personal level*, learning and testing is often related to significant others. At an organisational level, this process is beginning to be related to stakeholders. Although environmental management is not appealing for companies – because the sustainability concept is a radically different way of thinking – it is becoming interesting for the CEOs of some large companies. However, at other levels within these large corporations, attention to sustainability mainly occupies an accidental and marginal position in the daily routines (DHV, 2000).

In the next sections, industrial ecology is identified in relation to traditional and new industrial sectors and the service industry.

9.6.1. *The structure of sectors of industry and service activities and environmental change processes*

In traditional industries, such as metalworking, chemistry, and the agro-industry, pollution has, for a long time, been treated by traditional approaches (such as end-of-pipe technologies). Cleaner production projects have been introduced, but they have often been translated into isolated and incremental steps, and not into radical improvements.

Chemical industry thinking is mainly structured in an encoded knowledge infrastructure in such a way that it is very difficult to encourage the development of reflexivity. This situation does not support radical innovation. This is in accordance with the statement of Ashford (1999) at the 8th Greening of Industry Network conference that `old industries cannot innovate radically'. In the culture of old industries is seldom sufficient experience with new knowledge systems, which means both an inability to monitor such knowledge systems and a weak focus on innovation. However, traditional industry also faces the fact, from time to time, that production processes become obsolete. Severe competitive pressure worldwide can be the basis for radical innovations, for example in the production processes of the blast-furnace industry.[164] Also, ecologically induced changes can be observed, such as the combination of environmental and health aspects being the driving force behind the replacement of organic solvents with water-based paints in the Dutch paint sector.

In new industries, such as the advanced electronics sector (chips, computers) and in the service sector (Information and Communication Technology), the costs of materials and pollution are high, the product loops are short and the innovation level is high. Because technological innovations have short life-cycles, the prevention of pollution must, at best, be founded on the eco-design of new products.

In a global sustainability context, different situations have to be taken into account. Very modern MNC production subsidiaries, such as the car assembly plants in Mexico (*maquiladoras*), display the best practices in ecology, quality, labour conditions and information feedback to employees, while at the same time the salaries are low, even for that region.[165] This illustrates how economic factors have a dominant position in the plant . National governments play an important role in creating the establishment conditions for new foreign subsidiaries. For instance, the Huntsman Corporation is running their subsidiary in China with British personnel. The reason for this is that China has a traditional educational system (this is not expected to change in the coming ten years) that does not fit the requirements of the company. The government of Costa Rica, on the other hand, agreed to a sustainability contract with the INTEL corporation, including the provision of highly-educated local personnel for the new plant in their country.

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[164] For example, the move from separated phases in steelmaking (cooling down for inspection and reparation, and the warming up process for rolling into thin pieces of steel) to an integrated continuous process (from steelmaking via a passage furnace into thin pieces of steel). This was a qualitatively and quantitatively important improvement in material and energy efficiency (Voskamp, 1995).

[165] Personal observation in the Ford “Planta de Estampado y Ensamble” in Hermosillo, México, 17 January 2002.

Allenby (1999) states that evolution toward a sustainable and efficient economy will differentially favour certain industrial sectors and technology systems and disfavour others. Probably, the most important sectors for modern societies will not only be the new industrial sectors and services, but also agriculture as effect of a transition towards the delivery of biomass for renewable energy and safe biotechnology applications in crop-growing. In essence, one can also see a difference in approaches to cleaner production dissemination for high-tech and low-tech and craft industry. Traditional industry was a central focus for cleaner production tests and dissemination. On the other hand, the sustainability performance of the Information and Communication Technology sector has hardly received any attention. Overviews of increasingly more and less important sectors show the effects of these trends and also which type of preventive approach needs specific attention.

The increasingly more important sectors include: Electronics and Telecommunication, because the economy is becoming more information dense and complex; Biotechnology and Ecological Engineering, that is expected to find substitutes for energy and material-intensive engineered systems and use less energy and materials; and Agriculture, performing more functions than food production.

For sectors whose importance is decreasing, it is expected that change towards sustainability – including renewable energy – will challenge traditional industrial sectors, such as the Extractive industry, because of the expectation that material loops in the economy will continuously become more efficient. For the Steel & Petrochemical industry, it is expected that the use of recycled materials and renewables and demateralisation will have sizeable impacts.

The overall conclusion that can be drawn is that dematerialisation and the transition to renewable energy will be the focal points in the coming decades.

9.6.2. *Future industrial areas*

Future industrial areas will face a growing lack of space. The issue of *sprawl* is either under discussion (USA: *Sprawl* session at the Pollution Prevention Roundtable in Washington D.C., 1999) or on the political agenda (the Netherlands: 5th Policy Paper on Spatial Planning, 2001). Sprawl is associated with growth, not only in a physical sense, but also in the sense that sometimes cells are growing and need more space, but happens to grow in an unhealthy manner. This means that industrial areas need to be designed for an optimal use of space and to make linkages possible – according to a network approach. The eco-industrial park design and management can contribute to this development.

What can already be noticed now are constructions such as a plant linked into activities with surrounding companies, e.g. around a refinery in Singapore (Sharma, 2001), an agro-industrial park around a sugar beet refinery in the Netherlands (Dijkema and Stikkelman, 1999), a sugar cane factory in China (Duan, 2001) and the electricity works in Kalundborg – which has a major position in the Industrial Symbiosis project (Christensen, 1994). Also the construction of co-siting has evolved: companies buy or rent a part of an industrial area for their production and services. The organisation that owns the industrial area is responsible for the relevant infrastructure and permits.

9.7. Considerations about the dissemination and implementation of cleaner production and industrial ecology

During the concept development phase, the introduction of cleaner production by outside actors was primarily directed at individual organisations. Depending on the degree of commitment and urgency, the translation by the organisation did or did not affect the routines. Most of the findings in cleaner production projects are based on assessments of selected processes (see Annex V.1). The improvements that are analysed can be characterised as incremental steps: when the assessment results were implemented, they were limited to the modification of materials and production processes. Organisational change was not involved.

In relation to the dissemination of the cleaner production concepts, it was believed that merely providing evidence of an individual company's positive environmental and economic experiences with cleaner production would automatically lead to rapid and widespread mimicking by other companies on a voluntary basis. Because the cleaner production concept was based on a change in environmental management perspective, it was not in line with the concepts of enforcement through regulation. Besides, governments also considered the cleaner production concept to be business-fit, and on the basis of this perception, continued to be locked into the roles and routines of a pollution control approach that did not change the context in which industries were operating.

While cleaner production concepts were mainly translated in isolation within the boundaries of one organisation, the introduction of industrial ecology concepts went beyond individual organisations; this meant that the intermediary organisations and persons outside the companies who managed the industrial ecology process were dependent on the various company managers. Besides, economic and political developments, such as the liberalisation of the energy and water markets, the disengagement of government from several traditional roles and responsibilities, the outsourcing of companies' non-core business activities, and the increasing influence of stakeholders helped to support the introduction of industrial ecology. It was found in the INES projects that the translation of industrial ecology concepts within firms could be effective on the basis of an instrumental approach without many changes in routines. This is especially characteristic of the industrial ecology phase of regional efficiency improvements.

The debate about the sustainability agents of change (see Section 8.9) and the legitimacy of doing business in developing countries – which some multinational corporations derive from the debate – neglect an important dimension: the local culture. Local markets are approached with the culture of an industrialised country, which only modifies the economic aspects (such as selling small packets of washing powder instead of large bags) under the pretence of bringing prosperity. This does not mean that local cultures have to be immune to changes, because economic market operations and public/private partnerships perhaps provide better opportunities than governmental aid programmes. However, as this is the same issue as environmental regulation, weak governments cannot provide the required safety net for local markets. This means that a fourth dimension - *cultural responsibility* - needs to be a pillar of sustainable enterprises, especially multinational corporations, together with the economic, ecological and social dimensions. Along this line, *Corporations Taking their Responsibility for Working towards Social, Economic, Cultural and Environmental Sustainability* reflects a better integration of the dimensions of the acronym CSR that is currently utilized for Corporate Social Responsibility.

9.8. Main conclusions about cleaner production and industrial ecology dissemination and implementation in practice

In most of the companies' translation processes of cleaner production or industrial ecology interventions, the single-loop assessment (and single loop learning) was considered to be an improvement to operational practices rather than the integration of a new concept. As a result, learning processes were limited to the application of encoded knowledge. In order to go beyond this level, embrained learning processes are essential, for which the involvement of various professional levels within an organisation, such as managers, accountants, researchers, is needed; this provides the basis for starting double-loop learning processes.

It was observed that the cleaner production and industrial ecology concepts had to compete with the routines of traditional environmental management – which is partly based on externalities and neglects to some extent hidden environmental costs and benefits, within its] application of economic theories. The cleaner production and industrial ecology concepts were promoted for the common good of both business economics and ecology. Through this approach, an environment-included innovative response by industry was not challenged.

The main lesson learned was that the potential of new concepts must be recognised and appreciated by key persons (who are capable of mobilising multi-level and multi-discipline support for changing routines) in order to provide the foundation for success that will lead to further dissemination of the concept both within and among the companies. It was found that umbrella organisations, especially in the case of industrial ecology, have an important management role to play in these dissemination processes. The general obstacles in most of the projects were the lack of attention for the societal surroundings and internal infrastructure (organisational, institutional), the payback time constraints (economic, institutional), and resistance to innovation (power, routines). These issues were found to be crucial factors that were usually under-estimated at the time when the projects were planned and performed.

10 Organisational Annotations for the Dissemination and Implementation of Prevention Concepts and Approaches

In the previous chapter, it was concluded that the implementation of the concepts of cleaner production and industrial ecology faced the constraint of having an environmental perspective both in business economics and organisational routines, as well as the traditional requirements of environmental regulation. This institutional context conditions the domination of an *environmental* perspective over that of an uncertain and time-consuming *innovation* perspective. Although incremental steps such as good-housekeeping and regional efficiency improvements have gained credibility as part of these new concepts, stand-alone interventions have scarcely brought about radical breakthroughs to sustainability.

On the whole, it is recommended that in order to make more effective progress with cleaner production and industrial ecology in the future, the following should be done:

- All cleaner production efforts, in the case of application in the design, start-up and growth life cycle phase, need to be made with a comprehensive organisational support and involvement and should also include the stakeholders throughout the life cycle of the products and services that the organisation provides to society;
- Multi-loop learning processes should be used both within single companies and between or among clusters of companies. This should also increasingly involve the wider population in sustainable regional development planning and implementation;
- Cleaner production and industrial ecology concepts and approaches should be integrated vertically and horizontally from the policy and strategic levels down to the detailed operational levels of both individual companies and clusters of companies;
- The implementation of industrial ecology should be integrated within the regional economy, ecology, technology, culture, and sustainability plans of the region;
- Trust, transparency and confidence will need to be developed through an open, reflective and ongoing dialogue designed to ensure real involvement of diverse stakeholders in charting the future of their organisations and regions as part of the transition towards sustainable societies.

The context of these recommendations, that need continuous attention and interactive responsible stakeholder dialogues, is very important. In this chapter, the author makes recommendations about the importance of organisational aspects in the dissemination of the new concepts. Also, some perspectives on future developments of such dissemination and implementation processes are provided. Case studies have revealed that cleaner production and industrial ecology awareness-raising and implementation processes are time-consuming processes in companies, service organisations (such as hospitals and eco-tourism agencies), governmental organisations, regions and in educational institutes. The content of the concepts is such that it is essential that a modification and/or translation process must be followed in relation to the specific organisation's contextual conditions for change towards tailor-made sustainable pathways, both internally and externally.

Section 10.1 of this final chapter focuses respectively upon the different types of advice models for cleaner production based change processes (Table 10.1), a simple model for cleaner production dissemination policy analysis in developing countries (Section 10.1.2), and an "industrial ecology thinking" model (in Section 10.1.3). The author then proceeds with recommendations on the dissemination and implementation processes of new concepts (Section 10.2), and questions about pathways to new institutional arrangements (Section 10.3) and finally presents a new research tradition that includes considerations based upon the author's personal experience with research on the basis of such new concepts (Section 10.4).

10.1. Dimensions of dissemination models for cleaner production and industrial ecology

A dilemma for the promoters of new concepts, in general, is that pilot studies never meet the full conditions that are needed. The major obstacles in the chain: a) researcher/agent of change, b) the pilot project organisation, and c) the funding organisation of the research, are as follows:

- The researchers cannot, individually, be adequately knowledgeable in all the diverse academic disciplines that come into play;
- The organisations that have not asked for intervention may agree to limited involvement but are neither really fully committed nor really engaged;
- The funding organisations rarely fund new activities that do not fit easily into their existing programmes.

By the time such serious obstacles are finally overcome, usually the momentum for capitalising upon the positive expectations and interest of the corporate leaders has passed, resulting in, at best, only watered-down applications and definitions of cleaner production and industrial ecology.

