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Public Transporter RET:
Taking a New and Sustainable Route in Rotterdam

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11 SUSTAINABLE CITIES AND COMMUNITIES

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Introduction

Theo Konijnendijk, Coordinator of Innovation at the Department of Management and Development at the Rotterdamse Electrische Tram (RET), was observing the city from his office in Rotterdam, Netherlands, and saw how many buses, trams and metros drove on and off. Soon, the outlook of the city might be totally different, he realised. It was the summer of 2017 and RET, the incumbent public transport company which had been an integral part of Rotterdam for more than 150 years, had been competing with other companies for the concession of public transportation in Rotterdam for the period 2019-2034. RET's concession was renewed and RET had promised three conditions in the course of the bidding: RET would use cleaner buses, offer market-based prices, and introduce innovations to increase customer satisfaction.[1]

Earlier in 2017, the Dutch government had decided that only electric buses could be purchased from 2025 onwards, due to the adverse effects of diesel buses on the environment. Carbon emissions and local air pollution needed to be decreased.[2] After 2030, diesel buses would no longer be allowed in the city of Rotterdam.[3] For the sake of the public transport concession in Rotterdam and Rotterdam becoming a more sustainable city, RET aimed for zero carbon emissions of its entire bus fleet in 2030, by transitioning from (highly efficient) fossil fuel buses to fully electric or hydro-electric vehicles in 2030.[4]

Although RET's board and management felt confident in its course of action with this concession and the transition to zero-emission buses, major challenges were arising for RET: the company needed a business plan for electric buses; the company needed to change its infrastructure to suit electric buses; the company needed to consider IT systems, communication, service and aftersales in this context.[5] Especially the areas of infrastructure management (e.g. routes, scheduling) and financial costs (e.g. business case for electric buses, fluctuating electricity price) required great attention. Some of Konijnendijk's colleagues believed that transitioning to electric buses would lead the company into a financial abyss. [6] It would thus be important to demonstrate that embracing a zero-emission bus fleet could be beneficial for the company in the long-run.

This teaching case was written by Michelle van Koert under the supervision of Dr. Tobias Brandt. We would like to thank Theo Konijnendijk and Virgil Grot from RET and Tao Yue from RSM Case Development Centre for their input. We would also like to thank Pieter van den Berg and Ayman Abdelwahed from Rotterdam School of Management, Erasmus University.

This case is part of the RSM Sustainable Development Goals (SDGs) case series. It is based on field research and is written to provide material for class discussion rather than to illustrate either effective or ineffective handling of a management situation.

After the summer of 2017, a pilot with two Electric Hydrogen buses in Rotterdam would be carried out by RET, having a rapid change to electric buses as well as a more sustainable city region in mind.[7] In 2018, the first investments and financing of zero emission buses and the corresponding charging infrastructure would be RET's key focus points.[8] The clock was ticking for RET to become the first public transport company in the South part of the Dutch 'Randstad'[a] that successfully made a transition to a CO2-neutral bus fleet. All considerations needed to be taken into account for making the change to electric buses in Rotterdam, and finalise a plan for RET to make this transition. How could RET make the switch to electric buses? Which pathway should RET take to contribute to Rotterdam being a more sustainable city? And what would be the impact of this transition?

Industry Overview

In the European Union (EU), buses and coaches made up 8% of the passenger transport on land, which represented approximately 525.5 billion passenger-kilometres per year.[9] From the public transport sector, 55% consisted of buses, which made bus transport the most widely-used form of public transport in rural and suburban areas, and cities, in the EU.[10] In 2016, 892,861 buses were in circulation on Europe's roads and 40,380 new buses were registered throughout the EU. Factors that influenced the attractiveness of public transport included ease of access and use, value-for-money, reliability and punctuality, cleanliness, comfort, and level of service.[11] Additionally, buses vitally contributed to tourism and had the lowest carbon footprint per passenger compared to other forms of motorised transport.[12] The transport sector, however, experienced several issues with fuel, including the security of supply and varying costs of fuel, as well as sourcing green and locally.

