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When top-down meets bottom-up: Is there a collaborative business model for local energy storage?

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ABSTRACT

As the energy transition progresses, energy storage becomes increasingly important for safeguarding a reliable energy provision. At the same time, energy storage systems are used to increase the self-consumption of decentralised generation and are expected to result in lower electricity bills for the energy prosumers. Drawing on sustainability transitions and management literature, this contribution focuses on a neighbourhood battery with the aim to explore to what extent a collaboration between a network operator and renewable energy initiatives on local energy storage could help increase the impact of the latter in the energy transition. The concept of a neighbourhood battery involves strategic decisions, and perhaps a strategic innovation, whose transformative potential depends to a large extent on the perceptions and actions of those involved. This paper explores the opportunities and constraints for a collaborative business model for the neighbourhood battery in the Netherlands, as well as the challenges and tensions that emerge for the main parties involved. The perspectives of the network operator were compared with those of renewable energy initiatives in the country, including the Energy Service Company involved in the pilot and, in parts, with the perspectives of the involved end-users. This contribution registers a misalignment of interests and expectations which complicates the deployment of the neighbourhood battery concept. Recognizing the critical role of network operators, the conditions that may enable the emergence of collaborative business models for local energy storage are also discussed.

1. Introduction

While the total of renewable sources in the energy mix of the Netherlands in 2018 only amounted to 7.4% [1], this percentage is expected to substantially grow in the future according to the country's (inter)national commitments and plans. The anticipated (potentially accelerated) diffusion of renewables will necessitate alternative structures and modes of organising for safeguarding the reliable provision of sustainable energy. Due to their intermittent and fluctuating (yet predictable) nature, the wide diffusion of renewables will stress the functioning of the electricity grid. Energy storage, which helps balancing the grid and also enables sector integration, is set as a priority area in the European Green Deal for ensuring the EU's objective for climate neutrality by 2050 [57].

In the Netherlands, as in the EU, securing the reliability of the grid is the main task of the grid operator. Safeguarding grid capacity and operation is considered a public task, enabling proper functioning of the electricity market. Integrating energy storage into the existing energy infrastructure allows balancing the fluctuating renewables and thereby supports the reliability of the grid [2]. Pumped hydro storage (PHS) is the oldest and more mature kind of energy storage, using natural or technical reservoirs for electricity storage and grid balancing at a relatively large scale. It already provides more than 50 GW storage capacity in operation in the EU [3]. More recently, other technologies for electricity storage have drawn attention, including batteries that typically apply for storage at a smaller scale [3]. Apart from securing a smooth grid operation, small-scale energy storage is supposed to potentially offer additional values to local communities, such as enabling them to engage in electricity trading, thereby increasing people's engagement in community activities and public awareness of energy and environmental issues [4]. It is, therefore, claimed that local energy storage not only can support the technological side of the energy transition but could also support the social side of it by addressing issues like democracy, transparency, ownership that accommodate the needs and expectations of citizens and local communities [5].

Yet, despite its promising theoretical potential, there are numerous practical and technical barriers. These involve management issues, ownership rights, and taxation and grid fees [6]. If such hurdles to

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integrating local storage are not addressed, they may prevent a wider deployment of energy storage in Europe. While its potential has been discussed for long, only recently some actors began experimenting with alternative storage systems and various ownership models. As regulators are working on defining the legislative landscape, the merits of alternative storage systems and their Business Models (BMs) are being investigated through demonstration and pilot projects.

One such pilot in the Netherlands involves the "*neighbourhood battery*" project. The project has been an initiative of Liander, part of grid operator Alliander, responsible for the local gas and electricity networks in various parts of the Netherlands. Liander's overall position and role in the energy transition is unclear because it is an actor embedded within a centralised and (so far) mainly fossil fuel-based energy regime, as well as an enabler of an emerging distributed renewables-based regime. Its actual role is thus increasingly hybrid. As the grid can be an instrument that may increase the power of certain actors while undermining the influence of others, thereby contributing in the shaping of the power balance in the field, the role of the network operator is *per se* dubious. Focusing on the German energy transition, Blanchet (2015) argues that the role of the network operator is of *"divergent interpretations*" and a matter of conflicting visions of local energy transitions [7] (p.251).

In the case of the Netherlands, Liander has always focused on ensuring reliability, affordability and accessibility to energy [8]. Yet, acknowledging the new challenges caused by an increase (and anticipating accelerating increase) of renewables in the Dutch energy mix, Liander also got involved in innovation around decentralised renewable energy. On the one hand, with its involvement in energy storage, network operator Alliander may want to strengthen its role in the energy transition. On the other hand, the organisation has used the neighbourhood battery to initiate collaboration with a local renewable energy provider and to communicate with the residents producing the electricity to be stored. This would suggest that local energy storage may function as a vehicle for organisational change and the deployment of a Collaborative Business Model (CBM) between the established regime and emerging renewable energy initiatives. For the realisation of this potential, the neighbourhood battery would need to evolve from a concept to a solid CBM that guarantees a fair value exchange[1] between the parties involved.

This paper analyses the case of the neighbourhood battery with the aim to study the discourses related to the potential impact of local energy storage on the position of parties operating in both the energy regime, in this case, a grid operator, and parties operating in niches, such as local energy initiatives. Thereby, this paper explores to what extent *collaboration between a grid operator and renewable energy initiatives on local energy storage could help increase the impact of renewable energy initiatives in the energy transition.*

The concept of a neighbourhood battery involves strategic decisions, and perhaps a strategic innovation, whose transformative potential depends to a large extent on the perceptions and actions of those involved. For this reason, this paper explores two specific questions:

i) *What are the opportunities and constraints for a collaborative business model for the neighbourhood battery in the Netherlands?*
ii) *What kind of tensions and challenges emerge for the main parties involved, the network operator and the local renewable energy initiative?*

To address these questions this contribution explores and compares the perspectives of different actors in the case, i.e. network operator Liander, several Dutch renewable energy initiatives (REIs), including the Energy Service Company (ESCO) involved in the pilot, and end-users of the pilot. We analyse and discuss these perspectives in the context of institutional constraints for both the grid operator and local initiatives from end-users of the electricity stored. Section 2 presents the analytical framework and research methodology. Section 3 discusses the background of (local) energy storage as it is given by the literature on the topic: its expected benefits, its relation with community REIs, the legal framework around it, along with possible ownership models for it. Section 4 presents the findings as regards the societal costs and benefits as identified by the interviewees, the identified barriers and some first ideas on how a CBM for local energy storage could look like. Section 5 discusses the contrasting perspectives on the concept of the neighbourhood battery. Finally, in Section 6 we reflect about our findings and their significance in relation to the institutional context presented in Section 3, and then, we conclude.

2. Analytical framework & methodology

2.1. Analytical framework

The deployment of the neighbourhood battery concept and the realisation of its potential requires the establishment of a CBM to find a new way to arrange costs and benefits. Our focus is on the value flows involved (value proposition and value capture), on the particular products/services that may be offered, as well as the overall architecture of value; all these BM elements may have an impact on the system and its transformation [8–10]. To study this impact, this paper takes a broad orientation on value, allowing the consideration of financial, social and environmental values in line with Sustainable Business Models (SBM) literature [9–13].

To systematically study how the neighbourhood battery concept under study (may) affect(s) the system, specifically vis-à-vis the diffusion of decentralised renewable energy, and to identify the barriers and opportunities for the establishment of such a CBM, we combine a BM perspective with a broader systems approach, which is offered by the theory of sustainability transitions. Starting hypothesis is that such diffusion of renewable energy necessitates the emergence of structures and practices, like the ones involved in the neighbourhood battery concept, namely, active participation of end-users and their collaboration with established actors in the energy domain. Sustainability transitions research [14] identifies dominant cultures, structures and practices (a regime) that provide stability to societal systems. But such regimes (in this case the Dutch centralised, fossil-based regime of energy provision organised through the market and energy policies providing energy to consumers) are also path-dependent and resistant to transformative change [15]. A transition is a process in which such a regime is simultaneously confronted with increasing external societal pressures (landscape), emerging competition from alternatives (niches) and increasing internal tensions and crises leading to large-scale disruptions and non-linear change [16–19].