Because cleaner production and industrial ecology assessment models have been dominated by a techno-engineering approach, organisational aspects of the dissemination of prevention models need further elaboration. For the dissemination of cleaner production, a model for a more effective type of advise model of cleaner production assessments (Section 10.1.1), and guidelines for a more effective cleaner production dissemination policy analysis in developing countries (Section 10.1.2), are presented. For the dissemination of industrial ecology, the model of the interaction between empirical projects and responsible stakeholders is presented (Section 10.1.3).

10.1.1. *The advise model types of cleaner production based change processes*

Cleaner production concepts, approaches and assessments were expected to promote the paradigm change from pollution control to pollution prevention, on the assumption that managers would cognitively apply best business-fit concepts. However, the results from most cleaner production dissemination projects show a limited extent of implementation of the concepts during the emergence phase. Usually it has been found that the facilitating organisation offers cleaner production expertise, an instrument - the cleaner production assessment - and/or assessment supervision. However, since company leaders often expected that the facilitating organisation should perform the assessment, formulate the problem and the ways to tackle it, they usually have been disappointed because they did not receive this type of assistance.

This may be due to the fact that usually the cleaner production approach has not been sufficiently radical to bring about permanent organisational changes. Whitley (2000) concludes that codified knowledge cannot easily be introduced and used productively without having the appropriately trained staff. And innovations, in this case the cleaner production concepts, drawing on new perceptions and knowledge bases, are unlikely to be developed and implemented by firms without the ability and commitment to obtain and integrate a variety of information, attitudes and skills from different sources.

In organisational processes in general, legitimacy and power (Who gives the order? Who has the largest interests in the project? Who has the power?) play very important roles (Swart, 1979). In analogy to different types of advisory approaches to organisational change, the focus on the scope of the problem and its main emphasis for change determine the type of advice that is best for promoting cleaner production change processes. The types of advice range from incremental/instrumental to radical changes. The types of advisory models for cleaner production change processes link the fields problem solving and innovation, the involved actors, the main emphasis of the approach and the needed level of learning processes (Table 10.1):

Table 10.1 The model or degree of change needed by the company requires different levels of involvement and different types of problem-solving approaches and participation within companies

Types of company problem expressed	Actor(s) for solution	Advice model	Main emphasis
1) Solve **the** problem	External adviser	Expert; Medicine/Patient; Merchandise	Content
2) Solve the **problems**	Company + External adviser	Co-operation; Programmatic	Format: Procedure; Instrument
3) Learning organisations	Company capability For problem solving	Development; Innovation	Social-emotional: Organisational learning
4) Business progress re-design	Reformulation by the company with assistance from different experts	Therapeutic; Actualisation	Vision/goal of the company

The *first type of problem solving and advise model can be illustrated by* the original, end-of-pipe approach. A company has an environmental problem and has to do something. The solution in the case of machines or techniques comes from outside the company through the application of specific, technical expertise; the company buys either the advice (*medicine/patient* model: `we have a problem, do you have a solution?') or the solution (*merchant* model: `we need a waste water treatment facility with a certain capacity').

During the first phase of solving environmental problems companies were often confronted with the fact that the solution to one problem might generate problems in other areas. In order to solve such problems (the *second type of problem solving and advise model*) the company and an expert can co-operate in a study that leads to instrumental approaches, such as a procedure or a manual for the ongoing management of the environmental problems.

Beyond these two approaches to environmental problems, more fundamental methods of organisational development may be essential. Innovation and dissemination approaches require high levels of long-term commitment within learning organisations and business re-design processes. With the *third type of problem solving and advise model*, the social-emotional aspects of the company's problem-solving ability must receive attention. For this level of assistance, other types of expertise are required. Learning processes at different levels in the organisation must support the development and innovation processes that include the environmental performance of the company.

Finally with the *fourth type of problem solving and advise model*, the conditions for a breakthrough to sustainability may be present. The development of a new vision and mission statement of the organisation can form the basis for the re-design of the business and many of its organisational processes. Such an organisational change programme will need the assistance of transition experts and a proper time frame for the development and implementation of the results of the change processes. Reformulation of the goals of the company in terms of sustainability will be strengthened by this kind of approach because of the recognised need for the involvement of actors at all levels of the company.

The last three advise models are processes that require fundamental attitudinal, policy and procedural changes within the organisation. This requires that the members of the organisation have an open mind to innovative ways to frame the questions, and to seek for, and implement solutions. The environmental issues should not be addressed separately from the basis of the problems, because the final impacts on the environment have to be measurable and used as indicators. It will be inadequate if the organisational process of change is only focused on the environment and does not include this broader focus. The changes will not occur if such organisations rely solely upon traditional advisers, who only address the technical, legal and financial dimensions of environmental problem solving. Experience with the first generation of Dutch cleaner production projects illustrates this; even after extensive efforts to ensure nation-wide dissemination of the results in the PRISMA project, the hoped for, widespread industrial adoption of these approaches did not occur.

Under optimal conditions, the external adviser may be able to catalyse the introduction and application of cleaner production knowledge and at the same time have the capability to supervise the assessment process.[166] However, when the cleaner production knowledge of the external adviser is limited to instruments such as one-off assessments and quick scans, the conceptual framework and capacity to provide overall supervision of more comprehensive and essential social processes involved in organisational change are totally or largely absent.

In order for the company to make more effective improvements, different levels of the management process of the organisation must be addressed, such as their strategy, control, steering, operationalisation and performance processes. This includes the analysis of the position of the company in society and internal aspects such as power, authority, communication and decision-making. Findings from organisational theory suggest that such interventions should also involve work on the corporate structure, its surroundings, its decision-making processes, the people in the organisation and the company's dynamics of change.

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[166] This constitutes a crossroads between the application of cleaner production *knowledge*, the *capability* to supervise the assessment process and the *choice* - of the right moment - to interfere in the continuity of the process.

Until now such advise models have been designed because an organisation has asked for advice. The characteristics of these models are related to the different types of problems defined by the help-seeking actor. In the case of advisers seeking to bring new concepts to an organisation, the pattern is the opposite. The adviser is the help-providing actor looking for organisations who are willing to test and implement the new concepts. Following this line of reasoning, for the characteristics of a *prevention-oriented advise model for a new concept* the third and fourth level types of problem solving and advisory models need to be considered on the basis of an extensive assessment including a surroundings and organisational analysis (see Section 6.6).

10.1.2. *A quick scan of cleaner production dissemination policy analysis*

On a worldwide basis, disseminators of cleaner production concepts and approaches have discovered that the organisations that are expected to favour these new approaches already have institutionalised their own expertise, identity and approaches as a result of years of investments of time, human resources and money; these routines are not easy to change, at least not in a short time-frame. Although the continuous process of knowledge development is dynamic, the pathway is often specific. The new insights of cleaner production are nevertheless often perceived as being part of environmental policy approaches and only a few persons within an organisation recognise the potential applicability to the entire corporation in its broader dimensions.

It has been observed throughout the world that managers generally act according to the following type of certainty: `We had a waste waster problem; it was solved by a wastewater treatment facility'. That is to say: using a proven product instead of a cleaner production methodology, which comes from a broader, more preventive approach. Along this line, cleaner production promoters must be skilled in helping to change the mentality and framework behind the initial question: from `How do I get this waste stream properly treated?' to: `What is the cause/source of this wastewater problem?' and `At what level can we prevent this waste of resources and energy, in the first place?'

At the stakeholder level, we consider cleaner production to be a crosscutting and multi-sector issue. Currently, there is no single policy for cleaner production, and the promotion of cleaner production does not belong to any single government department or agency. Concern for the promotion of cleaner production should be an integral part of many policy areas. In this respect, the National Cleaner Production Centres (NCPCs) can greatly influence developments in favour of cleaner production promotion. They can develop a cleaner production dissemination and implementation policy via a *formal approach* involving public policy actors and organisations, and additionally via the *stakeholder network approach* in addition to the cleaner production demonstration projects within single companies.

In the stakeholder network approach, the involvement of new stakeholders means on the one hand that more societal commitment and better results can be achieved. Stakeholders can directly and actively bring in their interests and expertise and give support to the process if – according to De Bruijn and Ten Heuvelhof (1991) – they are:

a) Interdependent (the targets can be additional to each other but dependent on other organisations for success);
b) Multiform (the targets are different from each other but there is no competitors threat) and
c) Transparent (more focus on the surroundings).

On the other hand because such stakeholders are relatively autonomous, their interests, policies, targets and strategies to reach those targets may be so diverse that they complicate the process through their indirect and passive participation and by blocking experiments.

Within a cleaner production dissemination policy network, the achievement of the targets will be the result both of convergent and divergent activities. The features of such a network are:

a) An accumulation of actors (individuals, groups and organisations),
b) The interests, wishes and targets of those actors,
c) The issues and activities of the actors to meet their targets,
d) The rules, norms and assumptions of the actions and interactions among the actors (procedures),
e) The accumulation of (inter)action possibilities of each actor (means) and,
f) The accumulation of results, costs and benefits of each action and interaction.

The general practice for the NCPCs has been to start with demonstration projects within companies, taking the general context in which companies operate for granted. However, dissemination to other companies or corporations' subsidiaries has not been found to be a self-generating process. The whole society is a `market', in which different actors play different roles and can function as barriers to cleaner production. The ability of each actor to influence societal processes is relatively dependent upon its own values, targets and the interests of other actors. The application of relational knowledge[167] is important in order to anticipate and address resistance, to find and enlist expertise, and to learn about, and work with, the power structure. Such relational knowledge can help the cleaner production promoters to more effectively navigate through the political aspects of the facilitation of the implementation of such a concept (Dutton *et al*., 2001).

Government organisations have important positions at different levels in the surroundings of companies. At the same time, government is also an organisational entity within society and can be positively or negatively influenced. The stakeholder approach can be used in the promotion and dissemination of cleaner production, but co-ordination inside the network cannot be forced because of the different power, values, targets and interests of each actor and organisation.

Awareness-raising is an important part of the entire cleaner production implementation process. Although cleaner production demonstration projects in a whole country or region will provide positive illustrations of what it is to go beyond single projects, the promoters need to utilise a stakeholder approach so as to deal more effectively with the wider influence and power of organisations upon each other. In the case of two competing organisations the following situations can occur in theory (Bacharach and Lawler, 1980):

Pure *zero-sum* situation:	win - lose,	often results in conflicts (one organisation wins at the cost of another one)
Pure *positive sum* situation:	win - win,	often leads to co-operation (both organisations win)
Mixed motive situation:	combination,	often leads to bargaining

[167] Baumard (1992) defined relational knowledge as knowledge that actors have of each other and of each other's intentions, stakes, private goals and territories.

The positive sum approach - often on the basis of a mixed motive situation - is the principle of the cleaner production dissemination and dissemination process. It took a long time before NCPC leaders became aware of the necessity of a broader cleaner production dissemination policy that went beyond the engineering and technical applications. As an illustration of this, since 1998, the Mexican NCPC has recruited an economist and a lawyer with policy-making experience to market the cleaner production concept and lobby for the inclusion of cleaner production within the policy-making processes at the national and regional government levels.

In order to support the dissemination process a `Cleaner production dissemination policy plan' was designed for Mexico in 1998 (Baas, 1998). The plan has a basic format that has to be modified to take the NCPC's objectives and the culture of the country into account. The plan involves setting objectives, a strategy, an action plan and a time frame for the period of policy formulation and analysis. The scope of the policy research depends on time, funds, capacity and urgency. The policy research was started with three steps aiming at orientation on the cleaner production dissemination field. They focussed on environmental public policy, its influence on general public policy and the mapping out on a stakeholder approach. The results of those steps formed the basis of a stakeholder approach design for the NCPC (see Annex X.1).

10.1.3. *A typology for an industrial ecology framework*

In his exploration of an industrial ecology framework, Ausubel (1998) distinguishes a target, a holistic approach, means and monitoring. This approach can be taken further, as the following sentences will demonstrate. The *target* is zero emissions (Pauli, 1998): closing all loops and preventing any leakages. The environmental dimension involves physical, chemical and biological changes. The economic dimension in relation to the use of resources involves decarbonisation, dematerialisation, the durability of products (Nes, 2003), and the provision of services instead of selling products. As *means*, LCAs, and materials flow analyses and balance analyses, are included. For proper *monitoring* of the physical flows, indicators – such as the intensity of the use of materials, and the waste/product ratio (Schmidt-Bleek, 1993, Liedtke, 1994, Magerholm-Fet, 1998) – have to be developed and utilised. The dimensions of this industrial framework are related to the physical flows in the system.