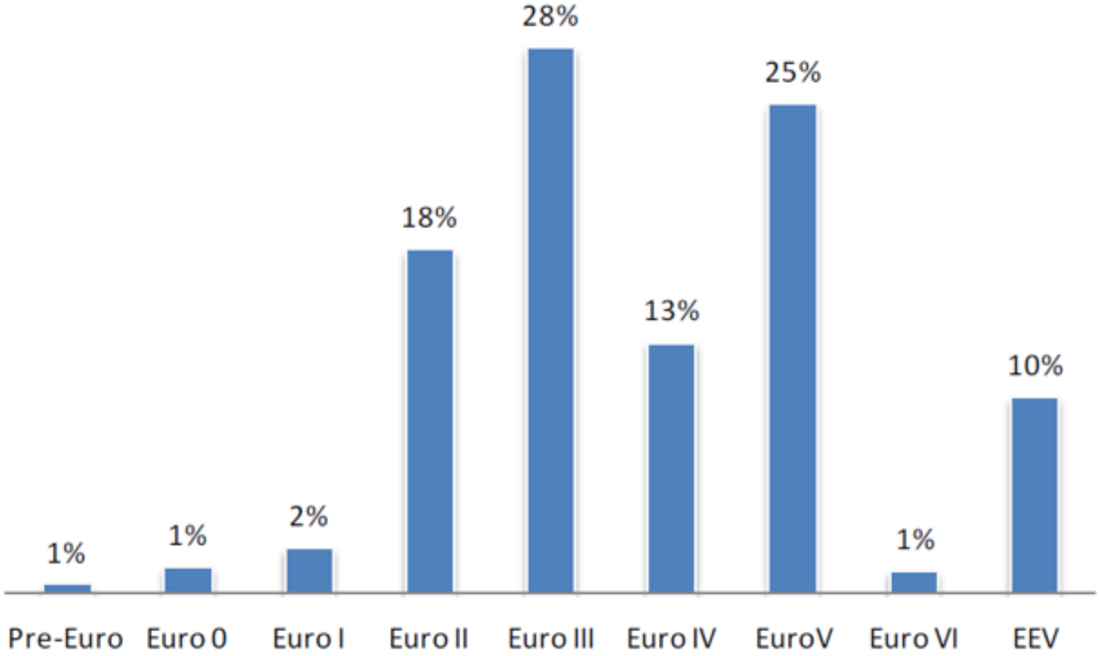
Although buses were considered to be the most cost-efficient and flexible form of public transport in 2017 and the sector had reduced CO2 emissions,[13] bus transportation still suffered a negative reputation with regards to environmental issues and politicians started calling for 'clean bus fleets' composed of electric and alternatively fueled buses. The largest share of the buses in the EU still ran on fossil fuels[14], while only 2% of the total bus fleet consisted of vehicles with alternative fuels. Since the average age of an EU bus was over 9.4 years,[15] almost 50% of the buses in the EU were still Euro III and older (**Exhibit 1**) and thus emitted higher rates of pollutants (**Appendix A**). New experimental technologies, such as new generation bio fuels, bio waste, and hydrogen were emerging on top of already proven and reliable technologies for alternative fuels (e.g. bio gas, bio ethanol, bio diesel).[16] Introducing electric charging standards throughout the sector could optimise fleet operating costs as well as reduce the infrastructure costs.[17]

In the Netherlands, the landscape for transportation businesses was moving due to changing national and international agreements and regulations.[18] The public transport sector was privatised and public bus transport was decentralised with the

[a] The Randstad is the ring of urban areas in the western part of the Netherlands; an area that includes the four largest cities of the country (Amsterdam, Rotterdam, The Hague, and Utrecht). It has approximately 7 million inhabitants on a total population of 17 million in the Netherlands.

obligation of tender due to the Passenger Transport Act 2000 (Wp2000).[19] The practice of the privatised bus market was that competition would lead to innovation and more affordable technologies in the sector.[20] In addition, similar to the global trend of growing urban population and even faster growing urban geographical areas, public transportation companies needed to adapt to the growing Dutch cities and expand their routes.

Exhibit 1: Bus Fleet Breakdown by Euro Standards[b], from 6 European Countries (2015)



Source: International Association of Public Transport (UITP)[21]

The Netherlands was on the forefront of implementing regulations to combat climate change and commit to the Paris climate change agreement. In April 2016, 14 transport authorities in the Netherlands together with their State Secretary for Infrastructure and the Environment signed the 'Zero Emission Regional Public Transport by Bus' agreement, which stipulated that only buses without harmful exhaust emissions could be purchased after 2025, and that the energy used by these buses needed to be sustainably generated, which would make urban areas more sustainable. Various cities in the Netherlands outside the 'Randstad' urban ring area, including 's-Hertogenbosch, Eindhoven and Helmond, already used electric buses (**Appendix B**) and led the way for the 'Zero Emission Regional Public Transport by Bus' agreement in the Netherlands. Transport provider Hermes in North Brabant had the largest electric bus fleet in Europe, consisting of 43 electric buses. VDL and Ebusco were main suppliers of electric buses, as well as the Chinese company BYD.[22]

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[b] These Euro Standards indicate different norms for pollutants with regards to diesel buses in the EU. The first norms were introduced in 1992 (Euro I), and then Euro II (1996), Euro III (2000), Euro IV (2005), and Euro V (2008). Pre-Euro is the least environmentally friendly type of diesel bus engine and Euro VI (since 2014) represents the most strict norms. 'EEV' represents electric vehicles and thus do not have diesel norms. The percentages are based on 3iBS project elaboration based on city and regional bus services in France, Italy, the Netherlands, Poland, Sweden and United Kingdom.