Regimes develop path-dependently through optimisation and incremental innovation [14]. Yet, aligned with shifts in the broader societal context, new radical alternatives develop and emerge, which inevitably bring regimes to increased stress, crises, destabilisation and systemic reconfiguration [14]. These iterative interrelated processes of construction and destruction are illustrated in the X-curve (Fig. 1), which has been introduced as a tool to discuss the dynamics and roles different actors take in the context of sustainability transitions [14].

For a more detailed mapping of the co-evolutionary dynamics between an innovation and its institutional context, we revisit the work of Smith and Raven [20]. Following Kern et al. [21], our framework specifically builds on Fuenfschilling and Truffer [22] who suggest considering niches as "*embryonic regimes*". As such, niches may mature and break through, but they may also be absorbed or dissolved by regime pressures [20]. Subsequently, niches can be understood as encapsulating the conditions for the emergence of potential future regimes, which may differ or conflict with the dominant regimes in a number of dimensions. These dimensions are used for the analysis of

[1] Note that here, we understand value as a benefit or gain for a person or a community.

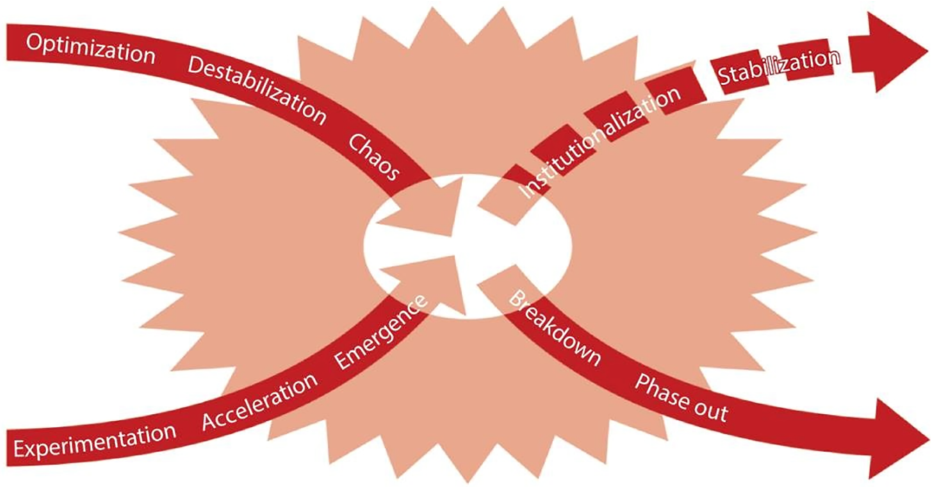

Fig. 1. The X-curve (Source: [34]).

the interplay between innovations and their institutional context [23].

1) **Technologies and Infrastructures**: the material dimension required for the societal function including all technologies and physical infrastructures;
2) **User Practices**: the application domain of the concept or technology, and the associated new routines and norms of the users;
3) **Cultural Significance**: the intrinsic values (valuable "in themselves") associated with the societal function, which may be widely accepted as guiding principles, including the system's representation and symbolic meanings;
4) **Knowledge base**: involving scientific and tacit, practical knowledge associated with the societal function;
5) **Sector Structure:** the organisational networks and partnerships, the particular sector capabilities, along with the interaction platforms for coordination and negotiation within the sector;
6) **Policies and Political Power**: the political power exercised to influence or maintain the regulations, including the support framework, and
7) **Organisational logic**: the specific logic of how an organisation generates value, including organisational decision-making processes, routines and activities directed towards the achievement of organisational aims, along with issues regarding ownership and the relationships between investors, producers and users.

A systems' perspective enables the study of innovations within their context and sheds light to the emerging instances of friction, which could be considered indicators of emerging transition dynamics. While in the experimentation phase alternatives to the regime are typically marginalised, costly and underdeveloped, as time proceeds some alternatives might mature and diffuse in co-evolution with increasing regime destabilisation (e.g. [24]). One of the key questions within transitions research is then how such alternatives interact with elements from the regime and are mainstreamed: do they become captured by the regime or support regime transformation? One way to start exploring this issue of niche-regime interaction and its effects is to identify different dimensions of interaction and explore whether these interactions are transformative or not.

Given the power dynamics and imbalances between niches and regimes, the transition perspective would suggest that in earlier phases, niches like the neighbourhood battery will only support optimisation or be confined to pilots and experiments. During later phases of the transition, a reversed phenomenon may be noticed: given a destabilising regime, different actors may reposition themselves [25] and link to innovations emerging in the niche to form new coalitions, structures and practices that could lead to capture as well as transformation [26].

The neighbourhood battery is a typical example of such a niche innovation emerging in the context of a destabilising energy regime. It exhibits the potential to contribute to the transformation of the energy system through the support of the diffusion of renewable energy projects; as local energy projects grow in numbers and size, the introduction of local energy storage may be necessary for ensuring network stability and power quality, among others. At the same time, it may also contribute to optimising the status quo. The details of the concept's implementation (that is the how and under what conditions) will illustrate its value, exemplifying in this way the benefits of collaboration between the network operator and the REIs. This is the reason why this paper scrutinises the role of the network operator in the deployment of the neighbourhood battery concept.

2.2. Methodology

2.2.1. Data sources and collection

This research followed a single case study approach [27,28] of an energy storage pilot, the Neighbourhood Battery, which provides an example of a collaboration between a Distribution System Operator (DSO), an ESCO and energy consumers. The placement of the first author within the pilot unit of the Dutch DSO Alliander enabled a closer understanding of the neighbourhood battery concept and the creation of the rapport necessary for the research within the organisation.

Academic and professional publications on decentralised energy storage and its deployment were reviewed to build background knowledge around the topic and to identify crucial issues therein. Case-study research included participant observation in meetings of the organisation involved in the pilot. Next, 17 semi-structured interviews were carried out (April-July 2017), which with the permission of the interviewees were recorded. The people interviewed were: a) employees from various departments and positions within the network operator; b) the director of the local ESCO Tegenstroom; and c) directors of renewable energy cooperatives that could express interest in the concept of the Neighbourhood Battery in the future. Additionally, the first author contributed and got access to a first survey on the end-users perspectives about benefits and concerns regarding the pilot.

Within Alliander's environment, the research encompassed four areas: first, the concept's societal costs and benefits (i.e. value and disvalue); second, the barriers for the deployment of the concept; third the Strengths and Weaknesses of the company's internal environment vis-à-vis the concept's deployment, along with the related perceived Opportunities and Threats (i.e. SWOT analysis); and forth, the position of the project on the X-curve. For the latter, after a brief explanation, the interviewees were also asked to justify their choice. As based on academic insights on complex systems change, positioning an actor on the X-curve is always subjective, the focus here was on mapping the different perceptions of Alliander's employees regarding the pilot's contribution to the energy transition.

To better understand how the pilot works in practice, the ESCO operating the battery was contacted. This interview focused on the motivations for the involvement in the pilot, the value of the neighbourhood battery for the organisation and its clients and the project's potential impact on the energy system.

Moreover, the benefits and costs of the neighbourhood battery concept as well as the possible interaction of the concept with the BMs and strategies of REIs was explored through interviews with 6 renewable energy cooperatives.

Additionally, after communication with Tegenstroom, the first author was given access to the first survey on the end-users and their perspective on the neighbourhood battery. Prepared in collaboration with the DSO, Tegenstroom and the researcher's feedback (the first author provided input to the questionnaire), the survey was conducted by the local ESCO; about 58% of the pilot participants (N = 19) filled the questionnaire in. Unfortunately, due to delays in the pilot, the survey took place before the interaction of the end-users with the neighbourhood battery was fully established through the Home Energy Management System (HEMS). The research process is shown in Fig. 2.