In the non-physical flows of the system, labour, capital (the role of innovation in relation to capital investments), human behaviour, social responsibility and policies are related to the vision and mission statement of the organisational system designed to integrate industrial ecology concepts. The expansion into a sustainable district can be approached as network learning development (Roome, 2001). In such an approach, a group of actors try consciously to co-ordinate their activities to reach a joint target. This is a long-term process in which the network actors become aware of the system as a whole (i.e. more than a subset of bilateral links) so that the actors can take those contacts into account within their normal daily activities. In general, these are difficult and time-consuming processes that require attention to issues such as:

- *The vision and mission statement*: the actors must develop an - evolving - strategic vision on sustainability and formulate their mission statement within an industrial ecology framework;
- *The political dimension*: the government must recognise and acknowledge the potential of such a framework. Because much time is needed for building trust and for

awareness-raising, a facilitating organisation is essential. There is much debate about the `freedom for companies not to pursue further pollution reduction', but this does not mean that governments cannot apply adequate pressure on companies and facilitate the development of an industrial ecology framework. In this context, three Dutch environmental advocacy organisations published a report – `Sustainable Chemistry' (1997) – that stressed the importance of a cascading and zero-emissions policy. Assuming that all parties perceive sustainable chemistry as being important, the Dutch environmental advocacy organisations saw themselves as providers of ideas and actions to keep the sustainability debate alive;

- *The organisational dimension*: going beyond company boundaries requires the development and institutionalisation of new organisational entities such as an intermediary organisation for the formulation and support of the industrial ecology concept. There are differing opinions on the matter: should it be a public or a private organisation, or a public/private partnership? Governmental actors can be involved in the initiation phase of creating eco-industrial parks or in renovating existing industrial parks, but from an industry perspective they are less legitimate as park managers. The ideal type of operationalisation of industrial ecology has to overcome the current system boundaries and integrate engineering and organisational thinking. For optimal acceptance it is recommended that umbrella organisations such as regional industry or branch organisations take the *régie*.
- *The activities dimension*: many potential industrial ecology activities can be explored. The industrial ecology development path of Allenby and Graedel (1995) anticipates all cycles of the material outputs of the production. Also, the substitution of non-renewables by renewables is an objective in this dimension. An illustration of new physical processes in the INES Mainport Rotterdam project is the development - on paper - of a Hydrogen cycle for the region. Furthermore, activities such as education, labour sharing, safety and joint transport can also be organised beyond the single company level;
- *The implementation dimension*: the actors base their activities on a sustainability vision and mission statement, which serves as guidance for the implementation of ground-breaking material and organisational innovations. This approach requires goodwill and trust in the competence of the network partners (Das and Teng, 2001)

If we add these dimensions into Ausubel's framework (1998) and modify them, we obtain the new typology depicted in Table 10.2, which covers the essential elements of the industrial ecology concept. What is often underestimated or neglected, is the organisational dimension of industrial ecology, especially in relation to the targets and the way to involve diverse stakeholders. Thinking about a regional covenant for the development and dissemination of industrial ecology is part of such an organisational process. Also, it is better if essential questions at the start lead the organisational change process; unfortunately the exploration of such new concepts does not usually fit into government funding programmes (Evaluation Eco-Industrial Park process manual, Boons, 2001).

Table 10.2 Typology of issues and dimensions of an industrial ecology framework

Issues and dimensions	Content
Target	*Zero emission*: cleaner production, closing all loops, no leaks
Policy	*Policy development*: the recognition and acknowledgement of the potential
Holistic Industrial Ecology concept	*Decarbonisation*: evolution of the energy system *Dematerialisation*: fulfilling more needs with less stuff and less energy *Material substitution*: the reduction of the environmental burden and toxics use throughout the production, use and after-life management of all products *Service for product* (functionality economy): provision of product-service combinations that require less total material and energy, from a life cycle perspective
Organisation	*Intermediary organisation*: organising activities that go beyond the scope or purview of individual companies; the development of a consensus-based regional `industrial ecology covenant' *Exchange system*: interactive information system *Public/private partnership*: infrastructure
Means	*LCA*: an industrial ecology quick scan method development, testing and adaptation to the industrial ecology context *Materials flow and balance analysis*: comprehensive accounting for industrial ecosystems at several levels (firm, sector, region) by elements (Cadmium, Chlorine) and by sectors (wood)
Material activities	*Utility-sharing*: compressed-air, energy, and steam systems *Cascade*: systems for water, waste and energy cascading *Joint treatment*: of bio-sludge, waste and wastewater *Resource delivery*: the production of basic compounds for the region
Non-material activities	*Education*: general in the area and specific on industrial ecology *Labour*: a flexible pool on industrial ecology development *Transport*: joint use for employee mobility and goods transport
Implementation	*Test*: sustainability basis *Trust*: good-will and competence trust
Monitoring	*Indicators*: intensity of use, waste/product ratio, improvement in the quality of life sustainability index of the region
Evaluation	*Reflection*: reporting, feedback and on-going support to ensure the long-term future of the regional sustainable development goals and objectives

10.2. Recommendations on more appropriate processes to support the dissemination and implementation of new concepts

- The cleaner production and industrial ecology dissemination practice has revealed that new concepts are, at most, incrementally tested and implemented. In order to facilitate the effective implementation of more radical approaches, one can recommend the following steps in process change:

- The provision of *information* about a new concept can be used to start *a process of awareness raising and commitment building*. The facilitators must be skilled and competent in communication and knowledgeable about the implications of new concepts and the process of change.
- After that, the *teaching* of the concept provides the basic knowledge for the development of the *concept exploration (the assessments)* and strategic discussions in *interaction with the internal key actors*. This phase must be designed to help the organisational partners to learn about, and learn how to utilise, the relevant assessment tools and to become open to being involved in an ongoing process of internal and external dialogue about how to develop and implement these new approaches within and among organisations.
- Finally, the promoters of new concepts must make use of a broader assessment within the *surroundings based upon organisational and inter-organisational analyses*.

The surrounding's analysis must involve the current situation with respect to regulations, the economy, information, location, stakeholders, possible trends in markets, and general and specific government policies influencing sustainability.

The internal analysis must involve the assessment of the organisational structure and culture and assess the interdependencies of the cleaner production approaches within and between organisations of the region. It must also engage the organisations in understanding the need for, and becoming open to, the processes and potential benefits of organisational and inter-organisational change.

A positive evaluation should provide the foundation for initiating the organisational change processes that can lead to the integration of these concepts within the organisation and among the organisations of a region. By means of incremental steps, such new interaction processes can become the basis for continuous improvement. The interdependent cleaner production assessments and organisational change processes can form the basis for a *cleaner production system* in which a general sensitivity to eventual radical improvements is part of daily practice.

Because it is not easy to change existing routines, *green champions* within and around organisations have been proven to be actors of particular importance. In order for a cleaner production (and industrial ecology) assessment facilitator to be effective, a positive attitude and commitment from the top management of the organisation(s) is essential. This is essential to create the appropriate conditions for change. Other powers in the organisation, such as the green champions, have to enforce the change. However, when the assessment procedures take too much time and are isolated from the top management, those seeking to implement the changes will not succeed in overcoming the resistance to change. Keeping in touch with the top management through continuous feedback will provide a better basis for follow-up phases in cleaner production and industrial ecology implementation.

The role of the learning processes requires special attention. When top management favours new knowledge, it spreads vertically inside the organisation faster if it appeals to the employees. When new knowledge can only be introduced into one department, it meets resistance inside other departments and faces the danger of a limited horizontal spread. The context of cleaner production's *learning by interacting* is strengthened by the input of knowledge that may be external to the firm: regulators, consultants, salespersons. Continuous improvement provides obvious benefits helping to ensure the success of implementation of cleaner production, by building a learning network that facilitates the transfer of experience, and creating knowledge that includes the description of a series of stages – from start-up, to spreading the word, to planning and establishing strategic connections. In this way, learning organisation(s) are built as a part of the capability for continuous improvement.

Internationally, countries that are not familiar with the concept are learning that the conditions for optimal cleaner production research and dissemination are difficult in the beginning. Introducing the `not asked for' concepts to new regions, managing the research and implementation, assessing the costs and benefits of the implementation, all at the same time, is not easy. The description of some cases (and anecdotes derived from them) provides the basis for further reflection. The application of a cleaner production dissemination policy analysis will help NCPCs to design cleaner production dissemination policy networks and to plan their activities for developing a broader basis for its dissemination and widespread utilisation.

The relationship between government and industry must also be changed. Because industrial leaders originally perceived environmental problems as non-core business issues, environmental regulation provided standards that the companies had to meet. In the phase of a developed regulatory framework and standardised relationships between government and industry, the fact that the actors do not know much about the real situation of the others has often been neglected: industry is dominated by the picture of time-consuming procedures and a lot of paperwork connected with regulatory issues; the regulator's dominant picture is that every environmental incident is representative of the entire industry. Because of such perceptions – based upon incomplete information – the distances between each other's perspective are greater than they should be in reality (Elias and Scotson, 1972). The positions and related perceptions of the organisations are also different in relation to the subject: for regulatory agencies, environmental issues are core business, for industry they are not. One might be tempted to say that environmental co-ordinators in industry have the same position as government regulators in relation to the whole government but in practice this is not the way things are experienced. Environmental co-ordinators function within an economic and engineering framework that constitutes a different core business context. Environmental regulators function within a framework of societal responsibility in an organisation that has the same focus at all levels.

All together, such differences in perception can make it difficult to bridge the gaps in viewpoints and they can generate a societal dilemma on how to cope with them. There are two ways out of a societal dilemma: top-down and bottom-up. A societal dilemma can be solved top-down when all members of a community fit in their individual views with an overarched structure to apply general measures. Government environmental policy was developed to cope with the effects of activities of all actors within one national community. This is not easy and when considering that numerous international agreements (Montreal, Rio de Janeiro, and Kyoto) have been reached, it is even more complex at the global level.

One can also think of collective acts of individuals (or communities or generations) independent from government actions, derived from a bottom-up awareness raising. Decisions are seldom made for financial reasons only. Differences in the norms and values of actors play a role too. When an individual also involves ecological arguments in cost-benefits analyses, this can modify the outcome of the weighing-up process. Such changed outcomes can actually be recognised in industry. Environmental management, environmental performance indicators, the pressure of external actors such as consumers, corporate image considerations, and emerging issues such as sustainable firms and corporate social responsibility are influencing ecological aspects in decision-making processes in industry. Experience with preventive approaches also encourages a shift in norms and values within companies.

In principle, a social dilemma is a decision-making problem. The structure of decision-making within different organisations[168] influences the optimisation of decisions taken by all members of the community. Also, it is relevant to consider which system boundaries are being focused upon with respect to spatial and time dilemmas. In relation to the system boundaries of local MNC subsidiaries of the whole chemical industry, the emerging challenge is to integrate the Responsible Care Programme with industrial ecology and sustainability specifications at the level beyond individual member-companies. The VNCI[169] should initiate a national and international[170] discussion about this.

The change mechanisms in an organisation supporting the transition from unsustainable to sustainable

In order for concepts such as 'sustainable enterprises' and 'corporate social responsibility' to be incorporated within companies, they must be integrated within the philosophy and structure of the organisation's management. It is also significant that *relevant others* can influence the change processes towards a better integration of sustainability concepts. Such relevant others may include:

Large companies: associations of large multinational corporations can influence the CEOs as relevant others (Turner, 1978). Some multinational corporations are exploring this pathway. Illustrative of this is Shell Oil (2000), which started to publish sustainability criteria in their 1999 annual report: *People, Planet, Profit*. Furthermore, technical, industry sector and management journals, and demonstration projects play a role in the dissemination process of new concepts.

As environmental management systems have developed from a focus on externalities (with regard to control) towards integration (on the basis of prevention), the function of the environmental co-ordinator can expand towards that of a *sustainability change manager* with a responsibility for internal sustainability education. A generation of freshly-educated sustainability managers can stimulate such evolutionary changes.

Medium-sized companies: these see trade organisations as relevant others. Trade organisations usually respond to encoded knowledge in daily issues, but as regards new approaches they play an intermediary dissemination role through pilot projects and trade journals. Also technical and suppliers' journals provide relevant information for an advanced category of organisations. Furthermore, they are influenced by their direct surroundings (Baas, 1989), sharing values and tacit knowledge with relevant others as part of the change process.

Small companies: these are often influenced both by their role of well-informed citizens and by their direct surroundings.

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168 Williams *et al*. (1997) found a large array of different decision-making structures and cultures within 32 industrial organisations such as: centralised, decentralised, hierarchical, *laissez faire*, democratic, and so on.

169 VNCI is the acronym for Verenigde Nederlandse Chemische Industrie (the United Dutch Chemical Manufacturers).

170 Such as the revival of the Responsible Care programme on the initiative of the Canadian Chemical Manufacturing Association in 1991.

10.3. **Towards new institutional arrangements**

The earlier question: `Are cleaner production and industrial ecology part of a paradigm shift towards sustainability?' is now going to be re-considered in this section. Implementation of the preventive approach via cleaner production and industrial ecology is viewed as an innovative process of change in this thesis. Such a process of change requires a long time frame; it covers both material and energy streams as well as changes in mental models, values and procedures.