About RET

In 2017, RET was one of the largest public transport providers in the Netherlands for city operations, operating in the area of Rotterdam. RET had been a key public transport player in the Netherlands for almost 150 years (**Appendix C**). RET had a history of both private and public ownership. The private company was founded in 1878 and at that time, the company provided horse and steam trams for public transportation as well as electric trams from 1904 onwards. RET became a public-sector company between 1927 and 2007 due to the purchase by the municipality of Rotterdam. After World War II, bus- and tram lines rapidly expanded throughout Rotterdam. In 1968, RET introduced the first metro line in the Netherlands. In 2017, RET operated 58 bus lines, nine tram lines and five metro lines. The company owned 278 buses, 128 trams, 160 metros, as well as one fast ferry.[23]

Since 2007, RET was a public owned company. Since 2017, RET's shareholders were the Metropolitan Region Rotterdam The Hague (MRDH)[c] and the Rotterdam municipality.[24] On average, RET recouped 60% of its revenues from ticket sales and subscriptions; the national government covered the remaining 40% of RET's revenues. In 2017, the bus transportation was divided between the departments Bus Employees, Bus Operations, and Bus Materials.[25] RET had approximately 3500 employees and provided transport for approximately 600,000 travellers a day in that year.[26] RET ended the year with a positive result of €4.7 million after taxes and a growth of 4.5% in traveller's kilometres[d].

In April 2017, RET's CEO Maurice Unck highlighted a challenge for the company[e]: it needed to timely invest in new connections and higher frequency of RET's transport in order to maintain high quality reviews of RET's travellers, as well as to create innovative solutions in collaboration with the municipality, MRDH and other transport companies. In 2017, the growing travellers kilometres in combination with decreasing investments from MRDH from €673 million to €590 million over the period 2017-2026[27] and the net result dropping from €5.1 million in 2016 to €4.7 million in 2017 due to agreements between RET and the Metropolitan Region Rotterdam The Hague[f] highlighted the need of these investments. In the forthcoming years, the travelers kilometres were expected to increase even more since Rotterdam and its surrounding cities were planning to build 250,000 new houses in area.[28]

Since November 2016, RET's environmental focus had shifted from reducing CO2 globally to reducing local pollution.[29] Although RET had highlighted that public transportation was sustainable by definition, RET's public transport services needed to contribute to improve air quality, noise and other environmental problems in the large

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[c] The metropolitan area Rotterdam The Hague (MRDH) is a metropolitan area with 23 municipalities. With 2.3 million inhabitants, 1.2 million jobs and a 15% contribution to GNP, it is a large and important region in the Netherlands.
[d] Traveller's kilometres: the total amount of kilometres travelled by all RET travellers in a year.
[e] Maurice Unck has taken over the management of RET since 1 June 2017.
[f] This has to do with agreements between the RET and the client, the Metropolitan Region Rotterdam The Hague, where the RET within the new rail concession repays the surplus revenues at more than 2.5% passenger growth (in euros). In 2017 this was 600,000 euros.

and busy Rotterdam region.[30] Through the European project 'Ticket to Kyoto', RET aimed for more efficient energy use and reduced the emission of greenhouse gasses in its tram, metro, and bus networks throughout the city. For instance, RET installed motion sensors and refuelling stations for the metro network to increase efficient use of energy.[31] A concept for a refuelling station of an electric bus was also thought of (**Appendix D**). Before 2017, RET had thus already taken some measures to meet stringent environmental regulations. However, RET's trams and metros already ran on 100% green electricity sourced from a foreign hydropower plant in 2017,[32] whereas RET's bus fleet still mainly ran on fossil fuels in that year. The 2025 and 2030 goals banning and phasing out diesel vehicles were thus particularly important to RET.

Exhibit 2: RET's Plan for Transitioning to a Zero-Emission Bus Fleet

Source: Ruggedised[33]

In the new bus concession (2019-2034), RET planned to transition step-by-step to a 100% zero emission bus fleet in 2030. In 2020, 55 electric buses would be purchased; in 2022, 50 electric buses; in 2025 another 50 buses, and in 2030 the last 110 new electric buses (**Exhibit 2**). In 2017, the first two electric buses would be tested. Based on this pilot, further decisions would be made about the type of electric vehicles to use and how to adapt towards electric vehicles.[34] Charging stations for the first batch of 55 electric buses would be placed at Rotterdam Central Station, Schiedam, Vlaardingen and Zuidplein.[35]

Challenges in the Transition

RET faced four main challenges with regards to making the transition to electric buses by 2030. The challenges included bus costs, electricity supply, routes and scheduling, and emission reduction.