Across the different stages, this research involved the participation of different employees of the network operator in interviews and meetings (co-)organised by the first author. This was made possible thanks to the official collaboration between the researcher and the organisation. The specific goal of this collaboration was (i) the exploration of the impact of the neighbourhood battery on the diffusion of decentralised renewables and the energy transition as a whole and (ii) the identification of all the central questions and insights that emerge in the context of the energy transition. It was agreed that such questions and insights would be discussed with the network operator in order to facilitate the reflection of the latter about the project and its overall role, something that can enable the organisation to respond strategically in the ongoing energy transition. In that, the research approach is close to what is described as action research [29,30]. Through collaboration with actors from the field, the research aimed to produce scientifically and socially relevant knowledge, supporting transformative action and the creation of new social relations [31].

2.2.2. Data analysis

Summaries of the interviews conducted (including transcribed quotes of higher interest) were made by the first author, which were then coded and analysed per topic and perspective. The perspectives of the sub-groups of interviewees were compared within and across the different groups. Respecting the interviewees' anonymity, the research findings were compiled in a report, which was circulated for comments across the interviewees. The external validity of the findings was tested through discussions with multiple (energy) experts in a number of professional and academic settings, like workshops and conferences.

2.2.3. Limitations

Given the exploratory nature of this research, possible relations between concepts were sought to be explored rather than explained [27,28]. Hence, our small sample was considered suitable for our purpose. By assisting the reflection among the actors approached regarding their ongoing actions and respective position on the energy system, and a possible shift of any of these due to the introduction of a neighbourhood battery on the energy system this research aspired to contribute to transformative action. Yet, as no meetings between all stakeholder groups were organised during the research period, this research did not result in the creation of new social relations, although some inspiration for that may have been provided.

Furthermore, other limitations of this research involve, on the one hand, the time constraints regarding the duration of the first author's placement within the DSO, and on the other, her ability (or lack thereof) to immerse in the culture of the people and the organisation under investigation.

3. Research background: energy storage

Advocates of electricity storage argue that this may improve the working conditions and the stress-resistance of the electricity grid, making it more secure, reliable and responsive [2]. Storage systems meet tasks like frequency control, capacity or voltage support, emerging as promising assets for grid services [32]. This is especially true for battery storage systems that exhibit a fast response, quick deployment time, and high scalability [32]. Batteries enable the shift of electricity towards off-peak times, reducing grid congestion and energy losses. Consequently, it might lead to a lower need for investment in grid expansion and upgrades [2].

At the same time, energy storage can be used to increase the local self-consumption of decentralised generation. Increasing the consumption of their locally produced electricity, the owners of solar PV can reduce their demand from the electricity grid, and thus, their electricity bills. In fact, combined with a battery system, the actual self-consumption of electricity produced by a household solar system may increase from about 30% to around 60–70% [33]. In areas with high electricity prices, and supportive regulatory frameworks in place, like in Germany, or in areas with an excess of solar resources and relatively low grid feed-in remuneration, like in Australia, significant battery storage in connection with new PV installations takes place [32]. In

End-Users
- Mapping of Benefits
- Impact on User Practices

Renewable Energy Initiatives
- CBA
- Impact on Business Model
- Mapping of Barriers, Opportunities&Threats

Involved Energy Service Company
- Motivation for involvement
- Mapping of value for the organisation & its clients
- Impact on the energy system

Network Operator
- CBA
- Mapping of Barriers
- SWOT Analysis
- Impact on the energy system (position on the X-curve)

Fig. 2. The research process.

Germany, for instance, every second newly installed residential PV system is combined with an energy storage system [34]. Such conditions are not present in the Netherlands but might in the near future as the diffusion of renewables accelerates, and energy prices are predicted to rise and government support schemes are developed.

Furthermore, the combination of energy storage and a HEMS in “smart home” concepts, is associated with optimising energy use and maximizing efficiency [35]. Research suggests that living in a smart home environment that could help reduce energy consumption and cut energy costs (with the support of smart meters, variable tariffs, smart devices, home automation, etc.) is met with positive reactions from the consumers [36]. Yet, some consumers are anxious about privacy, security, and, database transparency, as well as smart-meter capabilities in two-way communication with utilities [37]. Moreover, while in-home displays and persuasive feedback models may support sifting attitudes and behaviours to save energy [35], people find it difficult to change their lifestyles to save money [38].

Lombardi and Schwabe [39] having studied different scenarios through simulation models, argue that when battery owners share the service of their batteries with other users, the net value of the system almost doubles. When a battery is shared within a community, its levelized cost, i.e. the average total cost of building and operating it, per unit of total electricity generated over its assumed lifetime, drops by 37% for communities of up to 100 homes, as shown in a projected 2020 scenario in the UK [40]. Community energy storage also demonstrates higher financial returns than household storage [41]. Besides increasing affordability, also considering an initial investment for the installation, integrating energy storage into community energy systems supports the communities’ energy security, efficiency, resilience and helps developing cooperation among neighbours [4,5].

Nonetheless, batteries come at a cost. While the discussion on the public media often focuses on the sharp decrease of their financial cost (e.g. [42]), scholars have been assessing the environmental and social costs of the production and usage of batteries [43–45]. Batteries can be inefficient, and their production from scarce natural resources can have high energy and environmental impacts, due to the recycling issues they face [44,45]. McManus [45] argues that when it comes to the materials required in battery production, the lithium ion batteries are the most important contributors to greenhouse gases and metal depletion, while the nickel metal hydride batteries have a more significant cumulative energy demand. It is argued that while batteries involve many finite resources for their production, it is unlikely that minerals such as lithium will run out in the near future due to our use of batteries [45] However, researchers stress that while on a global scale the availability of lithium for batteries is significant, the same does not hold for the EU27 that may get dependent on politically sensitive areas [46]. At the same time, the production of batteries involves risk of human rights violations in the supply chain, in particular counties of extraction [47]. Therefore, the broader impact of mining, including its social aspects, underlines the need for increasing both recycling and material recovery [47].

To date few local, citizen-led, REIs engage with local energy storage as the concept is still in its infancy [5]. The different configurations that have emerged in the few demonstration projects worldwide involve (i) shared residential energy storage, (ii) shared local energy storage and shared virtual energy storage [5] as shown in Table 1.

When it comes to the organisation of shared local energy storage, end-users may (a) directly purchase a storage system to connect with their generation capacity, or (b) a third party may act as an aggregator to purchase a storage system for the management of their generation capacity [4]. When the management of a battery is done by an independent operator, the return on investment has been found to increase (at least slightly), and additional investment incentives emerge, because of higher workload, more flexibility and increased income opportunities [39]. Studies in Europe and the US have already demonstrated that the provision of a single service (e.g. kWh) is not sufficient to make storage schemes cost-effective; services such as frequency stabilisation and voltage stabilisation have a much higher commercial value [3]. Interestingly though, the Dutch DSOs, suggest that no large payments for flexibility should be expected from them, as generally, flexibility has “*relatively a limited scope and limited net benefits”* for the network operators [48] (p.39).

This statement illustrates the challenges around the market deployment of energy storage, which involves accessing and monetising multiple value streams, safeguarding that all parties involved can clearly see its value and pay accordingly for the benefits it offers [49]. While ownership models are fundamental for the deployment of energy storage, no consensus exists nowadays over the actors that should be given the ability to own and control storage devices. Yet, clear ownership rights are central for the owner/operator to evaluate the cost/revenue balance over the lifetime of the asset for one to be able to build a business case upfront for the asset’s construction [49]. If the estimated return is too low, uncertain, or spread across too many sources, the business case becomes unreliable, resulting in less attractive concept deployment [49].

Due to their access to information about electricity demand and supply, and their resulting ability to sell sufficient balancing and ancillary services at the optimal time, network operators are thought to be at the best position to optimise the use of storage technologies to balance the system (see also Table 2). However, although not substantiated by recent experience in Italy and Belgium, their involvement in owning and operating batteries brings concerns about a possible distortion of the competition in the generation and supply markets [49].

Actually, under the current energy law in the Netherlands, the use of energy storage by a DSO is merely permitted if the installation is only used by the DSO itself: no shared use is allowed. Connecting a battery to a solar PV and deploying it in an energy market violates the Group Prohibition (Article 10b of the Electricity Act) and the Prohibition of Competition (Article 17, first paragraph, E-Law) [51].