Although the more inclusive approach that involves both optimising the system and components, and devoting attention to the human factor is seen as important, developing cleaner production as a mainstream concept into business and government is strongly related to physical processes. Organisations always have to renew their activities for competitive reasons – either their technology or their policy, either the identification of their core business or capital revenue – and learning processes involving new concepts such as cleaner production is a way to do so. In effect, it is a specific way to innovate and to this end, it is best to integrate the cleaner production concept at the organisational management level. Not pollution control, not pollution prevention, but a catalytic process of instrumental and organisational changes via cleaner production and industrial ecology concepts can best pave the pathway towards sustainable industry and sustainable regions.

This requires that we foster system innovation focusing on a new balance between energy and material uses, (re)use of resources, and clean technologies in relation to the short- and long-term effects upon the biological, social and ethical environments of the company and of the region.

This results from another way of thinking: the **i**nitiation of the application of new concepts, the **i**ntervention in the organisation, leading to sustainability **i**nnovations (the **3i** approach: Baas, 1993). This is located at company level in accordance with the following principle: "Sustainable company management integrates economic, environmental and social policy in the careful use of resources for the production of environmentally responsible products and services, satisfying societal needs, sustaining the functions of the environment for present and future generations whilst respecting their culture".

Beyond the company level sustainability is in accordance with an integral approach to innovation in economic production chains and networks based upon economic strengthening, parallel development and strengthening of the knowledge infrastructure, and makes explicit the knowledge development system. It must also be developed on the basis of the trans-generational ethical responsibilities we all carry.

10.3.1. *The context for the facilitation of organisational and societal change processes towards sustainability:*

We are increasingly aware that there is an urgent need for the integration of sustainability-oriented environmental management into industry and for government bodies to consider how both sets of organisations will address the increasingly acute challenge of making the transition from unsustainable to sustainable societies. It is important for corporations to address non-core business issues such as environmental performance improvement based upon changes in public awareness and pressure, stimulation by government, the internationalisation of concepts and their integration into the organisation. It means that information and awareness-raising should play a much more important role in the formulation and enforcement of governmental regulations and facilitating activities so as to more effectively support corporate transitions towards sustainability thinking and actions.

When this facilitative support is missing, as is the case in many developing countries, multinational corporations have a difficult task in attempting to implement concepts and approaches pertaining to sustainability such as the integration of environmental and social responsibility into the strategic and operational levels of their corporate functioning.

Intermediary organisations must seek to convince political leaders that it is better to base public environmental policy on cleaner production and industrial ecology than solely on pollution control.

If one is to work towards long-term changes, consistent attention must be given to the development of sustainability professionalism and greater preventive expertise within academic disciplines for their integration into the entire educational system. The new concept can be institutionalised in a new professional framework and adopted in academic disciplines, but if it is not at the same time integrated at the interface of academic disciplines, the concept will be fragmented in its development. New concepts (such as sustainability) focus on a fair access to material and energy resources; this can only mean that the philosophy is based on transparency and the use of tacit and encoded knowledge within a context of embedded knowledge. This coupling of two types of knowledge can be developed at the different system levels of the concepts of cleaner production, industrial ecology and sustainability through the incorporation of interdisciplinary team efforts in education, training and research. These concepts must address a wide array of aspects as illustrated in Table 10.3 at the next page. The aspects are related to system boundaries of the structure (such as units) and processes of organisations (within, between, and beyond) and their main focus (Boons *et al.*, 2000) with respect to the concept. The aspects of change management towards sustainability (such as equity, time span of generation and vision) must be taken into account with respect to their implications for innovative developments that are essential for societal transitions.

Table 10.3 Significant aspects of cleaner production, industrial ecology and sustainable development that must be addressed by society

Aspect	Cleaner production	Industrial ecology	Sustainable development
Unit	Company	Industrial area	Community
Resource flow	Supply chain/ Product Life cycle	Supply chain/Cluster	Open/Closed loop
System	Components/parts	Life Cycle Assessment/Regional efficiency	Open/Closed economic, ecological and social management
Level	Operations	Co-operation	Value
Consumption	Components of the product or production processes	Cluster/cascade	Life style
Equity	Bottom-up meets top-down	Horizontal framing meets the power positions of partners	Controversy about agents of change
Generation	One generation	Intra-generational	Inter-generational
Vision	Concept vision/ Corporate philosophy	Concept vision/ Regional mission statement	Sustainability mission statement
Innovative Development	Limited, incremental	Limited, incremental[171] Radical in non-core business activities	More holistic, first incremental, later more radical

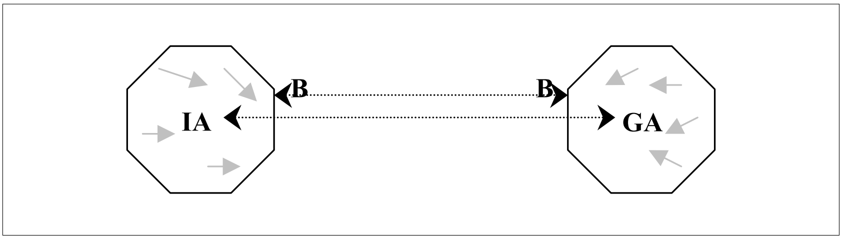
10.3.2. *Future sustainability-based relationships between government and industry*

As regards the operational level of industry it has been concluded that the development of environmental management was accomplished on a non-core business basis and as such has been a distraction from core production activities. EPA-representatives experience their function as their core business. In the evaluation of the INES Mainport project, Baas (2002) found a greater difference in the mutual perceptions of industry and government representatives than was expected. This means that the existing prejudice and distrust as underlying parts of differences in mindsets need to be understood more fully to be able to address these differences with the goal of reducing misunderstandings. For this purpose, the author has constructed a *trust development* model based on the observations presented in Section 8.7. In this model, an ideal type of trust development to decrease differences in mutual perception is constructed in which the groups jointly focus on the best illustrations. The regulatory agencies can treat bad examples of environmental performance on an individual company basis in a strictly regulatory context, thereby avoiding the castigation of those cases as representative for the entire industrial sector. Of course, separate organisations

[171] The start and growth phases of industrial ecology are first characterised by the application of simple technology, for instance pipelines for waste heat utilisation; in a later phase more advanced systems can be developed such as multi-core utility supply systems. Further sustainability development will foster the need for eco-technology and sustainability technology.

have different positions within and across industrial sectors or within different sections of government. The trust development model depicted in Figure 10.1 symbolises a development from these positions[172] in the direction of the best examples as the guiding principle for moving forward towards sustainability.

Figure 10.1 ***Trust development* model to decrease differences in perception, on the basis of the best examples shared by two categories of organisations**



The bridging of the gap between industry and government perceptions requires interaction on the basis of the stakeholders' goodwill and transparency in the results of demonstration and feasibility projects – in order to gain trust at different levels.

When the results of the projects and the conclusions of a strategic network forum become the basis for strategic choices – including the notion of the prisoner's dilemma, and the space and time dilemma – routines can be changed at the right moment. At that point in time, the majority of the actors will be knowledgeable about the concepts and will have formulated the steps that are needed for the change processes to be effective. However, organisations tend to continue with their traditional practices. Such practices will also set the pattern by which these organisations will approach all future innovations. The practices will be focused on as the core business of the firm, reflecting both its size and the nature of its industrial activity. The dynamics and urgent nature of daily practice routines often overshadow developments towards new routines. One needs to take into account the fact that efforts to change a structure must always follow possible patterns within the structure otherwise they will fail (Collins, 1992).

As regards the dissemination process of cleaner production it has been found that the improved knowledge from the pilot projects was not the basis for a further extension of that knowledge, but was used as applied knowledge in instrumental repetition and simplification of the assessments. As part of a second level change concept (innovation theory for non-core business items), the author has concluded that the social context of a non core-business concept can be utilised as a catalyst for change if introduced at the right moment and in the right way, but the dynamics of daily practice will never create the conditions for a full integration of innovation supportive behaviour.

Overall, the change of routines designed to generate new institutional practices is not only the result of intended actions (such as demonstration projects and their evaluation at higher

172 The arrows in the octagons symbolise the organisations within industry and government; **B** stands for **B**est example of a category, **IA** stands for the **I**ndustry **A**verage perception of the government and **GA** stands for the **G**overnment **A**verage perception of the industry. The arrows symbolise the desired direction of a smaller gap (and more trust) between the industry and government perceptions of each other.

strategic decision-making levels), but also of unintended influences, such as freshly-educated new generations, and an increased `sustainability' sensitivity in the continuous design and improvement processes of organisational structures and networks, capital investment and technology development.

The general line of application of concepts at the micro, meso, and macro levels for this change of routines is:

- The company: sustainable enterprises on the basis of cleaner production;
- The sustainable industrial district: on the basis of industrial ecology;
- The sustainable region: policy development on the basis of a dialogue to establish visions, policies, goals, strategies, indicators, information and education designed to help society make the transition towards sustainability.

10.3.3. *Changes in institutional arrangements*

The development of integrated environmental management within concepts such as sustainable enterprises and corporate social responsibility means that the regulatory context has to change too. A process of trust development and stakeholder dialogue guides a system based on public self-reporting and rewards, such as a reduction of regulatory requirements for detailed reporting in cases of improved corporate sustainability performance. This is likely to occur within the context of corporations that have integrated sustainability management by involving key functions that influence short-term activities, such as employee education and purchase activities, and longer term activities, such as research & design, and business development. This is not merely a cosmetic exercise; the latent attitude towards the environment is still very positive. Based on that attitude, the motivation for changing routines and achieving more efficiency can strengthen the competitive position of companies. A system of output checking by a stakeholder forum that is responsible for reporting publicly can be an important `stick behind the door'.

The various visions for a target of zero-emissions in regions are often based on the accumulation of preventive approaches within single companies. The application of industrial ecology can help the region's companies come nearer to that target. Some experts identify the need for a 'bubble' concept in a region; based on their view, the example of CO_2-emissions trading is anticipated to become an instrument for a bubble concept. Although in this author's opinion, emissions-trading is not ethically sound (nature belongs to everybody),[173] innovations in non-core business issues need economic incentives. Co-siting and multi-core utility networks are illustrations of this.

10.3.4. *Awareness-raising concerning industrial ecology processes*

The learning process within the INES Mainport project revealed that the industrial ecology potential is more fully realised as the result of awareness-raising in face-to-face consultations, when the project manager visits the companies as a knowledge (development)-broker. Furthermore, more attention needs to be paid to the innovative aspects of a regional industrial ecology project. The involvement of business development managers means a broadening of industrial ecology activities in the direction of a sustainable region.

Depending on the geography of a region, the organisation of changes in the utility sphere, the concentration of waste streams and the utilisation of waste heat come into focus at the

[173] A slogan of the Swedish Environmental Protection Agency.

cluster level. Strategic choices must be made concerning subjects such as: the development of new industries and new technologies, the issue of ownership (assets?) and the use (monopoly?) of multi-core pipelines. The potential commitment to co-operation and the need for a strategic discussion platform require a new development path with input of the main stakeholders. Lessons derived from experiences elsewhere, the translation of those lessons and the related knowledge of stakeholders and academia are key ingredients for such change processes.

`Owner' organisations of sustainability plans can prepare strategic discussions with stakeholders. Examples in the Rotterdam Harbour and Industry Complex area include the Port Authority (with the contours of the *Harbour Plan 2020* within the framework of their sustainable settlement policy), the *Development of New Industry* project team (with their plan), and the regional environmental advocacy organisation (with the theme *Creativity, innovation and diversity*). Such learning processes can reduce, but not remove, the cultural differences between perception and facts. This is anyway not recommended, because openness to different interpretations is a key ingredient in supporting changes. It is also essential in such processes that there is the willingness to co-operate, ensure transparency and produce well-prepared themes. The insights of this thesis' author into these dynamic processes were obtained from working within the Rotterdam Harbour and Industry Complex. This work experience constitutes the basis for an implicit elaboration of the *trust development* model to decrease differences in perception in perception, on the basis of the best examples shared by two categories of organisations*, which is viewed* as an essential requirement for sustainable region development.

10.4. **Towards a new research field and method?**

In a way, interactive university research about new concepts such as cleaner production and industrial ecology was a new approach in bringing the concepts into the research field, testing them and analysing the dimensions of a successful application of them. Developing the theory of dissemination and implementation of new concepts with methods from other research fields such as grounded, network, organisational and institutional theory also provided materials for educational purposes. In addition, students further researched aspects of the topic during their Master's and Ph.D. thesis research. The development of knowledge through interactions between practice and theory, and between research and education, created the framework for a new research field. The beginning of a new research field and method was elaborated along three dimensions: theoretical approach, substance and organisation of the research.

For the *theoretical approach*, it was observed that concepts such as sustainability have a degree of abstraction that is from another world for many business managers. Literally, for those who deny the need for a transition towards more equity, it is seriously challenging to see that structural multi-level 2nd order changes are needed in order to reach a better world. In the application of these notions an array of approaches such as giving lip-service to the concept, wrestling with criteria, powerlessness, goodwill or unwillingness, are illustrative of the operationalisation of the concept. One central question is whether evolutionary developments or shockwave changes, or a mixture of both, will help society to make real progress on the pathway toward sustainability?