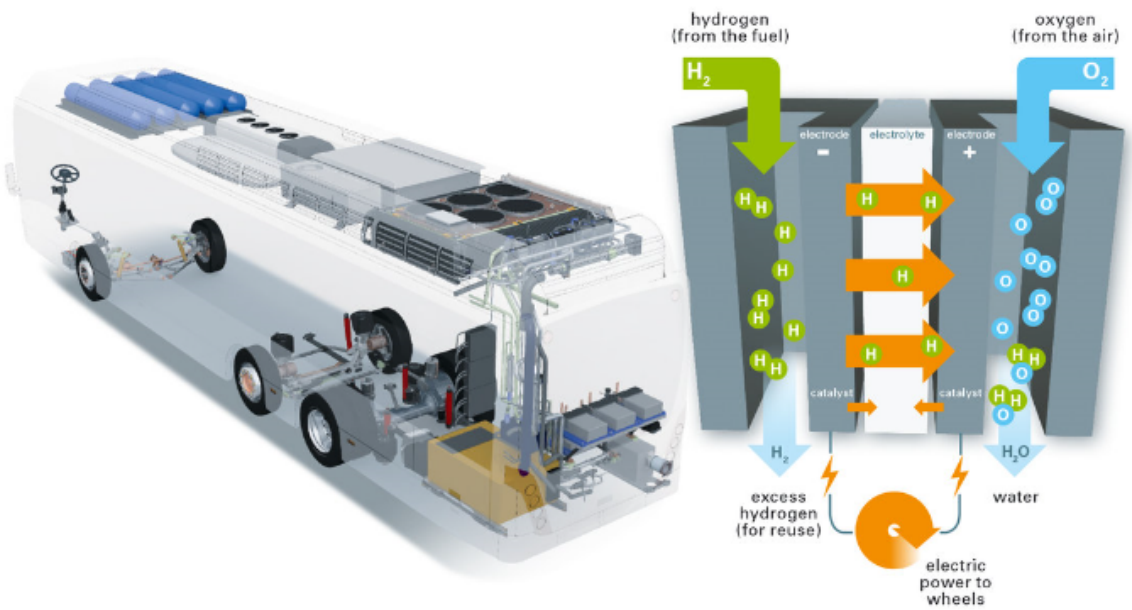
The costs of going green

The move towards a full zero emissions electric bus fleet needed to be affordable and cost efficient. Purchasing an electric bus presents an immediate cost 2 to 4 times higher than purchasing a conventional diesel bus.[36] In 2017 a battery-electric bus was approximately €245,000 to €310,000 more expensive than a diesel bus.[37] Replacing all the 268 vehicles at once would be financially impossible. RET's plan to replace its vehicles step-by-step allowed for ongoing rotational purchasing.

In addition to high purchasing costs, the lifecycle of existing batteries for electric buses were limited and the batteries were expensive to replace. It might take up to eight years for an electric bus to be profitable, although battery replacement might skew this estimate. Depending on the use of the bus, the assumed lifetime of an electric bus was 15 years, while RET needed to recoup its investments in the period until 2030. The lifetime for a dieselbus, in contrast, was considered to be 12 years. However, electric buses would save up on maintenance costs. Compared to diesel buses, electric buses did not require the various and regular inspections of the engine (**Appendix E**), and might save up to €880 per month.[38] Over time, the price of diesel buses compared to electric vehicles might be comparable, but the electric buses were expensive at the outset.

RET had different options for purchasing zero-emission buses, from electric to hydrogen fuel cell buses. For the pilot of the first two electric buses in Rotterdam, RET purchased the Van Hool A330 hydrogen fuel cell buses in 2016 (**Exhibit 3**).[39] However, the technology for electric buses was improving continuously. The highest quality electric buses purchased now might be outdated and cheaper in the future due to these technological developments (**Appendix F**). For example, a fuel cell bus in 2018 was approximately 40-50% cheaper than in 2010.[40]

Exhibit 3: Example Van Hool A339 Fuel Cell Bus[41]



Source: Van Hool

How to deal with fluctuating electricity supply?

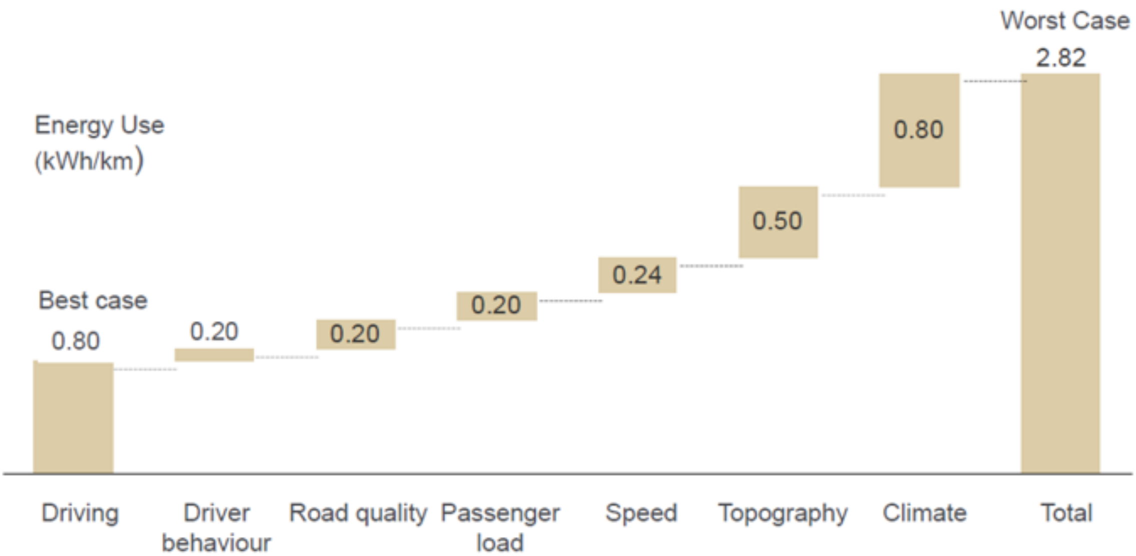
Another important consideration and challenge with regards to the transition to electric buses was the cost associated with electric energy, as well as the challenge to become as green as possible with electricity sourcing. In 2017, RET received all its electricity used for trams and metros from a Norwegian hydroelectric power plant, a green source of energy enabling a stable energy supply.