The recently adopted at EU level Clean Energy package (which was under negotiation during the period of the placement in the network operator) prohibits the DSO to own, develop, manage or operate energy storage facilities, unless specific conditions are fulfilled (see Table 3).

Instead, the Directive clarifies that third parties are the preferred actors to own, develop, operate and manage energy storage, as long as they can do it timely and in a cost-effective manner. Additionally, the Directive clarifies that consumers and citizen energy initiatives should be able to consume, to store, and to sell self-generated electricity to the market, and to participate in all electricity markets by providing flexibility to the system. For the system’s operational security, Transmission System Operators (TSOs) are urged to procure balancing services subject to transparent, non-discriminatory and market-based procedures. And in fact, the Directive also underlines that regulatory authorities and TSOs should establish the technical requirements for participation in those markets in close cooperation with all market participants.

4. The neighbourhood battery from different perspectives

4.1. Case description

Between the first quarter of 2017 and the end of 2018, a pilot neighbourhood battery with a capacity of 140kWh (125 kW inverter), was tested on 280 solar panels installed on a social housing project by Tegenstroom, an ESCO initiated by Haarlemmermeer municipality. Liander has not made the information on the undertaken investment costs for the battery available to the public[2].

The pilot allowed DSO Liander to study the battery’s behaviour and

[2] Nonetheless, national media suggest a cost of about €100.000: https://www.volkskrant.nl/nieuws-achtergrond/met-zijn-allen-aan-de-buurtbatterij-huurders-experimenteren-met-lokale-stroomopslag~b64da337/.

Table 1
Different configurations of community energy storage system (Adapted from [5]).

Storage type	Description
Shared residential energy storage	Network of residential energy storage of size up to 20 kWh installed behind the meter and EV batteries in consumer premises which can be shared among the community members of a specific location via the local physical grid.
Shared local energy storage	Energy storage of size tens to hundreds of kWh installed in front of the meter and behind the transformer in the local neighbourhoods with community ownership and governance as well as shared via the local physical grid.
Shared virtual energy storage	Network of decentralised stationary and mobility-oriented energy storage installed at different locations with independent ownership and governance which can be aggregated and virtually shared at national and international level via the main grid based on the market design and regulation. The size of the individual energy storage units is identical to that of residential energy storage or local energy storage. The range of virtual energy storage depends on the capability of the digital networking platform.

the reaction of the network. In parallel, 35 customers of Tegenstroom (renting 8 solar PVs each) were offered to maximise their self-consumption, as their excess electricity was stored in the battery until needed; each of these participants got access to a capacity of 3kWh in the battery. During the pilot period, the project participants received a discount of about €15 per month on their cost of renting their solar panels from the ESCO (50%). The participants also got access to a HEMS appliance, which they could keep after the termination of the pilot. Liander owns the battery, its management system, and the land where the battery is located. Access to the energy-related data was arranged in coordination with Tegenstroom, and a company, which created the ICT-tool assisting end-users in optimising their self-consumption by increasing awareness about consumption behaviour.

Next, the main identified societal benefits and societal costs of the neighbourhood battery are summarised (4.2). Building on that, the system dimensions listed in 2.1 are used to describe the value architecture and the main barriers and opportunities that arise from the tensions between actors in the niche and those in the regime (4.3) and how these might translate into a CBM.

4.2. The values related to the neighbourhood battery concept

4.2.1. Societal benefits

Apart from the perspectives articulated by interviewees from Liander, and initiators of several Dutch REIs, this section also reports on how the end-users involved in the battery-project view possible societal benefits. Table 4 highlights the perspectives from both the grid operator and the interviewees from various REIs on benefits that potentially follow from the neighbourhood battery.

From the perspective of the network operator the societal benefits can be grouped in three categories: a) benefits for the DSO or, a public company; b) benefits for a commercial party, like an energy cooperative; and c) benefits for the end-users.

As for the network operator, the benefits mentioned involve the (possible) avoidance of a *future* problem for the DSO; in a system characterised by higher diffusion of renewables and increased energy consumption, flexibility is seen as valuable for grid support. Energy storage offers extra capacity that may be used for balancing possible congestion and for controlling voltage on the grid. Energy storage is thus expected to improve power quality. Thereby, it may allow Liander to either avoid or postpone the investment in cables for low-voltage systems. Liander interviewees argued that local energy storage in

Table 3
EU Policy landscape (Source: [52]).

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
on common rules for the internal market in electricity and amending Directive 2012/27/EU (recast) - Article 36: Ownership of storage facilities by distribution system operators

1. Distribution system operators shall not own, develop, manage or operate energy storage facilities.
2. By way of derogation from paragraph 1, Member States may allow distribution system operators to own, develop, manage or operate storage facilities, where they are fully integrated network components and the regulatory authority has granted its approval, or where all the following conditions are fulfilled:
   (a) other parties, following an open, transparent and non-discriminatory tendering procedure that is subject to review and approval by the regulatory authority have not been awarded a right to own, develop, manage or operate storage facilities, or could not deliver those services at a reasonable cost and in a timely manner;
   (b) such facilities are necessary for the distribution system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the distribution system and the facilities are not used to buy or sell electricity in the electricity markets; and
   (c) the regulatory authority has assessed the necessity of such derogation and has carried out an assessment of the tendering procedure, including the conditions of the tendering procedure, and has granted its approval.
3. The regulatory authorities shall perform, at regular intervals or at least every five years, a public consultation in order to assess the potential availability and interest in investing in such facilities. Where the public consultation as assessed by the regulatory authority, indicates that third parties are able to own, develop, operate or manage such facilities in a cost-effective manner, the regulatory authority shall ensure that the distribution system operators' activities in this regard are phased-out within 18 months. As part of the conditions of that procedure, regulatory authorities may allow the distribution system operators to receive reasonable compensation, in particular to recover the residual value of their investment in the energy storage facilities.
4. Paragraph 3 shall not apply to fully integrated network components or for the usual depreciation period of new battery storage facilities with a final investment decision until … [the date of entry into force of this Directive], provided that such battery storage facilities are:
   (d) connected to the grid at the latest two years thereafter;
   (e) integrated into the distribution system;
   (f) used only for the reactive instantaneous restoration of network security in the case of network contingencies where such restoration measure starts immediately and ends when regular re-dispatch can solve the issue; and
   (g) not used to buy or sell electricity in the electricity markets, including balancing.

Table 2
Proposed business model specifications for DNO ownership and operation of storage assets (Source: [50]).

Model	Description
DNO contracted	The Distribution Network Operator (DNO) owns and has full operational control over the storage asset. Before the storage asset is built, long-term contracts are agreed for the asset's commercial control in certain periods of time.
Contracted services	The DNO offers long-term contracts for services at specific locations with commercial control in certain periods of time.
Charging incentives	The DNO sets the DUoS tariff to create signals that incentivise peak shaving to reflect the value of network reinforcement.
DNO merchant	The DNO owns and has full operational control over the storage asset.
'DSO' role	The DNO owns and has full operational control over the storage asset. In addition, the DNO is given a regulatory role in balancing and controlling aggregated demand and generation, taking on an active role as a Distribution System Operator (DSO).

Table 4
Identified societal benefits of (local) energy storage.

Network operator perspective	Renewable energy initiatives perspective
Energy security	Energy transition support and acceleration
Power quality	Autonomy/ Independence
Improved connection with clients & public	Financial benefits
Financial advantages through energy markets access	Image
- Reduced energy cost (incl. tax) for end-users	
- Increased ROI for 3rd parties	
Autonomy/ Independence	Energy security
Social cohesion	Lower network costs
Energy awareness	
Relative benefits compared to household-level batteries	
Lower financial cost for network operator / Avoidance of investment for end-users	Higher efficiency
Less material	Higher cost-effectiveness
Higher efficiencies	Higher capacities
Less hassle for society	Easier for the network operator
Safer solution	Less administration required
No cost in residential space	

"stressed" areas is possibly a cheaper solution than grid reinforcement, provided that grid reinforcement will be needed anyway. Additionally, it was argued that the neighbourhood battery may also enable Liander to improve its relations with its clients and the public overall. Although the main advantage is possibly not observed by the end-users, the battery contributes to energy security and power quality, which is a public interest provided by the DSO.