Goodin (1982) states that incremental steps are not always sufficient. Learning processes are often based on a single-loop approach, which often neglects tacit knowledge. The complexity of the many organisational variables at the micro, meso and macro levels is constitutive of the existing routines in the market and must be addressed if anyone is to promote new concepts.

Accommodative learning (Kolb, 1984) and internalisation through learning by doing (Nonaka and Takeuchi, 1995) seem to provide the basis for Lam's (2000) coherent conceptual framework designed to integrate micro-level learning activities with organisational forms and macro-level societal institutions. This type of inter-linking is needed for the development and implementation of the sustainability concept. Because the dissemination of new concepts is a fragile process including many uncertainties, researching such processes is heuristically even more a learning approach to find the optimal methodological route to analyse the findings in the concept dissemination and implementation projects.

The development of diverse cleaner production dissemination projects has been interpreted by methods of hermeneutics and within a framework of *verstehen*[174] (Glaser and Strauss, 1967, Van Strien, 1986). This was possible because the researcher's position was part of the researched field: the researcher could observe, describe, and interpret what happened in many demonstration projects. This situation is an important basis of the research method. As a next step, interviews for testing the researcher's understanding of several elements of the dissemination processes can be used. Here, the data of respondents consist of retrospective accounts. It is difficult to distinguish neutral from normative talks about successes and failures. Also, the exact recall of events and processes is difficult or impossible. Different types of bias, such as the confirmation trap and hindsight bias (Lammerts van Bueren, 1999) regularly occur. The confrontation of *what is said* and *what is done* makes it difficult to fathom the realities as they are. Taking this reality into account, the researcher has to prudently argue her/his interpretation of the research data.

The understanding of environmental research results is often based on single indicators: the physical results of the projects in terms of pollution reduction, toxics substitution and the organisational results in terms of the number of involved employees and organisational change. In this thesis, a qualitative interpretation of the internalisation of the concept was used. It was found that it is not easy to test new concepts in practice. In relation to the beginning of cleaner production and industrial ecology research, the organisations were often reluctant because:

- The projects contained uncertainty about the potential results;
- The companies saw emissions and waste as secondary, not as part of their core business;
- The companies `tolerated' the project (they did not really ask for it and most of the managers did not fully embrace it);
- The projects were met with the perception of an environmentally-driven approach, not with the recognition of an innovative business economics approach;
- The project researchers showed uneasiness and weakness in organisational counselling skills;
- The companies had a mono-disciplinary approach to the concepts;

[174] The understanding of the interpretation.

- There was, according to Dieleman (1999), a lack of attention to the structural and cultural issues at the micro-level of companies.

This is why the conditions for optimal research are peculiar. It is essential that one addresses the `not asked for' concepts, manages the research and analyses the developments while, at the same time, acquiring critical reflection on the progress, as argued by Popper (1976): `..seeing just white swans doesn't help you to prove that there are no black swans..'. The description of cases and illustrations provided the materials that support Popper's reflection.

Ragin (1995) provides a valuable social science framework for the elaboration of complex systems in practice and for an effective, interactive confrontation with theory, especially with several qualitative theories such as grounded theory (Glaser and Strauss, 1967) and institutional theory (Scott, 1995). In this thesis, a sort of institutional change theory, a mixture of grounded, institutional, and symbolic interaction theory as interpretation of perceptions and activities, has been used. Symbolic interaction is an important theory in modern pluralistic societies with a high degree of complexity; however it is difficult to analyse structural models (Feldmann, 1993).

Two subjects were found to be difficult in managing `the market of concept transition processes'. Firstly, the problem of validity: who defines the situation (for instance, contradictory interpretations by government and industrial representatives concerning the result of stationing windmills at an industrial location in the Rijnmond area)? Secondly, you cannot repeat the format of case studies and/or the interpretation of similar loops continuously. The question, when the bouncing ball test model has ended, will be answered by arbitrary arguments.

In relation to the applicable methods, it was observed that research positions such as participating observation and action research could be applied to (new) industrial ecology projects focusing on the concept of innovation in complex open systems.

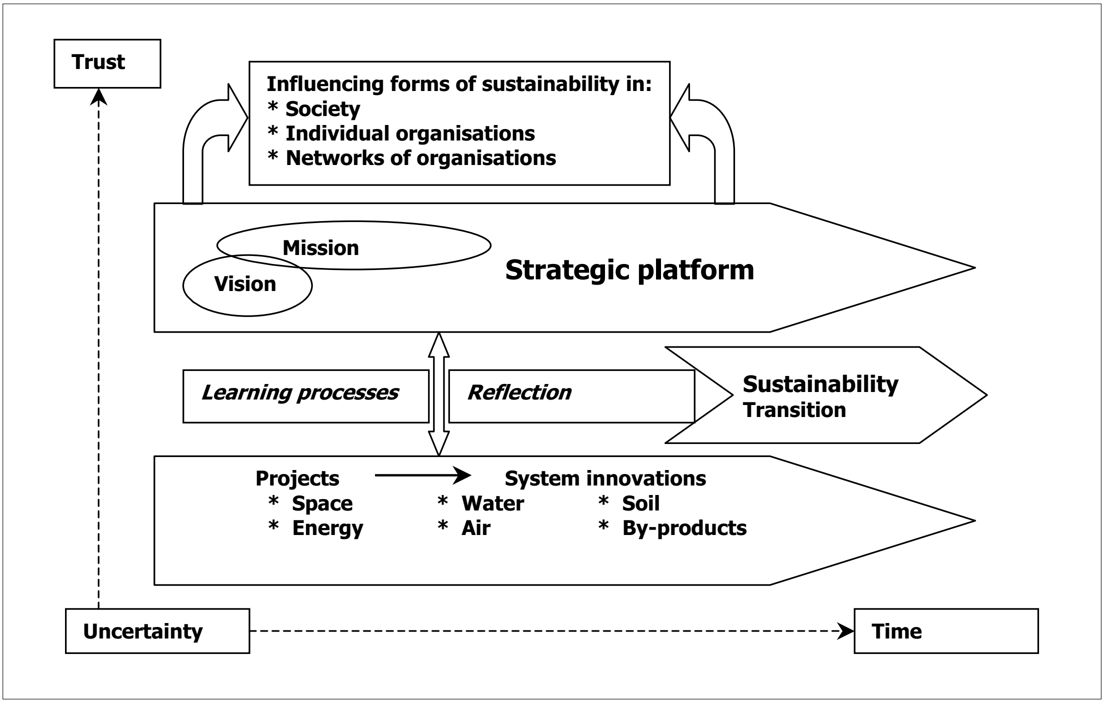
As regards the *substance* of the research, to foster sustainability and to minimise the use of physical space, the revitalisation of industrial regions in decline deserves extra attention. Industrial ecology development in old industrial (urban) areas involves subjects such as: transformation into sustainable regions, and research on the conditions for industrial ecology development in industrial estates (according to UNEP, 1997, there are 12000 industrial estates larger than 40 hectares in the world) – which challenge single companies to learn coping with the complexity of integration and collaboration with other companies on environmental, economic and social issues beyond their organisation's boundaries.

As regards the *organisation of the research*, the various processes analysed from the perspective of a system boundary theory revealed that:

a) The position of actors (responsibility for decision-making),
b) The scope (authorisation and mandate),
c) The perspective (value of the project or concept),
d) The commitment and the authority that is derived from this position, scope and perspective,
e) As well as the translation culture, status and power position of their organisations,

all influence the outcomes and intensity of changes at the aggregate level of sustainable development. The optimal way to link these many variables is through the interaction of sustainability projects evaluated by a multi-stakeholder evaluation process designed to develop strategic choices. This forms the basis for the construction of an *ecological concept learning and innovation* transition model (see Figure 10.2):

Figure 10.2 **Reflective learning from projects to system innovations: the transition towards sustainability**



The information and communication structure will involve questions such as: 'What lessons can we learn from the surrounding world and how can we translate policies and academic information into our own situations?' Those questions help to generate materials for in-depth strategic discussions and choices. In the Rotterdam Harbour and Industry Complex, the mature phase of a *formal network* has been achieved, which is characterised by strong competition, a low level of trust and a separation of the core and periphery of the network. Concrete applications such as in Kalundborg and (scientific) knowledge of processes provide external contributions that prevent the development of a *club* that is inclined to maintain the existing situation.

This approach also requires the quantification of economic, ecological and social results. On the one hand this constitutes an external means of communication about the projects, on the other hand it provides the test basis in benchmarking processes. If the various stakeholders include this quantification in discussions within a strategic platform, the development of a multi-stakeholder knowledge infrastructure is feasible in the long term. Such a knowledge infrastructure is the core of a vital, innovative and sustainable region, in which system boundaries are acknowledged and elaborated in a dynamic way.

The dynamic approach to system boundaries is rather more focused on the processes within the system, and is based on a development perspective in a certain time frame. Within this perspective, the multi-stakeholder approach, in particular, emerges, in which the endeavour to achieve sustainability in terms of growth of activities and diversity of actors will be made. Learning processes on the basis of a regional public-private partnership in a strategic platform context are important instruments for strategic choices in sustainability developments (Baas, 2002).

In general, we must increasingly strive for the goal of a closed-cycle society that mimics the closed loop ecosystems upon which we are fully dependent. Local initiatives are essential for the development of such sustainability efforts by communities to work more strongly towards new sustainability structures. In some local government departments, truly holistic thinking is beginning to appear; this results in another perspective about managing industrial complexes on the basis of ecological streams instead of controlling and managing waste. This perspective is connected to the function of the material and energy life cycle as a co-ordination mechanism for the long term. It reflects core business better than re-use. It also means that the commitment of other actors such as "business-developers" is important for the development of sustainable regions on the basis of strategic networks that integrate new organisational forms, technologies and sustainability. Such changes, made on the basis of collective interest, have the potential to leap over the system boundaries of the separate organisations and thereby involved actors become able to help local regions to make real progress towards decreasing their ecological footprint with regard to materials and energy use as well as human equity for present and future generations.

Σ Afterword

In conclusion to this thesis, I would like to make a few points of a more personal nature. After 15 years of experience and observation of the emergence and dissemination of the new preventive concepts described in the body of the thesis, I am amazed as a researcher about the roles different actors have played in effecting the evolution, dissemination and implementation of those concepts.

Firstly, in the case of cleaner production, one actor saw the potential of this approach and started to develop it in his company; another actor disseminated the concept worldwide.

Secondly, in the case of industrial ecology, one article by two authors (Frosch and Gallopoulos, 1989) triggered the re-emergence of the concept; as regards dissemination at the level of instruments for material and energy streams, Life Cycle Assessments were already under development. As regards eco-industrial parks, the Kalundborg industrial park (where the term Industrial Symbiosis was launched in November 1989) already developed in that way and became known in the whole world.

Thirdly, in the case of sustainable development, a UN committee invented and elaborated this concept. National governments, however, were originally not successful as disseminators. For more than a decade, sustainable development was a broad container term for many discussions at all levels of society. After that period, sustainable development (including the integration of environmental awareness) became both more practical among citizens groups and instrumental in the formation of the concepts of sustainable enterprises and corporate social responsibility. Also, university researchers from diverse disciplines such as economics, ethics, ecology, management, political theory, management accounting and engineering became involved, sometimes within their own disciplines, sometimes as part of integrated multi-disciplinary teams. A proper balance between the economic, ecological and social dimensions still remains to be found. In addition, a lack of respect for the local culture is still too often present in the activities of multinational corporations.

As regards cleaner production and industrial ecology, it can be concluded that many new insights can be labelled as `open doors' once knowledge about these prevention-oriented concepts had made a breakthrough. Looking back, it seems now evident that the wasted steam energy of one company can be a supply for the neighbouring company. However, we have learned to optimise activities within small system boundaries of departments and companies. The steam usage/wastage system was seldom evaluated and modified or utilised beyond the company boundary before some of the industrial ecology approaches had been tested and implemented.

Furthermore, it is remarkable that university researchers have played such an important role in the dissemination of cleaner production. Not only were the concepts new, but also the existing dissemination organisations were not skilled (or interested) in spreading the concepts. Similarly the concept of industrial ecology was first explored by university researchers but in the Netherlands, following a national government White Paper (1997), it took only a short time to set up government funding programmes and to arouse the interest of consulting firms and municipalities in working with the concept.

Reflecting on the observations and lessons in this thesis, the reader may conclude that the cleaner production concepts have remained within the research phase of development and testing. This is not a correct conclusion: one needs to take into account the fact that this thesis more particularly deals with policies and instruments from the early phase to the growth phase of the concept's dissemination process. Now, in the mature phase, cleaner production is more a tool at the operational level than the result of an internalised and integrated concept, and in addition, it is also a centrally important prevention-oriented framework that requires further translation into environmental and sustainability management.