However, when the bus fleet would transition to use electricity, RET's already large electricity consumption would increase considerably; dependence on the Norwegian power plant may be risky. In addition, RET preferred locally sourced energy over energy sourced from abroad.[42] Notably, the energy use for electric buses varied (and thus related costs), depending on several factors including the weather, charging practices, and duty cycle (**Exhibit 4**).[43]

In order to decrease energy use as much as possible, RET closely followed public debate about green energy and explored new local sources.[44] One of the ideas was to install loads of solar panels in the Southern part of Rotterdam on roofs of buildings and metro stations. The sourced electricity would then be stored in a DC battery and connected to loading poles to result in an electric DC battery grid (**Appendix G**).[45] Unlike diesel, however, the availability of green electricity from solar and wind power was more volatile due to changing weather conditions and the pricing of green energy was more complex and fluctuated on hourly bases.

Key challenges for RET with regards to electricity supply included the facilitation of a higher amount of electricity use and finding solutions to facilitate high peak demand from (local) sources, so that RET would have a stable and reliable energy supply for its electric buses.[46]

Exhibit 4: Power Consumption of Bus Routes



Source: Ruggedised[47]

No electric buses without new infrastructure

In addition to the cost of the electric buses and energy sourcing, there were further large, immediate investments in infrastructure and utilities required for the transition to electric buses in Rotterdam, including the instalment of recharging equipment along the bus routes. The most glaring disadvantage of the electric fleet would be the low battery range, with current electric vehicles having to recharge every 35-50 kilometers taking the available charging times into consideration.[48] While on-route charging might result in higher infrastructure costs to adapt current routes and scheduling, this would decrease battery costs due to the smaller batteries needed.[49] Worldwide, the share of electric buses compared to fossil fuel busses had been increasing and with improved battery technologies a paradigm shift from long-range electric vehicles towards fast charging (opportunity charging/OC) techniques started in Europe.

In addition, RET had to consider how to integrate the electric buses into the timetable and network of existing diesel buses without causing interruptions of service.[50] For a bus route that usually would take 25 minutes, a charging time of 3 to 4 minutes was needed for electric buses.[51] When a diesel bus would be late on a given route, it could use buffer time provided at the end of each round trip to start the next round on time. This may not be possible with the combination of electric buses and their schedules, as the electric bus would require all the currently available time to recharge. RET needed to take the charging requirements for electric buses into account with the bus routes and scheduling, as well as traffic demand.[52]

Closing the loop of greenhouse gasses

While the bus costs, energy supply, and the need to adapt infrastructure towards electric buses was crucial to consider, RET should not lose their vision out of sight: a 100% emission free bus fleet by 2030 and an improved environment in Rotterdam and surroundings. The International Association of Public Transport (UITP) argued that a 'clean' bus fleet would be one causing 'near-to-zero-emissions'.[53]

With regards to air quality however, older buses were known to emit so-called black carbon (**Appendix H**), a short-lived climate pollutant that had a warming impact 900-3200 times as much as carbon dioxide and also caused health issues.[54] For this reason, specific bus routes in Rotterdam needed special attention (**Exhibit 5**). RET foresaw a 20-25% reduction in the carbon footprint of RET's operations when diesel buses would be replaced by electric buses, as well as improved air quality in the Rotterdam city and region.[55] It was RET's challenge to replace the older diesel buses rather sooner than later.

In addition, different ways of measuring zero carbon emissions came into play. The 'tank-to-wheel' approach was commonly used in benchmarks, whereas the 'well-to-wheel'[9] approach was suggested to assess the full environmental impact of electric buses.[56] Among others, the battery (origin, production and disposal) and the origin of

[9] With the 'tank-to-wheel'-approach, climate impact is measured from the tank of the bus to the tank tail, while the 'well-to-wheel'-approach entails a broader and more inclusive look (e.g. considering how climate-friendly the fuel is generated and transported, instead of only looking at the climate-friendliness of the fuel within the bus itself).

the electricity mix, which varied per European country, should be considered for the CO2 balance of electric buses.[57]

Exhibit 5: Air Quality on RET's Bus Routes

Source: Ruggedised[58]