As for the commercial party, in this case, the ESCO Tegenstroom, the value offered relates to the opportunity to enter the energy capacity- and frequency markets. The ESCO or the end-users engaged in decentralised renewable energy production can use the neighbourhood battery as an option to get involved in electricity trading. Access to the battery may also enable a precautionary stance against very low (or negative) prices for the energy generated.

For the end-user, benefits from the neighbourhood battery would relate to issues like increased energy autonomy, as they now use more of their "own" green electricity. Interviewees on the side of Liander also expect the battery to raise energy consciousness and social cohesion.

Liander interviewees also pointed out a number of relative benefits as compared to household-level batteries, such as lower costs for both network operator and end-users, less environmental impact by saving (scarce and expensive) materials, higher efficiencies, less hassle for the public as well as less impact on scarce public space.

Interviewees from several REIs expressed difficulties with articulating a community perspective. In general, they acknowledge that integration of energy storage into decentralised energy systems may offer several opportunities to local communities, like energy resilience or increased affordability [4]. Yet, since its diffusion in the Netherlands has been rather minor, their reactions offer general insights that are also ambiguous. From the REIs perspective, the principal value of energy storage would relate to supporting the energy transition. By securing the network, the initiatives would be encouraged to proceed with investing in renewable projects. Storage facilities are expected to function as a backbone to the sustainable energy system of the future since it will take away the "*what if the wind doesn't blow*" argument.

Being supportive of the *future* energy system, energy storage is also seen as crucial for materialising the initiatives' vision for energy autonomy, ownership and control. On a different note, although the REIs "*already have a good image*" (Initiative 3), the addition of a battery to their system is also thought as having a positive impact on their image.

Moreover, REIs expect financial benefits. Beyond being assisted to "stabilise" their energy price, with the addition of energy storage REIs are also enabled to take part in energy trading, which may increase their Return on Investment on renewable energy generation. REIs could engage in trading either through the energy utilities they currently collaborate with or on their own. Furthermore, the REIs anticipate that local energy storage will, eventually, result in lower network costs, which may result in lower energy bills for everyone. It was even suggested that members of local REIs would be "*willing to pay a bit more for using their own local energy*" (I2) that a battery would support.

As regards the neighbourhood battery vis-à-vis household batteries, the REIs interviewees prefer the former. They expect a neighbourhood battery to be more efficient, more cost-effective, offering more capacity, while also being "*better*" for the grid operator. Yet, in their opinion, its realisation requires quite some organisation. However, household-level energy storage would involve too little capacity and too much administration, which is a hassle for organisations dependent on working with volunteers.

Worth mentioning is that a survey carried out by Liander after the installation of the neighbourhood battery sheds some light on the ideas on values (societal benefits) identified by consumers involved in the battery project. A large majority, 84% of the respondents, expected to pay less for their energy, which could be related to the fact that they received a discount because of their participation in the battery project. Regarding their energy related behaviour, a large majority, 90%, mentioned that they monitor more often the production of their solar PVs. However, over two-third, 68%, did not take any additional energy-saving measures since. Lastly, contrary to the expectations of the network operator, the survey does not show evidence for a change in the interaction pattern between neighbours due to the battery project: 74% of the respondents pointed out not to engage in more discussions with other neighbours. We cannot conclude from this finding, as we do not have information with respect to the communication of the project and how it was presented in advance.

4.2.2. Societal costs

Table 5 gives an overview of the societal costs (disvalues) identified by interviewees from Liander and REIs.

The employees of Alliander mostly pinpointed to material issues related to technology and infrastructure. The information on the undertaken investment costs for the battery to store 140kWh is not public. Nonetheless, Alliander employees consider the battery concept as still "*pricy*" with unclear reduction of CO_2 emissions across the asset's lifecycle. Some interviewees also pointed to environmental costs related to battery storage, such as issues of waste, safety, the emission of soft low-frequency noise and, especially for the densely populated Dutch cities, the issue of scarce space. Aesthetics are also important, as an employee of the organisation pointed out that local governments do not want to sell their land to the organisation "*because they make it look ugly*" (Employee 7). Interestingly, interviewees pointed out that higher energy self-consumption would have the negative impact of a decline in tax income for the state, which will result in higher network costs for

Table 5
Identified societal costs of (local) energy storage.

Network operator perspective	Renewable energy initiatives perspective
Material costs	Material costs
Possible environmental damage due to the difficulty of recycling	Environmental damage due to the impossibility of recycling
Space & aesthetics	Space & Appearance costs
Loss of tax income for the state	Maintenance costs
Emission of soft low-frequency noise	Emission of soft low-frequency noise
Safety concerns	Safety concerns
"Socialisation of costs" at the local environment	Potential (societal) costs across value chain

the non-prosumers who do not share in the possible benefits of local energy storage.

The REIs interviewees mostly pointed to environmental costs, including the (perceived) impossibility of recycling batteries. The initiatives stress the importance of the overall quality of the batteries, in relation to both safety and characteristics such as capacity and speed to load and/or unload. They consider the environmental performance of the technology as crucial, together with the issue of maintenance. Some brought up the issue of social sustainability and the worrisome conditions in countries of extraction/production of the material of the batteries. The issue of noise was mentioned but considered of less importance.

When discussing social costs with the REIs interviewees, some were unable to mention any. One interviewee mentioned that in view of their goal for self-sufficiency, "*one important step is storage… so I can't think of any social costs*" (I2). Cost, nevertheless, functioned as a *silent* decisive factor, although not initially expressed, the current high costs of the technology was mentioned as a barrier for the development of local energy storage.

Interestingly, two opposing attitudes emerged concerning the decision-making process about community energy storage and its deployment by local REIs. While some of the interviewees suggested that the preferable solution should be decided by the people locally, others pointed that proper communication and adequate cost-benefit distribution among partners could address possible resistance by the locals on issues like aesthetics or noise.

4.3. Value architecture

Interviewees were asked about barriers and opportunities. Alliander's employees were also consulted about the strengths and weaknesses of their organisation and how they relate to the deployment of the neighbourhood battery. Then, interviewees were invited to share their ideas regarding the possibilities of deploying such a CBM.

4.3.1. Barriers

The first step in the architecture of value is to identify, for each of the distinguished system dimensions, the barriers for the deployment of the neighbourhood battery concept, as discussed by the employees of the network operator, and the interviewees from the REIs. Table 6 summarises our findings.

4.3.1.1. Policies & political power. For both the network operator and the REIS, the main barriers relate to the policy domain. The current legislation strongly restricts the competence of the DSO as regards ownership and operation of a local storage facility. REIs interviewees argued that the current net-metering ("Saldering") and tax relief regulations ("Postcoderoos") do not make energy storage an attractive solution for the end-user. This is because the end-users are exempted from paying energy tax over renewable energy which they have produced themselves on their rooftop or within their immediate living environment (postal code area arrangement). They uttered concerns since Dutch government has announced to repeal these regulations in the near future, whereas there is uncertainty as to whether they will be replaced by other measures enabling citizens to invest in "their own" renewable energy. However, the abolishment of current regulation would make it more attractive for citizens to invest in local energy storage. REIs interviewees also fear restrictive regulation and bureaucratic hassle, if they would have to apply for specific permits in case, they want to operate an energy storage facility in the future. In fact, for the neighbourhood battery itself, the newness of the concept made it quite difficult for Liander to acquire a permit from the municipality concerning the pilot. No rules exist for the civil servants responsible to make a decision.