In contrast with cleaner production, industrial ecology was already a buzz word in the birth phase of the concept and before there had been any proper reflection based on industrial ecology tests. This shows the great amount of interest in and, at the same time, the lack of knowledge about, the dissemination in practice of the industrial ecology concept at the end of the 20th and the beginning of the 21st century.

The broad interest in industrial ecology also shows the grown sensibility and needs for the performance of activities in a sustainable manner. In my opinion, this sensibility and the articulated needs stimulate cleaner production and industrial ecology as the prevention-oriented potential of sustainability practices within the trajectory of *Corporations Taking their Responsibility for Working towards Social and Environmental Sustainability*.

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Annex IV.1 Cleaner Production Policy Decision

Government of the Czech Republic

DECISION

of the government of the Czech Republic
from 9th February 2000 No. 165

to the National Cleaner Production Programme

The Government of the Czech Republic

I. a c k n o w l e d g e the National Cleaner Production Programme as contains the part III a IV of the proposed material, adjusted according to the governmental comments;

II. i m p o s e on the Ministry of Environment of the Czech Republic, to follow this Programme on the ongoing basis, and, starting 31st March 2001, each year, to submit the evaluation of benefits of this programme to the Government of the Czech Republic;

III. r e c o m m e n d to Ministries of Environment, Industry and Trade, Agriculture, Spatial Planning and Development, Defence, Transport and Communications, Interior Affairs, Education, Youth and Sport and to vice-chairman of the Government of the Czech Republic and Ministry of Finance and to vice-chairman of the Government of the Czech Republic and Minister of Work and Social Affairs and to Ministry of Health to utilise the principles of the Cleaner Production Programme into their practise and to implement it into the daily operation of their resorts.

<u>Will be carried on by</u>:

Ministries of Environment,
Industry and Trade,
Agriculture, Spatial Planning and Development,
Defence, Transport and Communication, Interior Affairs,
Education, Youth and Sport,
Vice-chairman of the Government and Minister of Finance and,
Vice-chairman of the Government and Minister of Work and Social Affairs,
Minister of Health

Prime Minister

Ing. Miloš Zeman, v.r.

Annex IV.2 Cleaner production policy development in Zimbabwe

In 1994, the Environmental Forum of Zimbabwe, a group of leading local private industrialists, took the initiative to host the National Cleaner Production Centre. The centre was set up in response to local industrial concerns with the Business Charter for Sustainable Development, whose sixteen principles of environmental management were to be addressed by the Centre.

The Centre received a significant number of responses from industry that was interested in participating in cleaner production demonstration projects. The centre selected six factories from the sectors of sugar refining, breweries, packaging, and timber product manufacturing, and completed the feasibility analysis of cleaner production options in 1996 (Verspeek, 1996). Although appreciation for cleaner production concepts and the benefits brought about by the projects was high, organisational problems hampered the acceptance and dissemination of the cleaner production options. Major problems included (UNEP, 2001):

- Lack of management commitment where long-term investments were recommended;
- Too few skilled cleaner production people in the companies;
- Staff turnover – trained personnel left the companies before the implementation of the high-cost options had been accomplished;
- Lack of funding for large investments and lack of the technology required for implementation.

During information meetings about cleaner production, industrialists expressed their fear of high-cost investments in advance. It was a task to convince them that it would be inaccurate to fear the high costs of investments in the first cleaner production assessment. Experience with cleaner production development shows everywhere that it is possible to start at the level of good housekeeping measures and limited organisational changes. High-cost investments come later into the picture.

In the Zimbabwean practice, various conditions were lacking for cleaner production dissemination, such as the capability within industry to elaborate the concept. Furthermore, the culture of a strict division of labour and limited responsibilities for employees made it difficult *to look with new perspectives*.

This was also the case with politics and environmental policy (Baas, 1999). Environmental regulation is in general weak. This is why the Zimbabwe NCPC Environmental Awareness Programme focused upon the integration of links between different ministries, the regions and major cities, industry associations, a consumer organisation and education institutes. With respect to the positions of these organisations, the Zimbabwe NCPC's has played a facilitating role in various cleaner production policy workshops for cleaner production awareness-raising by establishing internal and external links within, and between government departments (in Zimbabwe: the Ministry of Environment & Tourism and the Ministry of Trade & Industry), regional environmental agencies (together with other regional departments), industry and relevant stakeholders such as local councillors.

A *Cleaner Region* programme was presented as a *positive sum* approach for all stakeholders. Representatives of regions and municipalities were shown that they could enter into partnerships as facility managers in communities to develop a Cleaner Region Network.

Many partners however, expressed their need for additional assistance, as most of them felt too isolated to create much impetus for this approach. A quick-scan analysis with the representatives of regions and municipalities stressed the need for further cleaner production information and regional workshops for councillors to receive commitment at the political level.

Also during the workshops, regional representatives and councillors had open minds for, and a good appreciation of, the cleaner production approach as opposed to the pollution control approach. However, just as in the case of the regional and municipal officials, these representatives also expressed their need for more assistance, further feedback and assistance to stimulate them in their daily practice. Most of them also felt both not knowledgeable enough about the cleaner production concepts and too isolated to create much impetus for this approach. Continuous education would need to become part of the developing network of cleaner production promoters.

The NCPC declared that it was willing to assist in awareness-raising programmes in the regions and municipalities. This role has often been discussed: on the one hand this will not mean that the NCPC must continuously do the work, on the other hand it is a tenet of the cleaner production philosophy that stakeholders are in the best position to stimulate change both within their organisations and in their contacts with other organisations.

The evaluation of these workshops made clear that the participants did not see themselves as cleaner production innovators because of a lack of power and cleaner production knowledge. They did not take any responsibility and considered the other stakeholders to be in a better position – all participants pinpointed the NCPC as the optimal dissemination organisation.

Even when the NCPC did take this responsibility, they met with many structural difficulties themselves. The relationship with the host institute was difficult from the start, for several reasons: a) uncertainty about assistance by a professional manager from the host institute; b) dissension about what should be paid by the host institute; and c) what should be covered by the UNIDO funds. Furthermore, the Centre's cleaner production capacity building was frustrated by the lack of conditions for proper personnel management. Several consultants who had been trained in cleaner production left the NCPC (in general job rotation in Zimbabwe is rather fast).

In 1997 it became clear that the host institute expected to make profits after three years. The host institute had not internalised the NCPC philosophy. This was a reason to disconnect the relation with the NCPC and to stop housing it. After some years, the government took over the role of host institution.

Due to this situation, it was difficult to give a follow-up to several initiatives. Continuous influence on environmental and economic policy formulation and development, assistance to regional cleaner production plans, and editing cleaner production newsletters constituted a big workload.

The existing infrastructure provided many obstacles to cleaner production dissemination. Also, the dependence on external funds resulted in severe limitations. Bilateral funding organisations favour cleaner production projects with demonstrable results as such; they are hardly interested in the cleaner production capacity-building that is needed for generating, marketing and assisting in industrial cleaner production demonstration projects in various sectors, or for cleaner production dissemination policies, or for the facilitation of, and the feedback loops to, cleaner production initiatives and networks.

Annex IV.3 Cleaner production policy development in Mexico

A cleaner production policy dissemination research team (Baas, 1998) identified three key issues in the introduction of cleaner production in Mexico. Firstly, an overarching problem is that Mexico as a whole needs to develop the foundations for a new approach to environmental policy. Addressing lingering issues of corruption and establishing transparency and equity in policy development will be critical to the success of a new approach. Secondly, the regulatory structure is of the *command-and-control* type for the most part, with a special focus on air pollution and solid and hazardous waste. The development of new landfills for hazardous waste is a major problem for both government and industry. Thirdly, micro companies (mostly family enterprises) form a large proportion of the industrial sector; they live on the edge of the informal economy. About 100,000 micro enterprises have a monthly income of less than US$ 1000 and are barely surviving.

There are some developments in the Mexican environmental arena that are positive with regard to cleaner production. As cleaner production reaches all levels of industry and links industry with other stakeholders, new ways of policy-making and co-operating are needed. This was recognised by almost all respondents, and the team found that some organisations were already experimenting with new approaches.

During the three years prior to the study, there were efforts to incorporate economic instruments into environmental policy. These focused on developing economic indicators, incorporating environmental accounting and applying economic valuation methods to ecosystems.

On the other hand, several respondents mentioned economic barriers to cleaner production. These included lower taxes on imported environmental end-of-pipe equipment and a programme to apply accelerated depreciation to the first year of investment in end-of-pipe technologies. A joint programme of the Ministry of Environment and the Ministry of Industry and Commerce produced a specific list of imported environmental control equipment that is eligible for financial incentives. The Ministry of Environment discussed the possibility of applying these incentives to cleaner production but the Treasury Department (*Hacienda*) was not willing to consider this alternative. The financial benefit is 100% of the income tax (10-20% of the value). The NAFTA agreement will phase out the import tax in general for equipment from the United States and Canada.

A key observation made by the cleaner production policy dissemination research team (Baas, 1998) was that there seemed to be a lot of confusion about the different terms relating to this approach in Mexico; these included clean technology, environmental management and eco-efficiency, and so on. There was little understanding of how these terms differ and in what ways they overlap. A second basic observation was that the government acknowledged the need to co-operate with industry to effectively reduce pollution over the long term. High on the list of priority environmental problems were the loss of bio-diversity and the loss of land and fisheries, but interestingly, industry was not longer mentioned at the top of the list as it had been in the past. Some of the oldest and most polluting industries were indeed being phased out.

In a cleaner production awareness training workshop in 1998, the stakeholders identified several barriers to the implementation of cleaner production. Mexican society as a whole was open to change, under the condition that special attention be paid to the problems of integration between the decision-makers and society. The Chamber of Deputies gave incentives to companies that incorporated cleaner technologies and energy savers into their production process as this new technology can considerably increase productivity. However, the General Law on Ecological Equilibrium and Environmental Protection (1996) and its application shows the following shortcomings:

1. The environmental legislation is based on command-and-control objectives instead of focusing on new approaches of self-regulation and cleaner production;
2. There are about one hundred environmental norms that are unequally applied in industry. This generates distorted competition among a large number of firms because some of them are forced to comply with international norms while others are not;
3. There are problems with the current environmental legislation, such as the duplication of functions within both national and local authorities, giving rise to confusion and additional costs to industry;
4. There is a lack of legal knowledge among the micro, small and medium-sized companies;
5. There is a discrepancy in the effectiveness of the environmental norms, basically due to lack of adaptation to the local context.

A scarcity of ecological culture was identified in the industrial sector. Within that context a pro-active link to international developments – such as a consistent diffusion strategy of the cleaner production concept, access to new technologies, economic and fiscal incentives and both training and information about the benefits obtained from residuals accounting – was missed.

There was also a deficiency in information systems and in straightforward ways of access to the public authorities. For instance, limitations on sub-products trading as an input to new production processes and the minimum resources for training, management, credits and access to new technologies for small and medium-sized companies were not discussed.

In the particular case of state-owned companies, problems included: bureaucracy, the misuse of environmental problems for political objectives, the lack of continuity in projects, government resources diverted to other purposes or areas, and preferential treatment as regards compliance with environmental regulations.

One barrier in government that was identified was that the actions of government bodies differed from the statements of the National Development Programme (*Programa Nacional de Desarrollo*) about sustainable development, which urges internal change. The Department of Treasury (*Hacienda*) and the Ministry of Commerce and Industry (*SECOFI*) were hardly in touch with each other on this issue.

Also, the team noticed that there was an insufficient number of trained and educated staff and a lack of suitable financial schemes. Finally, the priority for an economically sustainable approach to environmental problems was not generally agreed upon.

Another general conclusion in Mexico was that a typical pollution control framework, together with an understaffed regulatory agency, constituted a sizeable barrier to cleaner production. Under the influence of the UNIDO's Cleaner production and the USA's AID programme, societal stakeholders such as industrial associations, government organisations, politicians, and universities were open to change. As a result of a cleaner production awareness-raising workshop for major stakeholders, representatives of these stakeholders started tuning their activities every three months, discussing joint approaches as well as separate developments. For instance, new instruments were developed by the Ministry of Commerce and Industry, and changes were made to the cleaner production/sustainability educational curricula at the Technical Universities of Baja California, Hermosillo, Mexico City, Monterrey and Tampico. Furthermore, the environmental management research information exchange on the occasion of a workshop at the Universidad Autonoma México in México City, (18 and 19 November 2004) displayed the long-term and in-depth academic research being carried out in this field.