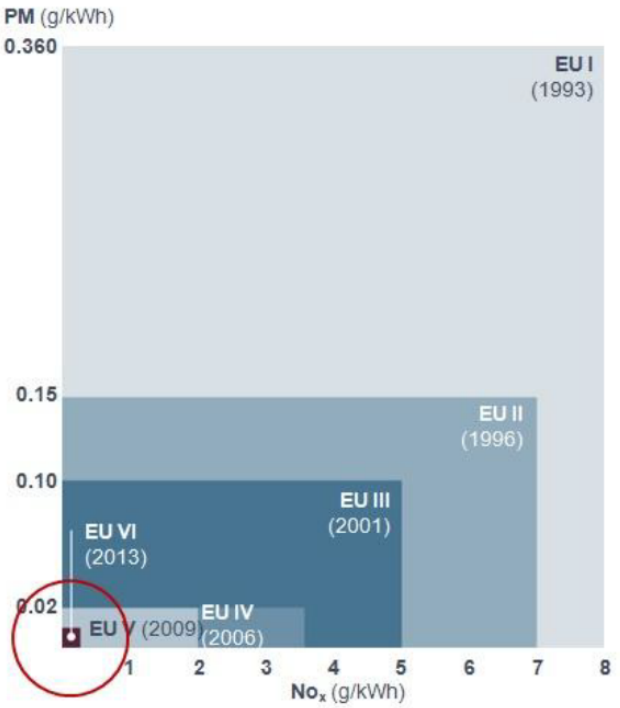
On the positive side, the energy consumption and CO2 emissions of RET's bus travellers significantly decreased between 2016 and 2017 (**Appendix I**). In addition, public transport was, anyway, a way of transport that generally reduces resources used in transport (**Appendix J**). According to the UITP, the "purchase of more alternatively-fuelled or electric buses should not lead to a reduction of overall service due to budgetary restraints. Instead, the key strategy to reduce CO2 emissions in cities should be to make more people shift from individual to public transport".[59] For instance, subsidies encouraging the use of public transport in combination with using alternatively-fuelled buses in Vienna led to an increase of the modal share of public transport to 39% and a decrease of CO2 emissions related to transport of six per cent.[60]

Putting the Puzzle Pieces Together

RET stood before a challenging decision-making process that would influence the company's future as well as the future of Rotterdam as a sustainable city. RET had become more efficient and sustainable in its use of energy for metros and trams in Rotterdam, but now it was the turn for the bus fleet to become more environmentally friendly. The bus concession, in which RET had promised a cleaner bus fleet, would start in 2019 and the first investments needed to be carried out soon (e.g. which bus, what infrastructure and energy sources). On top of that, the public policy agreement on zero emissions with regards to bus transportation in 2030, posed an increased need for the transition to electric buses. The question was: how?

While Theo Konijnendijk looked towards the Erasmus Bridge that connected the two parts of the city with each other, he realised that RET would need to come up with a solution that functioned as a bridge between all the different aspects of this transition to electric buses. How would RET compromise between a cleaner city and financial feasibility of the transition? Which buses should be purchased, and what infrastructure would make the transition feasible for the existing time schedules? And how could the energy supply be secured during peak hours while more energy was sourced locally?

Appendix A: Pollutants by EUR IV Standards in Comparison to Previous Euro Norms[61]



Appendix B: Bus Charging Operation Eindhoven[62]

Watch video: https://www.youtube.com/watch?v=nq5_yVXOu38

Appendix C: RET's History in a Timeline

1878
- horse trams
- steam trams

1906
- first electric tram
- 6 tram lines

1927
- RET's acquisition by municipality of Rotterdam

1930
- 7 bus lines
- 25 tram lines

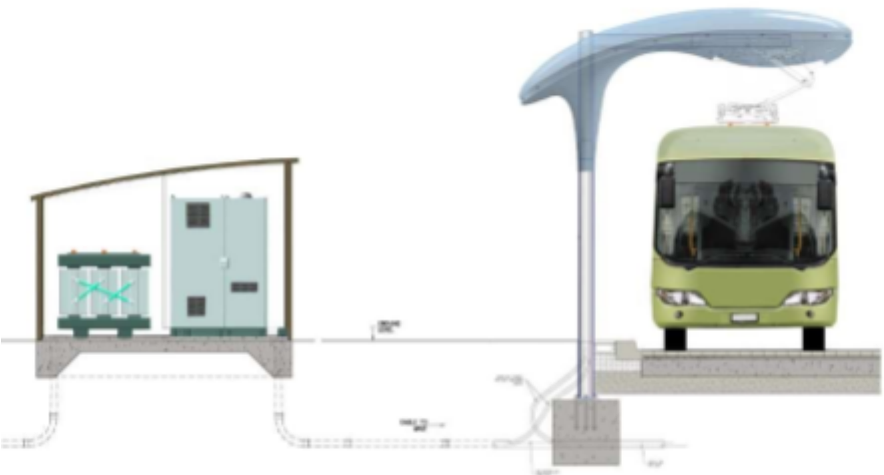
1940
- 11 bus lines
- decreased tram and bus transportation due to World War II

1968
- New: first metro line in the Netherlands, in Rotterdam

2008
- 2007: RET was privatised
- New: 1 Fast Ferry

2018
- 58 bus lines
- 9 tram lines
- 5 metro lines

Appendix D: Concept of an Electric Buses' Refuelling Station



Source: Ruggedised[63]