4.3.1.2. Organisational logic & sector structure. Liander interviewees made some critical comments about the organisational weaknesses of the DSO vis-à-vis its ability to develop and support innovations. Used to pursue long-term investments with 40 years of assets cycles, Liander was depicted as cables "*cookies-factory*", lacking structure and people with the required expertise to pursue innovative storage options. The organisation would lack people with the technical skills necessary to manage battery safety and possible environmental risks, as well as the skills to interact with customers. More importantly, the interviews documented a certain gap between innovation and operation, explained by the lack of a supporting structure coupled with real incentives for the managers to embrace innovation; this was underlined as "*the biggest issue for this company*" (E8). Overall, the company is portrayed as too slow and bureaucratic, with a lack of ability to absorb changes in its daily operation.

When asked about the position of the neighbourhood battery on the X-curve and its significance for the transition, most of the interviewees placed the project on the experimentation phase, as the pilot specifically involves testing completely different technologies, which require

Table 6
Barriers, mentioned by interviewees, for the implementation of the neighbourhood battery.

	Network operator perspective	Renewable energy initiatives perspective
Policies & Political Power	- Legislation	- Lack of additional value (today) - Taxation issues - Permits issues
Organisational logic & Sector structure	- Vagueness in roles & responsibilities - Lack of social business case: financial transaction as a bottleneck - Uncertainty about energy price development - Difficulty of collaboration with local governments	- Uncertainty about roles & responsibilities (ownership, control, maintenance) - Unclear cost-benefit distribution (across value chain)
Knowledge base	- Lack of knowledge vis-à-vis the development of CBMs - Uncertainty about energy price development - Lack of / low societal interest - Limited consumer knowledge & associated concerns	- Lack of knowledge vis-à-vis batteries' maintenance - Lack of public awareness around energy
User practices	- Safety issues & Health concerns (radiation) - Consumer preference for household batteries - Privacy issues (linked to smart meter)	- Lack of space & place - Aesthetics
Cultural significance	- "Pricy technology" - "Ugly installations"	- "Ugly installations" - "Ethics issue" regarding social risks in countries of production - Lack of full control of energy delivery
Technology & Infrastructure	- Relative high financial cost - Lack of / ambiguous CO2 reduction potential across life-cycle	- Low cost/benefit ratio - Lack of full control of energy delivery - Emission of low-frequency noise

different ways of thinking and organising around the societal function of energy provision. Some interviewees argued that the project is slowly moving to the acceleration phase, which involves the emergence of new networks and partnerships. For some others though, the neighbourhood battery fitted under the optimisation phase, as the network operator is thought to only be using the concept to improve its own position and the processes that it is already involved in. Lastly, it has also been argued that the neighbourhood battery concept cuts simultaneously across both the experimentation and the optimisation phase: it is a new technology and overall process that, under certain conditions, may still support Alliander in its main purposes.

The lack of transparency, connected to the organisational culture, has also been pointed as critical for hampering the development of innovations like the neighbourhood battery. Liander interviewees mention that their company is scared of sharing information with the outside world, possibly because of the need to maintain the image of a "*very very reliable grid*" (E9). The focus on security and reliability, in turn, results in a lack of attitude for collaborative problem solving with the participation of other stakeholders.

It was suggested that the company is able to collaborate with other actors only when the latter follow the company's plans and ideas. For this, Liander does not necessarily want to own the battery, but it has to be in control in order to avoid possible system failures. As argued, the organisation's role is to maintain the network "*stable and trustworthy*", and thus, giving market parties access to the battery to trade could only be possible, if this would not obstruct its core business. Some interviewees pointed out that not being involved in the business of managing rage facility would be preferable as long as the grid operator will "*make the rules so that the third party can come and do it*" (E9). Thus, instead of collaboratively designing and carrying out a shared value creation for local energy storage, the ideal situation for the network operator would be: "*we will collaborate, but we will tell you what to do*" (E9). Interviewees add that the organisation appears to lack a clear vision on local energy storage and, because of this, might face difficulties in designing the guiding principles necessary for coordinating its different departments in the deployment of innovation projects like the neighbourhood battery.

From the discussion above it follows, that for the Alliander interviewees, while the organisation is considered to have the "intention to collaborate with a third party", collaboration might undermine Liander's main task to maintain full network stability. Its specific problem-solving capacities may, therefore, become inhibiting for the development of a CBM for local energy storage if the organisation wants to top-down set the rules of the game.

For them, a second barrier follows from this. For the deployment of the neighbourhood battery concept there is much uncertainty with respect to the future roles and responsibilities of the actors involved. This directly relates to the lack of clarity around the financial transactions involved in the (still) lacking social business case. The divided ownership and control, and the question who has the right for a "first ride" on the asset are in conflict with the focus of the network operator on complete control of system assets for full network stability.

The uncertainty about roles and responsibilities is also central for the local REIs, who are supposed to operate as a third party. Who owns, who controls and who maintains the battery system? Financing such a concept that involves different partners is seen as very complex and the lack of relevant knowledge is evident. Crucial for the REIs is also the overall cost-benefit distribution across the entire value chain: starting from the regions where delivering the raw materials for the battery to the specific location where the battery is going to be installed. On the latter, the interviewees from the local REIs argued that rational arguments combined with *sufficient* financial benefits will be necessary for the deployment of a CBM for the neighbourhood battery; it was suggested that "*anything that has to do with making the energy system better is interesting - as long as there is a business case behind it*" (I5).

4.3.1.3. Knowledge base. Future technological breakthroughs that are potentially more efficient and financially preferable for the DSO and could outcompete decentralised energy storage through batteries were considered as possible threats. Linked to the technology, the consumer knowledge base was also seen as problematic for the deployment of the concept. Specifically, Alliander's employees focused on the existence of a low societal interest in the topic of energy storage, linked to issues about safety and health concerns (possible radiation), or privacy (regarding the smart meters connected to them). REIs interviewees pointed to lack of public knowledge by stating that "*people are not aware that nowadays we are using the grid as a big battery*" (I2&I5).

REIs interviewees also mentioned the maintenance cost of batteries due to lack of relevant expertise Other barriers related to the newness of the concept and the level of control of the battery and the technical unfeasibility to direct specific kWhs from a specific source to specific end-users, if this would be required.

4.3.1.4. User practices. When it comes to possible threats for the deployment of the neighbourhood battery, the people involved in the REIs pointed to low social acceptance because of "general mistrust in new technology", resulting from, for instance, malfunctioning or safety-risks. Furthermore, consumers could shift to private storage systems, if this would bring lower cost or getting off-grid. Also, the communication between Alliander and the consumer could provide a barrier.

4.3.1.5. Cultural significance and technology & infrastructure. A lot of statements cited above relate to the novelty of the technology. Many interviewees have argued that this will create uncertainties, but it has the potential to also affect the current culture within the three stakeholder groups involved. This is especially true for the grid operator, which was depicted as cables "*cookies-factory*", lacking structure as well as people with the required expertise to pursue innovative storage options. No doubt, that innovative storage options will bring about changes in the culture within the organisation of the network operator. In case of a CBM, the neighbourhood battery is expected to also change the culture in the energy system at large. REIs may need to expand their activities into the field of energy trading, which may provoke resistance within the energy communities as well as among end-users who may get involved into a new type of responsibility they have not chosen for. However, since REIs in the Netherlands are supposed to engage in partnerships with existing energy companies who can do the trading for them, the cultural shift may be less significant than it seems.

4.3.2. Opportunities

4.3.2.1. Policies & political power. From the network operator perspective, the main barriers for the future deployment of the concept of local energy storage relate to the policy domain, which is also supposed to offer a major a central opportunity. Interviewees expect that overcapacity on the grid will decrease by the closing down of coal-fired electricity plants, starting by 2020. A decrease in overcapacity will put pressure on the grid operator and energy companies with responsibility for grid management, to treat the electricity transported in a more economical way, which would be an incentive for expansion of storage capacity. These interviewees also pointed to the net-metering regulation and the energy tax relief scheme which are supposed to phase out after 2023, or significantly change by 2020. The general progress in the Energy transition also comprises an opportunity for the concept in itself, since the increased share of renewable energy may demand more batteries as the backbone of the electricity grid.