Annex IV.4A Current and Planned [+3 years] Services/ Activities of NCPCs

Type of Services / Activities	IND	CPR	ZIM	MEX	BRA	CEH	SLO	HUN	TUN	NIC	ELS	COS	CRO
Training 1 day	●	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O	●	● O
2-5 days	●	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O
More than 5 days	● O			● O	● O	● O	● O	● O		● O	Ø		● O
In-plant Assessment	●	● O	● O	● O	● O	● O	● O	● O	● O	● O	Ø	● O	● O
Information										●			
CP in general	●	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O	● O
Technology	● O	Ø	Ø	● O	● O	● O	● O	● O	Ø	Ø	Ø	● O	● O
Policy Dialogue	● O	● O	● O	● O	● O	● O	● O	● O	Ø	Ø	Ø	Ø	● O
Education Curricula Education institutions	Ø		● O	Ø	● O	● O	● O	● O		Ø	Ø	Ø	Ø
Own (Centre's programme)			Ø	●	● O	● O	● O	●		●	Ø	Ø	Ø
EMS ISO 14001 Training		● O	Ø	Ø	● O	● O	● ?	● O	Ø	Ø	Ø		Ø
implementation of projects		● O	Ø	Ø	● O	● O	● ?		Ø	Ø	Ø		Ø
certification/auditing		● O	Ø		Ø					Ø	Ø		
information dissemination		● O			● O	● O	● O	● O		Ø	Ø	Ø	Ø
LCA Training		Ø	Ø		● O	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
implementation of projects		Ø	Ø		Ø	Ø	Ø			Ø	Ø		
information dissemination		Ø			Ø	Ø	Ø	Ø		Ø	Ø	Ø	Ø
Ecodesign		Ø	Ø		● O	Ø	Ø		Ø	Ø	● O	Ø	
Env. Benchmarking/Performance Indicators	● O	● O	● O		Ø	● O	Ø	● O		Ø		Ø	Ø
Hazardous Material Management		Ø	Ø	Ø	Ø	Ø					Ø	Ø	Ø
Pre-End-of-Pipe	● O	● O				● O	Ø						

● Current O Planned/continuing Ø Planned/ new*? not yet under consideration*

R:NCPC/T-traing (July 5, 1999)

Annex IV.4B Current and Planned) [+3 years] Services/Activities of NCPCs

Type of Services / Activities	IND	CPR	ZIM	MEX	BRA	CEH	SLO	HUN	TUN	NIC	ELS	COS	CRO
Energy Efficiency													
Training	● O	Ø	● O	● O	● O					Ø	Ø		Ø
implementation of projects	● O	Ø	Ø	● O	● O					Ø	Ø		
assessment/auditing	● O	Ø	Ø	● O	● O	Ø	?			Ø	Ø	Ø	Ø
information dissemination	● O	Ø		Ø	Ø		Ø		Ø	Ø	Ø		Ø
Environmental Reporting		Ø	Ø		Ø	● O	Ø	● O					Ø
IPPC Directive	● O	Ø	Ø			● O	Ø	● O					Ø
Environmental Accounting/Total Cost Assessment													
Training		Ø	● O		● O	● O	● O	● O		Ø	Ø	Ø	
implementation of projects		Ø	● O		● O	● O	● O	Ø		Ø	Ø		
Advice on CP Financing	Ø	Ø	Ø	● O	Ø	● O	● O		● O		Ø	Ø	
Safety and Health at Work						?							
Training		Ø	Ø	Ø	● O			Ø					Ø
implementation of projects		Ø	Ø		Ø								Ø
information dissemination		Ø	Ø		Ø		● O	Ø					Ø
Emergency Preparedness & Response						?							
Training			Ø		Ø		● O					Ø	
implementation of projects			Ø		Ø		● O					Ø	
certification/auditing			Ø										
information dissemination			Ø		Ø		● O	● O				Ø	
Supply Chain	Ø	Ø	Ø	Ø	● O	Ø	?	● O	Ø		Ø		
Technology Transfer	● O	Ø	Ø	● O	● O	● O	Ø			Ø	Ø	● O	
Social Aspects/Trade Unions		Ø	● O	Ø		Ø		● O					

● Current O Planned/ continuing Ø Planned/ new *? not yet under consideration*R:NCPC/T-ENER (July 5, 1999)

Annex IV.5 Green Productivity in Asia: The Six-Step GP Methodology

As Green Productivity (GP) focuses on productivity improvement and environmental protection, the central element of the GP methodology is the examination and re-evaluation of both production processes and products to reduce their environmental impacts and highlight ways to improve productivity and product quality. Implementation of these options leads on to another cycle of review and so promotes continuous improvement. The six principle steps of the GP methodology are:

Step 1. *GETTING STARTED*

The beginning of the GP process is marked by the formation of a GP team and a walk-through survey to gain base-line information and identify problem areas. At this stage it is vital to get the support of senior management to ensure that adequate manpower and resources are available for successful GP implementation.

Step 2. *PLANNING*

Using the information gained in the walk-through survey along with a number of analytical tools such as material balance, benchmarking, eco-mapping and Ishikawa diagrams, problems and their causes are identified. Following this, objectives and targets are set to address the problem areas. Performance indicators are also identified.

Step 3. *GENERATION AND EVALUATION OF GP OPTIONS*

This stage involves the development of options to meet the objectives and targets formulated in the planning stage. It involves both a review of pollution prevention and control procedures that have already been devised or implemented and the development of new options. Options are screened and prioritised in terms of their economic and technical feasibility and their potential benefits. They are then synthesised into an implementation plan.

Step 4. *IMPLEMENTATION OF GP OPTIONS*

The implementation of the selected GP options involves two steps: preparation and execution. Preparatory steps include training, awareness building and competence development. This is followed by the installation of equipment and systems along with operator instruction and hands-on training.

Step 5. *MONITORING AND REVIEW*

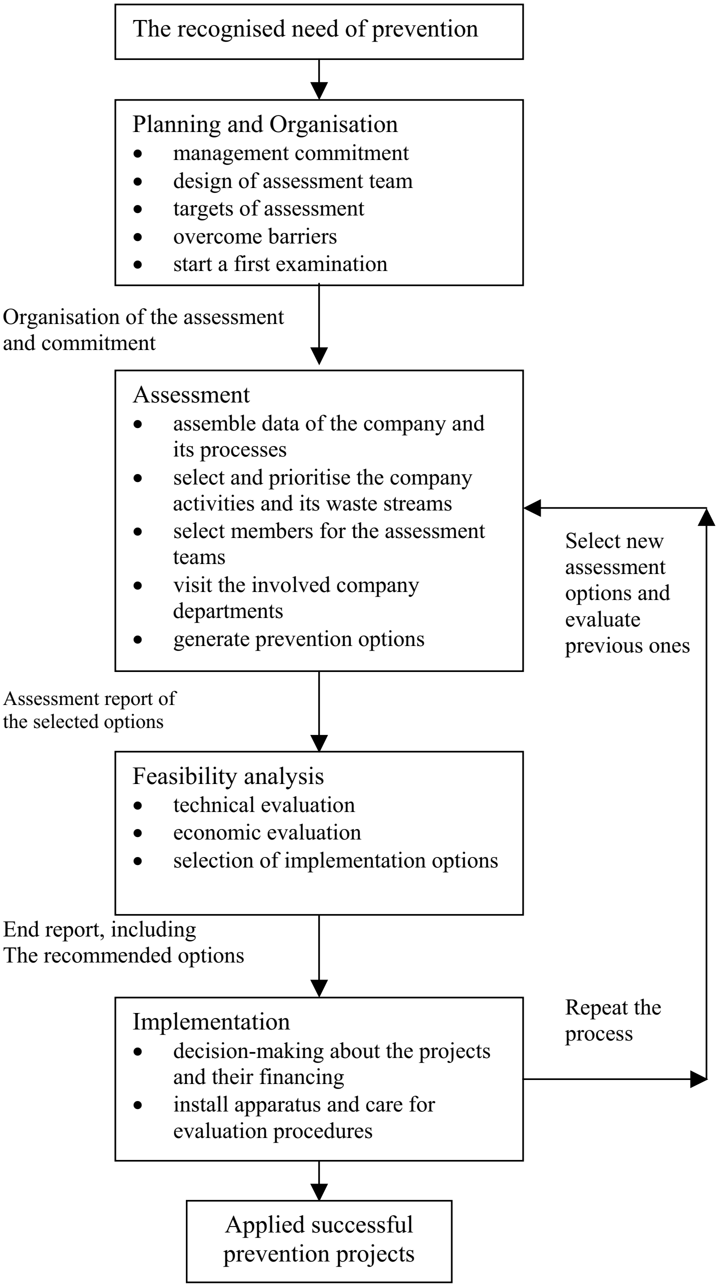
Once the selected GP options have been implemented it is vital to check whether they are producing the desired results. This involves monitoring the overall GP system to ensure that it is proceeding in the right direction and that targets are being achieved as per the implementation plan. Findings are reported for management review.

Step 6. *SUSTAINING GP*

In light of the findings of the GP evaluation, corrective actions can be taken to keep the GP programme on target. In some cases targets and objectives themselves will have to be modified. As the programme progresses a feedback system should be implemented so that new problems and challenges will be highlighted and dealt with. In this way the GP cycle will loop back to the relevant step to implement a process of continuous improvement and ensure the continuing relevance and effectiveness of the GP process.

Recognising that a new balance is required between environmental protection and economic activities, the Asian Productivity Organisation (APO) established the Green Productivity programme in 1994 (www.apo-tokyo.orgT).

Annex V.1 The cleaner production assessment method



From: De Hoo, S. et al, Handleiding voor preventie van afval en emissies (Manual for the prevention of waste and emissions), The Hague, 1990

Annex V.2 Progress indicators of 1997 of Hercules Europe

Theme	Indicator	Basis year	Result in 1997
Production	Volume index (1992 = 100)	1992	123
Environment	Emission to the air	1987	- 72%
	Volume air emission/ Production volume	1987	- 80%
	BOD	1994	- 52%
	COD	1994	- 13%
	Non hazardous waste	1994	- 7%
	Hazardous waste	1994	+ 18%
	Come out of toxic compounds (TRI)	1987	- 58%
Energy use	Energy use (1992 = 100)	1992	117
	CO2	1992	112

Source: NCI journal, 40:15, 1998, 23

Annex V.3 CEFIC list of 16 SHE indicators

Number indicator	Parameter Subject	Year of introduction
1	Number of fatal accidents annually (itemised for employees and contractors)	1999
2	Absence of minimum one day per 1 million labour hours (also itemised)	1999
3	Absence per 1 million labour hours with respect to labour related factors	2002
4	Removal of hazardous waste (in tonnes)	2002
5	Removal of non-hazardous waste (in tonnes)	2002
6	Emission of Sulphur dioxide (in tonnes SO2)	2000
7	Emission of Nitrogen oxide (in tonnes NOx)	2000
8	Emission of Carbon dioxide and other greenhouse gasses (in tonnes CO2)	1998
9	Emission of volatile organic compounds (in tonnes)	2001
10	Emission of Phosphates (in tonnes)	2000
11	Emission of Nitrates (in tonnes)	2000
12	Chemical Oxygen Demand (COD in tonnes)	2000
13	Emission of heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn in tonnes per metal)	2001
14	Emission of other compounds that can possibly affect Health &Environment	?
15	Energy-use and Energy-efficiency	?
16	Distribution incidents (in number of incidents per tonne per logistics modality)	2001

Source: NCI Journal, Volume 40, Number 21, 25-11-1998, p. 15

Annex V.4 Overview of key variables of mature NCPCs in 2002 (n = 7)

NCPC	Number of employees	Number of disciplines	Three major activities
1	9 + 20 external consultants	5	* capacity building * technical assistance * information dissemination
2	14	7	* eco-industrial park * introduction of market mechanism for promotion of cleaner production * ISO14000
3	7,5	3	* implementation of National Cleaner Production Programme * implementation of integrated projects * integrating cleaner production into other activities and policy
4	7	6	* dissemination of cleaner production information and policy * demonstration projects * training
5	2 + 80 professionals from host institutions	2	* cleaner production awareness creation via clinics, media and information dissemination * capacity building of institutions, regional centres, and industry associations * demonstration projects in cluster of industries and as sectoral focus to demonstrate benefits
6	15	3	* cleaner production and environmental management systems in-plant assessments and cleaner production training workshops * policy dissemination via environmental management systems in municipalities, Mexican Pollution Prevention Roundtable, lobbying in government and proposals for regulations * strategic studies on cleaner production-related subjects such as financing, surveys, and resource management
7	6	2	* training * cleaner production assessments and demonstrations in companies * information acquisition and dissemination

Annex V.5 Process profile analysis at DSM-Andeno plant in 1994

	Max Points	I	II	III	IV	V	VI
OPERATIONAL COSTS							
I Resources	15			7			11
II Profit: Overall	5			5			3
Average	5			5			4
III Process time	10			8			6
IV Output per volume unit	10			6			6
	45	28	27	31	24	28	30
CAPITAL COSTS							
V Total steps I-IV	10			7			5
VI Special apparatus or new technology	10			10			7
	20	16	17	17	13	13	12
PROCESS CONTROL							
VI Reproductiveness	3			3			2
VII Tolerance to variation in process parameters	5			5			2
IX Linearity of convergence in reaction scheme	2			2			2
	10	6	10	10	6	6	6
INTERNAL RISKS	5			5			
X Environmental load	10			10			3
XI Health risks							7
	15	10	12	15	15	12	10
EXTERNAL RISK FACTORS							
XII Availability of key resources	5			5			5
XIII Sensitivity to government actions	3			2			1
XIV Patent protection	2			1			2
	10	7	7	8	9	8	8
IN TOTAL	100	67	69	81	67	67	66

Annex VI.1 The application of selection criteria to industrial ecology projects in the INES project 1994 - 1997

The INES project team assessed the fifteen projects according to three types of criteria: environmental, economic and management commitment to potential development of industrial ecology. Furthermore the number of links in a chain was taken into account. The possible project scores were divided into four different categories:

I good prospects for performance on own power of companies;
II good prospects under the condition of further research being conducted;
III good prospects, but not feasible in the short term;
IV No prospects at all within the INES framework.