Appendix E: Maintenance Tasks not Required with Battery-Electric Bus

	Description	Preventive Maintenance Item	Component	Maintenance Interval	Applicability to Battery-Electric Bus
1	Replacement	Bearings	Alternator	2 years	Not required
2	Restriction Inspection	Air Filter	Engine	5000 km	Not required
3	Drain and Refill	Fluid and Filter	Engine	9500 km	Not required
4	Replacement	Primary Fuel Filter	Engine	10000 km	Not required
5	Replacement	Secondary Fuel Filter	Engine	24000 km	Not required
6	Inspection	Turbocharger	Engine	48000 km	Not required
7	Inspection	Vibration Damper	Engine	48000 km	Not required
8	Inspection / Replacement	Spark Plugs	Engine	72500 km	Not required
9	Inspection and Test	Ignition Coil	Engine	72500 km	Not required
10	Adjust	Valves	Engine	95000 km	Not required
11	Filter	Oil-Water Separator	Engine	2 years	Not required
12	Inspection	CNG Tank Vent Caps	Engine	6 months	Not required
13	Inspection	Oil-Water Separator	Engine	6 months	Not required
14	Replacement	Air Filter	Engine	As needed	Not required
15	Check Dipstick level	Fluid	Engine	Daily	Not required
16	Inspect	Crankcase Breather Tube	Engine	Daily	Not required
17	Drain and Inspection	CNG Fuel Filter	Engine	Daily	Not required
18	Inspection	Muffler	Engine	Daily	Not required
19	Inspection	Air Intake Piping	Engine	Daily	Not required
20	Inspection	Gas Leak Detectors	Engine	Monthly	Not required
21	Inspection	CNG Fuel Talks	Engine	Yearly	Not required
22	Inspect Breather, Mounting, Bolts, Oil Leaks	Various Conditions	Transmission	9500 km	Not required
23	Drain and Refill	Fluid	Transmission	120000 km	Not required
24	Change	Filter	Transmission	120000 km	Not required
25	Check Dipstick level	Fluid	Transmission	Daily	Not required

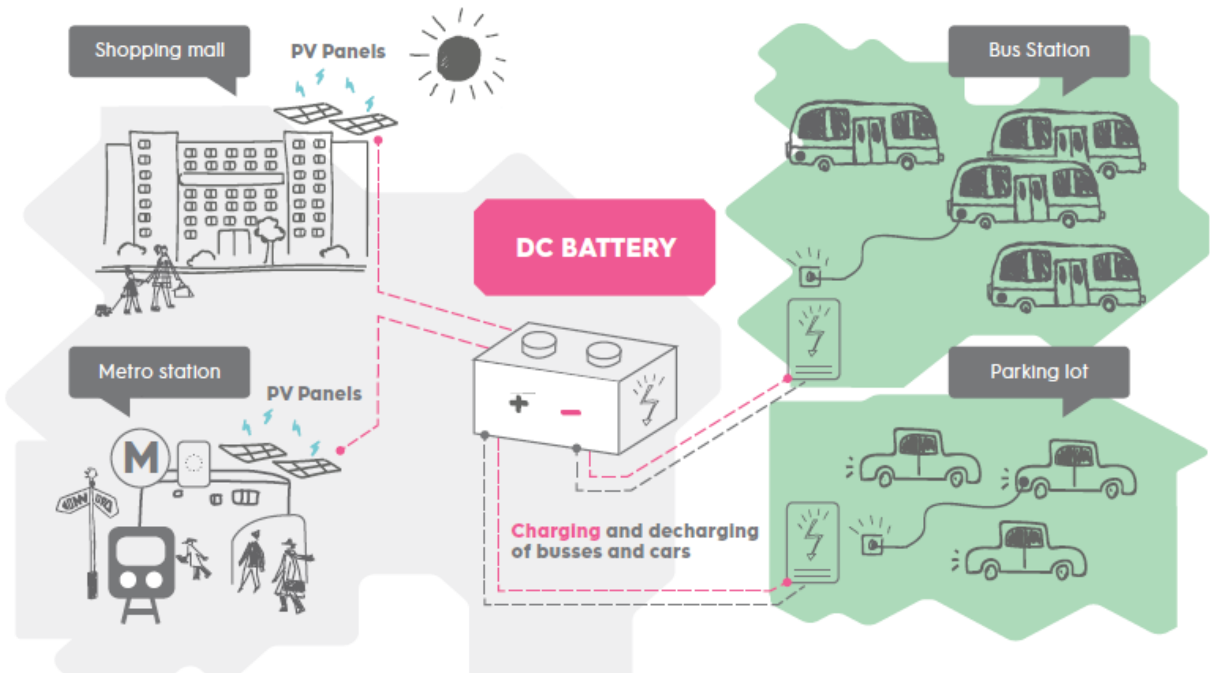
Source: adapted from The German Business Case[64]

Appendix F: Technological Development in Electric Buses' Batteries

	First generation Battery Electric Bus	Extended Range Next Generation Batteries	Fuel Cell Bus
Power	300 kWh	350 kWh	80 kWh, 38 kg hydrogen
Kilometres	200	290	480