From the perspective of the REIs, the focus has been also on policy, specifically on the possible phasing out of the net-metering regulation and the energy tax relief scheme. Obviously, such measures would undermine the vulnerable BM of the REIs, but at this point, local energy storage presented by the neighbourhood battery could function as their

Guardian angel. After all, energy storage would enlarge their opportunity to benefit from their "own" locally produced electricity. Hence, together with the overall progress of the energy transition, the neighbourhood battery could emerge as a critical opportunity.

The policy framework for electricity storage, as discussed in Section 3, offers yet another opportunity for the REIs. Batteries comprise a tool for them to enter the energy trade market since grid operators trade is a no-go area. The REIs imagine that by managing the neighbourhood battery, their current suppliers or other commercial parties will enable them to benefit from energy trade. At the same time, they do not exclude the possibility of engaging in energy trading themselves, transitioning in parallel towards becoming Programme Responsible Parties (PRPs)[3]. Therefore, the possible development of the REIs embodies another opportunity for the deployment of the concept.

4.3.2.2. Organisational logic. With its assets "*literally connected to society*" Alliander is portrayed as a pioneering and visionary organisation, with plenty of ideas, energy, funds, creativity and intention to work together with other actors. Its problem-solving capabilities and its knowledge and experience with managing energy systems were also mentioned as its crucial strength for the development of the battery. While some might see the network operator as being "*naughty*" and looking for the boundaries of the law, as pointed by one of its employees (E6), the organisation is actively involved in looking for solutions that support the energy transition. Yet, when the external environment allows, it is unclear whether the organisation would be able and willing to develop and maintain a project like the neighbourhood battery.

4.3.2.3. Technology & infrastructure. The majority of other opportunities raised by employees of the network operator relate to technology and infrastructure. The focus went on the expected decrease of the energy storage cost (only up to a level, since the neighbourhood battery competes with home batteries), or a possible increase of the market energy prices in the future. Technological developments such as the emergence of smaller and more efficient batteries (keeping in mind the competition with household energy storage), or social developments as the emergence of the need for energy independence while remaining on-grid, were also mentioned. The possibility of using the decentralised batteries for "*Bottom-up black start*" in case of emergency, was added as another opportunity. This refers to the use of energy storage to restore the system after a black-out [3] (p.33). Lastly, the black-out fear factor was thought as another opportunity for the deployment of energy storage; specifically, it was argued that a less stable system could actually function as a facilitator for the deployment of energy storage systems (E5).

4.3.3. Towards a collaborative business model for local energy storage?

The employees of the network operator did not elaborate on a CBM on local energy storage. As pointed out by one interviewee, this lack of a concrete idea about a possible CBM is due to the fact that the organisation is not interested in capitalising this market opportunity. Nonetheless, during the pilot phase, some exploratory discussions between Alliander and some REIs were taking place. It was suggested that the network operator would be more interested in designing the rules for a third party to come, organise, and operate the local energy storage.

On the other hand, the lack of concrete ideas from REIs on the possible influence of a neighbourhood battery (or, in fact, any other configuration of energy storage) on their BMs may be explained by their lack of experience on the topic. During the interviews, the REIs principally focused on the benefits that energy storage involves for them, namely the opportunity to increase their self-consumption, together with stabilising the financial return from it.

For some, the main advantage of the battery is that it would allow them to continue with their current project plans, leaving their BM structure intact. Conversely, others argued in favour of developing completely new BMs, focusing on making full use of the potential benefits that energy storage entails, such as the provision of ancillary services to the network operator.

Specifically, on the development of a CBM, some suggested, for instance, to only discharge the battery during off-peak hours. The saved costs from such services to the network operator could be then split between the DSO and the REIs, thereby allowing the latter to pay back the battery to the former and gain full ownership of it. Others pointed out that local energy storage could actually enable REIs such as renewable energy cooperatives or cooperation between them, to become PRPs. While the former proposition involves the assumption that the battery is (initially) owned by the network operator, the assumption behind the latter proposition is that the ownership and control of the battery belongs to the REIs. Most interviewees from REIs, nevertheless, questioned this idea regarding the acquisition of energy storage assets because the initiatives lack the required technical expertise, especially for their maintenance.

The explorative interviews suggest that the concept of the neighbourhood battery could be a competitive energy storage option for local REIs, with or without the involvement of a third party for the ownership of the battery. Yet, while the higher capacity and efficiency it offers, also translating in better cost-effectiveness, are considered desirable, the REIs approached expressed the impression that more effort would be necessary for the deployment of such a CBM and, thus, the need for proper communication and adequate cost-benefit distribution among the parties involved was stressed.

It worth noting that a report from DNV-GL Energy (2018) suggests that at the current prices of battery technology, the neighbourhood battery concept is feasible at specific locations [53]. It discusses a scenario where a technical need for congestion management, namely 10 MW power for 1.5 h, present during 15 identified peek-weeks, can be serviced by a Li-Ion neighbourhood battery (10 MW/25 MWh). It is suggested that with a cost of 350 €/kWh, a business case appears to be feasible, through the uncertain revenues from services to the grid. The report underlines the principal role of the DSO for the concept's implementation.

5. Contrasting perspectives on a collaborative business model

As the energy transition is accelerating, it is still largely unclear which pathways will be taken and how actors and elements from incumbent regimes and emerging niches will reconfigure towards future energy regimes. The case of the neighbourhood battery illustrates the tensions and uncertainties when niche and regime encounter each other, while they both seek for their own position. This is illustrated by the ambivalence among the interviewees from both DSO and the REIs with regards to all BM elements presented in Section 2. First of all, for a CBM clarity is required with respect to the values involved, and the cost-benefit distribution. In the case of the neighbourhood battery, this is far from self-evident. This section discusses and contrasts the different perspectives, thereby focusing on the implications of institutional constraints for the prospects of battery storage as social innovation.

Concerning the values involved, the employees of the DSO exhibited a wider perspective as compared to the interviewees from the REIs, as they mention issues of relevance for the DSO itself, third parties and the end-users. However, the most important benefits mentioned by Liander interviewees are not necessarily considered as such by others, as these values are also inherent to the current system, i.e. energy security and power quality. Still, the REIs interviewees acknowledge the (future)

[3] Program responsible parties develop and provide to the system operator programmes for production, transport and consumption of electricity. They are then expected to act in accordance with these programs and if they fail to do so they face penalties.

relevance of these values. The REIs interviewees comprehend that a more secure and cheaper network will help them realise values of their own, ranging from the feeling of energy autonomy to financial benefits, but it would not necessarily imply a new modus operandi for REIs themselves. Instead, the main values mentioned by both Liander employees and REIs imply a trade-off to be made by the grid operator between different means for carrying out its primary societal task, to maintain energy security in the most cost-effective way.

For a DSO like Liander, grid reinforcement would probably fit in best with its current organisational logic, lacking structure and people with the required expertise to pursue innovative storage options. A related barrier is that, for a neighbourhood battery, the DSO must collaborate with other parties in realizing a societal goal that by definition is the responsibility of the grid operator. Interestingly, institutional constraints imposed on the DSO by Dutch and European regulation[4] could provide a barrier for implementing small-scale battery storage options, because they would add significant organisational complexity to the grid operation task, producing uncertainties that could affect the system. With this in mind, a grid operator would be incentivised not to engage in battery storage activities, even if this would prove to be a more cost-effective option than grid reinforcement.

As regards the disvalues of neighbourhood battery storage, representatives of both REIs and Liander stressed sustainability issues of battery technology across the value chain, especially referring to the ecological and societal impact of mining and hazardous waste because of difficulty of recycling. Both also pointed to local environmental impacts, such as safety risks, low-frequency noise and loss of (urban) landscape quality because of battery containers.

All in all, although expectations concerning the neighbourhood battery slightly differ among the parties involved, we do not yet observe strong incentives for the grid operator to proceed with the neighbourhood battery. It is widely assumed that a neighbourhood battery comprises *relative* benefits for those who are currently considering options for energy storage already, household storage in particular. However, in case of inaction on the side of the grid operator, these benefits will not be materialised. Even more, there is a likelihood that in case of inaction practices will emerge outside the realm of DSO control that may negatively affect the system. So, the grid operator faces a dilemma: taking action may lead to uncertainties, challenges to the established organisational logic and loss of control because of the involvement of third parties, whereas inaction may, in the end, have an even worse impact.