The following table provides an overview of the types of projects assessed and their respective scores according to category (I - IV) and dimension (1 - 4) – which include the environmental potential (Env), economic potential (Econ), management commitment potential (Man) and the number of links in the chain.

Projects	Scores				
	Env.	Econ.	Man	Chain	Cat.
* cargo waste in transit & storage	2/3[a]	2	3	(2)	III
* small-size packaging	3	3	2	3	I
* off-spec products	3	3	3	2	II
* re-use of Sulphur	3	4	2	3	III
* desulphuring	4	4	3	2	I
* silicon- & aluminium oxide	4	1	1	2	IV
* crude oil sludge	2	3	3	3	III
* demand/supply steam	4	?	2/3	2	II
* air capacity	3	3	3	2	II
* off-spec natural gas	4	4	4	2	I
* high-caloric waste incineration for generation of electricity	4	4	4	2	I
* bio sludge	3	4	4	2	II
* waste water	1/3	4	4 (?)	3	II
* ballast water	2	1	1	1	IV

[a] 1 is not relevant, 4 is most relevant

Annex X.1 Quick-Scan Questionnaire on Cleaner Production

The Quick-Scan Cleaner Production Questionnaire has a basic format that has to be modified to reflect both the objectives and culture of the NCPC's country. The questionnaire involves the establishment of the objectives, the strategy, an action plan and a time frame for the period of elaboration and analysis. The scope of the policy research depends on time, funds, capacity and urgency. The policy research starts with three steps of orientation in the cleaner production dissemination field. These steps focus on environmental public policies, the influence on general public policies and the attitude towards a stakeholder strategy. The results of the steps form the basis for the design of a stakeholder approach.

Step 1 Environmental public policy

In this step the current environmental public policy is analysed in relation to its integration with other types of public policies and policy instruments. The lead questions in a context analysis within a cleaner production dissemination policy analysis are as follows:

* What are the current policies in your country concerning business and the environment?
* What are the characteristics of the current policy instruments in your country?:

  Direct regulation: laws, regulation, directives, regulatory inspection, permit writing, enforcement;

  Indirect regulation: economic instruments, self-regulation, facilitating experiments.
* What is the political attitude towards integrating cleaner production in public policy in your country?
* What are the characteristics of the consideration of new policy in general?
* Which factors could lead to cleaner production being recognised as an important tool that should be integrated into the industrial and environmental policies of the government?
* What instruments and approaches could you use to arouse the interest of various stakeholders?
* What role could the NCPC play in influencing the public policy process?

Step 2 Influencing the public policy processes

In this step the current public policy in general is analysed, on the assumption that integrated environmental public policy is weak and is dominated by political considerations related to better economic conditions and labour. The leading questions in this step are the following:

* Who are the stakeholders?
* What are their positions?
* Are any networks currently active?
* How can NCPCs play a role in mediating a cleaner production stakeholder process?

Step 3 The stakeholder orientation

In this step, the stakeholder's positions are analysed in the general and environmental public policy processes in relation to the dissemination of cleaner production. The leading issues are: the identification of the relevant stakeholder groups, the determination of their stake and how effectively the expectations of each group is presently being met, and the modification of corporate objectives and policy to take stakeholders' interests (Freeman, 1984) into consideration. The leading questions in this step are:

* Who are the stakeholders in cleaner production dissemination and what is their stake?
* What are the strengths and weaknesses of their positions in relation to policy on business and the environment?
* Do network activities provide an extra push to cleaner production promotion and are there any opportunities for co-operation?
* Please name the relevant stakeholders and classify the importance of their position.

Step 4 The organisation of a stakeholder strategy

After the analysis by means of the first three steps the next actions are ascertained. Bearing in mind that stakeholders should have an incentive to join, while at the same time they must not feel they are being overwhelmed, the leading questions are the following two:

* How can you organise the stakeholder strategy in your countries?
* Who will you involve in your stakeholder strategy plan?

For this assessment, the questions framework *How/What/For Whom* can be used. The framework was used as background material for the `Quick-scan cleaner production questionnaire' in Mexico (Baas, 1998a). The framework covers the issues *what?* (covering knowledge about the new concept), *who?* (covering the relationship to the concept), *what for?* (covering knowledge about the applications of the new concept), and *how?* (covering the methods of dissemination of the new concept).

WHAT: The *what?* issue covers knowledge about the substance of the new concept. It uses the questions `What knowledge is present? What knowledge is needed? and What knowledge can be produced?' A further distinction can be made according to type of aspects and disciplines that play a role in the research:

A. *Which issues can play a role?*

1 *Environmental* aspects: knowledge about the state-of-the-art of cleaner production is a basic need for the development of a strategy to go from demonstration projects to mainstream internalisation and to move from single companies to cleaner regions;

2 *Functional* aspect: there are more functions than management control: knowledge about the business economics, innovation, product policy, and training focus needs to be included in the analysis of the dissemination process;

3 *Temporal* aspect: the tension between short-term and long-term developments. It is often said that cleaner production is something for the future, but `we need to make profits now!'

4 *Institutional* aspect: which formal and informal roles are institutions and actors playing and what is their knowledge of, and their reaction to, cleaner production?

B. *Which disciplines will play a role*?

1 *Additional* discipline: the practical knowledge gained from cleaner production demonstration projects;

2 *Multi*-disciplinary: the integral approach to various dissemination strategies to information, awareness-raising practical projects, policy, and training;

3 *Mono*-disciplinary: the specific need for cleaner production knowledge embedded in an integral approach.

WHO: The *Who?* issue covers a scheme of relationships that can be of help in order to develop a stakeholder network. Under this heading, the following questions may be asked: `From whom do possible stakeholders get their knowledge, Who can use the cleaner production knowledge and With which stakeholders is it possible to co-operate?' The existing format for knowledge dissemination can also be focused upon.

A. *Which institutes and/or actors have and/or can supply knowledge in the sectors?*
1. Environmental policy-making circles
2. Industrial/economics policy-making circles
3. Industrial organisations
4. University/polytechnics
5. Planners: physical planning, industry
6. Knowledge/Policy intermediary organisations
7. Environmental advocacy organisations
8. Consumers

B. *Is a format for knowledge dissemination available and/or feasible?*
1 *Public domain*: what knowledge is feasible in general: journals, newspapers, TV, internet, scientific magazines, industrial sector magazines
2 *Exchange/dissemination* relation: when both parties benefit, it is easier to exchange knowledge
3 *Market* relation: the **commissioned** research and and knowledge generation
4 *Policy-making* relation: when several actors, for instance in bargaining processes, are making policy products, much knowledge is generated in the process. Those actors can apply that knowledge.

WHAT FOR: this question covers the knowledge applications of a new concept. Under this heading the following questions can be asked: `For which applications is our knowledge suitable, Which new knowledge will be generated by these applications, and For which applications are funds needed?'

A. *For what kind of action is the knowledge that is supplied suitable?*
* A vision, framework, consideration, strategic plan, design, norm, operational plan or performance decision

B. *Decide about the application levels for this knowledge*:
* Global, national, regional, fluvial and local

HOW: This issue covers the dissemination methods of the new concept. It involves the following questions: 'How can the disseminators gain the required knowledge, How can the disseminators provide knowledge to others, and How can we elaborate knowledge?'

A. What methods and techniques are needed to obtain the requested knowledge, and is the knowledge supplied applicable?
1 *Research methods*, such as literature search, interviews, modelling
2 *Learning methods*, both at collective and individual levels
3 *Organisational methods*: to shape relations as required
4 *Planning methods*: to gain people's commitment to the concept, to develop databases for orientation, illustration and feedback

B. *Decide about the most effective involvement of relevant relationship networks.*

Finally, this whole process should lead to a *cleaner production dissemination policy plan*. This involves examination of the state-of-the-art of the major stakeholders' cleaner production knowledge. The interviews that are part of the research are not only designed to find data on daily practices and cleaner production knowledge, but can also be used to get commitment to further steps in cleaner production information. The analysis carried out during this phase will result in the next phase: the design of a cleaner production awareness-raising policy workshop, which involves the decision about which organisations and representatives will be considered as suitable participants.

During the cleaner production awareness-raising policy workshop, participants must develop a clear understanding of the greater benefits of cleaner production as opposed to pollution control solutions, via information, cleaner production simulations and interactive sessions. The understanding must involve the impact on economic competitiveness and how participants can influence cleaner production dissemination in their organisations.

The NCPC's policy must secure financial and organisational resources in order to ensure that other policies do not create disincentives. Although hiring new staff with specific knowledge may not be an option, the allocation of staff time to stimulate market incentives for cleaner production is recommended. The Mexican NCPC recruited an economist and a lawyer with policy-making experience to market the concept and lobby in the policy-making circuit from 1998.

The implementation of a cleaner production framework can be financially supported by:

* International programmes, that constitute a source of funding for specific initiatives;
* The national government, that finances programmes from general funds or environmental taxes;
* Local government, using disposal fees or national government support;
* When a higher status is achieved, the use of existing funding mechanisms through the integration of cleaner production concepts can increase.

Continuous information and training in simple and clear terms are essential to the success of cleaner production. Both traditional information providers – such as brochures, posters, workshops, clinics, interviews in local papers, professional journals and advertising – and the opening of a website are recommended. A stakeholder network that meets each quarter in order to receive feedback and to reflect on cleaner production activities is a good basis for a continuous improvement platform on cleaner production dissemination policy.

As a result of a cleaner production awareness-raising workshop for major stakeholders in Mexico (Baas, 1998), representatives of these stakeholders have been tuning their activities four times a year, discussing joint approaches as well as separate developments. The stakeholders also spread the concept within their own organisation. For instance, the Mexican Ministry of Commerce and Industry developed new policy instruments in order to provide better support to cleaner production dissemination.

Overview Annexes

IV.1	Cleaner production policy decision
IV.2	Cleaner production policy development in Zimbabwe
IV.3	Cleaner production policy development in Mexico
IV.4A	Current and Planned [+3 years] Services/ Activities of NCPCs, page 1
IV.4B	Current and Planned [+3 years] Services/ Activities of NCPCs, page 2
IV.5	Green Productivity Asia: The Six-Step GP Methodology
V.1	The cleaner production assessment method
V.2	Progress indicators of 1997 of Hercules Europe
V.3	CEFIC list of 16 SHE indicators
V.4	Overview of key variables of mature NCPCs in 2002
V.5	Process profile analysis at DSM-Andeno plant in 1994
VI.1	The application of selection criteria of industrial ecology projects in the INES project
X.1	Quick Scan Questionnaire Cleaner Production

Overview Boxes

Overview Figures

Overview Tables

About the author

Leo Baas (1946) has a Master of Science in Sociology of Industry and Management with a Specialisation in Environmental Sciences. He started his career in industry in personnel and organisational management. After being the liaison between the citizen's association and the government about solving the problems that citizens met through living on contaminated soil, he changed his job to scientific researcher and lecture of environmental issues. He is working at the Erasmus centre on Sustainability and Management (ESM) at Erasmus University Rotterdam since April 1986.

At ESM, he co-ordinates the International Off-Campus Ph.D. Programme on Cleaner Production, Cleaner Products, Industrial Ecology & Sustainability, and the Social Science Track of the Inter-University M.Sc. Industrial Ecology (in co-operation with Delft University of Technology and Leiden University).

He has performed research on cleaner production since 1988 and on industrial ecology since 1994. He has been a member of the daily board of the European Roundtable on Cleaner Production in the period 1994 – 2003 and is a lifetime member of the International Association of Cleaner Technology. He is an advisor of the UNEP/UNIDO National Cleaner Production Centres Programme since 1994 and a member of UNEP's High Level Expert Forum on Sustainable Consumption and Production. He is a member of the Strategy platform of the long-term programme *Sustainable Enterprises in the Rotterdam Harbour and Industry Complex* in the Netherlands.

He is the author of many publications on cleaner production and industrial ecology and is frequently invited to give lectures all over the world.