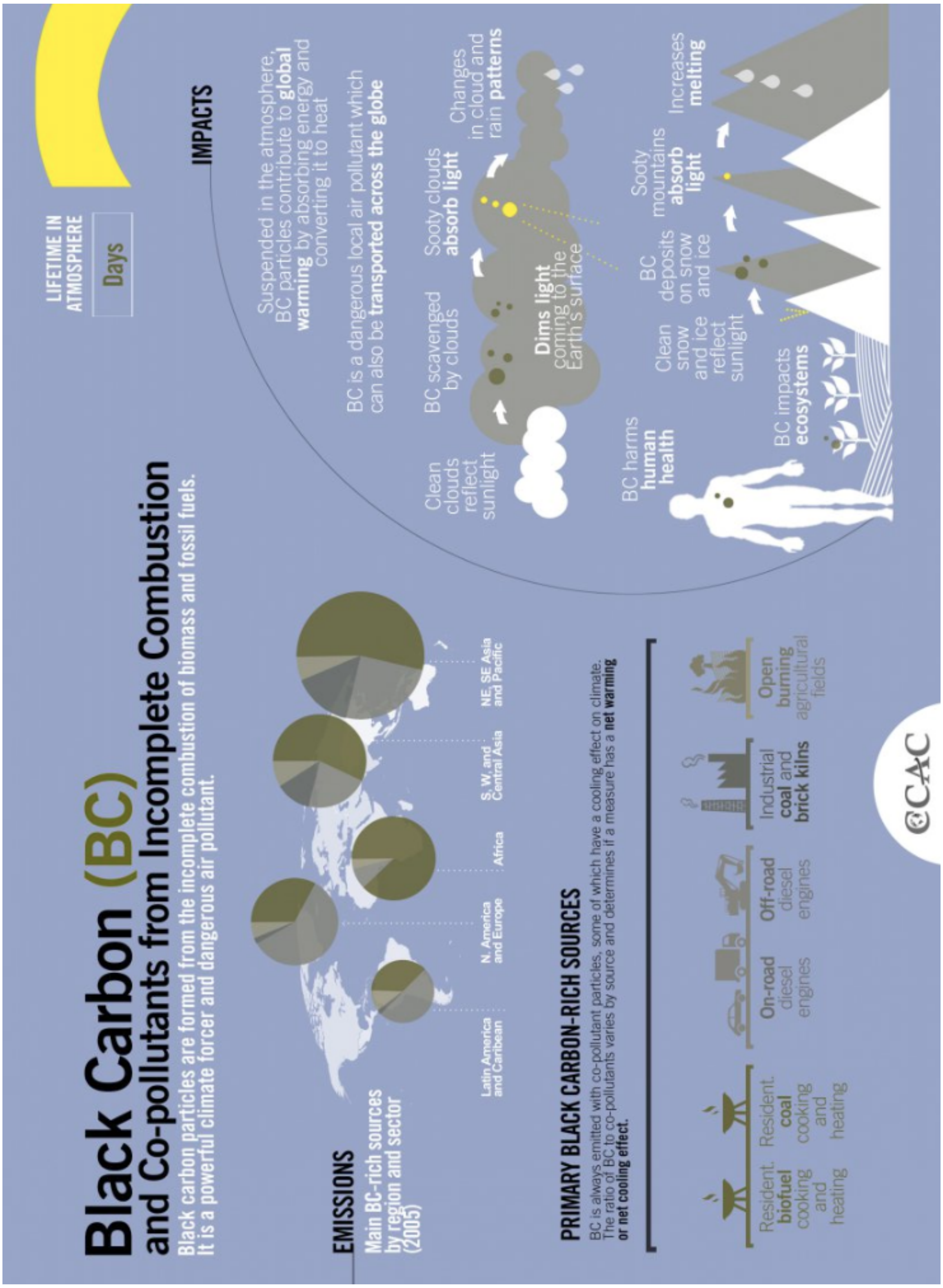
Source: adapted from The German Business Case[65]

Appendix G: Idea for Electric DC Grid



Source: Ruggedised[66]

Appendix H: Understanding Black Carbon



Source: Climate & Clean Air Coalition (CCAC)[67]

Appendix I: RET's Energy Consumption and CO2-emissions per Travelers' Kilometre, in 2016 and 2017

	Energy consumption (in kWh) 2016	Energy consumption (in kWh) 2017	CO2 emissions (in grams) 2016	CO2 emissions (in grams) 2017
Bus	0,55	0,47	181	154
Tram	0,18	0,17	97	91
Metro	0,13	0,13	69	68

Source: Adapted from RET's Annual Report 2018[68]

Both the reduction in energy consumption and CO2 emissions per traveller's kilometre were caused by an increase in total amount of travellers, while the change in electricity and diesel use remained relatively limited or even decreased from 2016 to 2017 (e.g. due to LED lighting, a more economical driving style and more efficient use of vehicles).

Appendix J: Resources Needed to Transport 10,000 People over 1 Kilometre

	# of passengers	# of vehicles	Space (m2)	Fuel (liters)
passenger car	5	2,000	24,000	200
8 m (midi)	25	400	8,500	120
12 m (standard)	100	100	3,200	50
18 m (articulated)	160	63	3,000	35
23 m (bus-train)	185	54	3,200	35
24 m (double-articulated)	200	50	3,000	26

Source: Volvo Bus Corporation, MAN Truck & Bus AG, and UITP Bus Committee © 2015

Endnotes

[1] Concessie Bus Rotterdam (2020-2034). (31 October 2018). OV in Nederland. Retrieved January 14, 2019, from http://wiki.ovinnederland.nl/wiki/Concessie_Bus_Rotterdam_(2020-2034)
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