Second, there is the related issue that grid operators, performing as public actors vis-a-vis market parties primarily driven by private interests, would like to leave a clear mark on the transition, but, instead, are faced with developments that decrease their weight. In the Netherlands, the privatization of former government (provinces, municipalities) owned energy companies, merging into big transnational companies, led at the beginning of the 21st century to regulation that forced the private companies to renounce their grid divisions, which had to remain public. Over the last 15 years, attempts of grid operators, Alliander in particular, to take a more proactive role have failed. REIs have welcomed the organisation as an ally in their struggle for energy independence. As was confirmed by some interviewees, the neighbourhood battery could provide an opportunity for the operator to manifest itself as a public player.

A CBM together with community energy initiatives for the Neighbourhood Battery would imply both a technological and a social innovation. To realise this, the possible conflict of interests of the grid operator and the REIs must be given attention. The latter requires negotiation of the cost-benefit distribution and clarification of the roles and responsibilities of the parties involved. The major institutional constraint thereby is that, under normal conditions, the grid operator is not allowed to manage the battery, since an important element in battery management is energy trading. Whereas grid operators are not allowed to trade, REIs are.

As mentioned by several interviewees, trading will enable REIs to strengthen their position in the energy transition and compensate for the loss of income that will follow from abandoning current tax reduction schemes in the Netherlands. It is not self-evident that REIs and their membership have a primary interest in trading, as their motivation may differ [54]. So-called self-consumption at neighbourhood level will, also in a situation with new regulation (net-billing instead of net-metering), mean that no tax has to be paid over the electricity that is consumed by the producer. Whereas a neighbourhood battery can mitigate the 'import' of electricity and the taxation costs for consumers, trading will tend to make this positive impact of the battery undone. Furthermore, the battery is meant to reduce network operation costs. If end-users through a cooperative would become owner or manager of the battery, they will provide services to the DSO and are expected to receive a payment in return; although this may look nice, it is anyway the end-users that pay for network costs. However, it can be argued that a neighbourhood battery contributes to mitigating network costs, as long as the electricity stored will be consumed by the local producers. Hence, even if there would be a business case for a neighbourhood battery, it is uncertain as to whether this will be a collaborative business case for DSO and end-users.

Our observations strengthen the need for absolute transparency with respect to the distribution of alleged costs and benefits of a neighbourhood battery. Both REIs and DSO need to be reflexive to connect the project to the developments occurring at the broader context of the energy transition and address institutional constraints taking into account the primary value of local energy storage. If the neighbourhood battery is an innovation meant to secure the integration of renewables into the transport system and adapt this system to the challenges created by the energy transition, energy trading may turn out unnecessary, even in conflict with the very purpose of the undertaking. At that point, objections against a strong involvement of the DSO may very well become irrelevant.

6. Discussion and conclusions

The purpose of this paper has been to examine the potential impact of the neighbourhood battery on the contribution of REIs to the Dutch energy transition, and the opportunities and constraints for developing a CBM around it. To this end, the different values (and disvalues) that the concept might create as well as a possible allocation among the stakeholders involved were investigated. In this, the dynamics between this innovation and the dominant regime were analysed, focusing on the barriers and opportunities for its implementation, and paying special attention to the role of the network operator therein.

Overall, concurring with other scholars (e.g. [4,5]), this paper provides evidence that the perceived benefits of the neighbourhood battery concept differ among the parties involved, and their expectations are not necessarily aligned. The interviews with the different stakeholders did not result in the discovery of such a CBM and only managed to map some preliminary ideas about it.

Even though the network operators are (in principle) not allowed to own and maintain storage facilities, their role in the deployment of a CBM for local energy storage is critical. Overall, transparency and clarity regarding the trade-offs that the organisation would be willing to make are crucial for establishing the trust necessary for the collaborative deployment of the neighbourhood battery. The network operator would need to prepare for this collaboration pursuing several changes in its organisational culture, structure and practices. The organisation would benefit from a shift beyond its "*cooperation intent*" culture towards a truly collaborative professional attitude, supported by the institutionalisation of the associated structures and practices (i.e. pilot units that do not dissolve without translating the acquired lessons in the soft and hard elements of the organisation).

[4] Through its transposition in the Dutch context in the coming future.

Given the current legislative framework that does not allow the DSO to own and maintain local energy storage facilities, one could expect that for the deployment of a BM that involves local energy storage, REIs will collaborate with specialised ESCOs acting as aggregators, and/or they will professionalise to the extent that they become aggregators. The ultimate effect of local energy storage, such as a neighbourhood battery, on the energy transition and the impact REIs will be determined by the broader conditions on a multitude of system dimensions. In some dimensions, the collaboration with the DSO is critical, and in others, the support from other regime actors would be necessary.

The introduced Clean Energy package (2019), which was under negotiation at the time of the research, provides the rights for consumers and citizen energy initiatives to consume, store, and sell their self-generated electricity while giving them access to all electricity markets [52]. This regulation may catalyse the deployment of the neighbourhood battery concept, yet its real impact will only be visible after its transposition by the Dutch regulator (due in June 2021). Mechanisms as net-metering may have contributed towards the uptake of solar PVs but are counter-productive for the adoption of energy storage; the speed of its deployment depends on their phase-out. Local energy storage might benefit from new legislation and tariffs structures, such as time-of-use tariffs and location-based net-metering [5]. The ownership model of the local grid also affects the uptake of local energy storage and its operation [5].

The possibility of active participation of the "user" in the energy system and market directly at the level of consumer, where one is able to choose whether to use, store, share or trade the locally generated electricity will be critical for the deployment of local energy storage. In fact, this comprises the major change at the level of consumer practices, together with the requirement for coordination among all the actors involved. Digitalisation will also help facilitate the ease of market participation for electricity consumers as well as renewable energy communities. The establishment of a neighbourhood battery would also require the provision of information to increase awareness, reduce risk perceptions and ease concerns. Especially the use of blockchain-based technologies, may facilitate peer-to-peer exchange bringing trust and security for those involved while creating legitimate or less legitimate concerns for those who are not part of the system. The emergence of local energy storage depends on the maturation process, which also involves the social shaping of the concept [5].

The interplay between all these factors will determine the emergence of local energy storage and the value that REIs can gain through it. The coordination between the different stakeholders can result in new CBMs entailing new roles and responsibilities for those involved. Therefore, depending on the particular BM established, the collaboration between REIs and the DSO could help increase the initiatives' impact. In a model where the battery is owned and managed by a third party, for instance, a party which takes the responsibility of developing the HEMS, along with the access in the flexibility market, the collaborating REIs could benefit from the local balancing of their intermitted renewables, which may enable them to optimise their energy use [50] by limiting curtailment of energy; the DNV-GL report distinguishes various possible products and services from the neighbourhood battery to various clients [53]. Moreover, community engagement and energy awareness might also increase, as end-users could become more active in the energy field, reacting to the different incentives provided by the intermediary organisation (in accordance to the signals provided by the DSO). The involvement in such systems may also help end-users and REIs increase their knowledge about the energy system, thereby possibly also increasing their commitment to act as energy ambassadors for more renewable energy projects as well as more responsible energy consumption (see also [56]). At the same time, it is also possible that the introduction of storage systems and their combination with automation may result in bringing the user back to its passive status due to the total complexity.

To conclude, our contribution adds to the literature on SBM [9–13], regarding questions such as how and what values are created and shared among the different actors in sustainability-oriented CBMs, what challenges emerge in establishing these, and what is the role of such CBM in sustainability transitions. Our findings also shed light on the role of hybrid actors, like network operators, in the energy transition [7], and the niche-regime dynamics that play out in a predevelopment phase. Future research could examine how hybrid actors could be supported in facilitating sustainability transitions. Lastly, network operators like Alliander could be considered as "*regime-based transition intermediaries*" [55] as they are part of the established prevailed institutions yet inclined to work towards transformative change. From this perspective, future research could also explore the changes in intermediation over the course of transitions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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