

RUGGEDISED

Designing smart,
resilient cities for all

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Written By	Virgil Grot (RET)	2018-09-28
Checked by	Olivia Guerra-Santin (Uniresearch)	2018-10-31
Reviewed by	Laura McCaig and colleagues (Transport Scotland)	2018-10-19
Approved by	Klaus Kubeczko (AIT) - Innovation manager Albert Engels (ROT) – Coordinator Olivia Guerra-Santin (UNR) – Project manager	2018-10-31
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Project partners:

- 01 - GEMEENTE ROTTERDAM (ROT)- NL
- 02 - UMEA KOMMUN (UME) - SE
- 03 - GLASGOW CITY COUNCIL (GCC) - UK
- 04 - RISE RESEARCH INSTITUTES OF SWEDEN AB (RRI)- SE
- 05 - ISTITUTO DI STUDI PER L'INTEGRAZIONE DEI SISTEMI SC (ISSINOVA) - IT
- 06 - AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH (AIT) - AT
- 07 - NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO) - NL
- 08 - ICLEI EUROPEAN SECRETARIAT GMBH (ICLEI) - DE
- 09 - ERASMUS UNIVERSITEIT ROTTERDAM (EUR) - NL
- 10 - UMEA UNIVERSITET (UU) - SE
- 11 - UNIVERSITY OF STRATHCLYDE (US) - UK
- 12 - VYSOKE UCENI TECHNICKE V BRNE (UB) - CZ
- 13 - STATUTARNI MESTO BRNO (Brno) - CZ
- 14 - COMUNE DI PARMA (Parma) - IT
- 15 - URZAD MIEJSKI W GDANSKU (Gdansk) – PL
- 16 - Ballast Nedam Bouw & Ontwikkeling Holding B.V. (BN) - NL
- 17 - ROTTERDAMSE ELEKTRISCHE TRAM NV (RET) - NL
- 18 - ENECO ZAKELIJK BV (ENE) - NL
- 19 - Koninklijke KPN NV (KPN) - NL
- 20 - AKADEMISKA HUS AKTIEBOLAG (AHAB) - SE
- 21 - VASTERBOTTENS LANS LANDSTING (VCC) - SE
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- 23 - UMEA PARKERINGS AKTIEBOLAG (UPAB) - SE
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- 25 - SP POWER SYSTEMS LIMITED (SPPS) - UK
- 26 - TENNENT CALEDONIAN BREWERIES UK LIMITED (TCB) - UK
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- 28 - PICTEC (PIC) - PL
- 29 - UNIRESEARCH BV (UNR) BV – NL
- 30 - INFOMOBILITY SPA (INF) - IT
- 31 - FUTURE INSIGHT GROUP BV (FI) – NL
- 32 - THE GLASGOW HOUSING ASSOCIATION LIMITED IPS (WG) - UK
- 33 - GDANSKA INFRASTRUCTURA WODOCIAGOWO-KANALIZACYJNA SP ZOO (GIWK) - PL
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Executive summary

RET is concessionary for public transport in the city of Rotterdam and its periphery. Public transport is very important as it is an important way to travel for the citizens and the region also deals with air quality issues and congestion. It is necessary for RET and its public transport authority MRDH to introduce a significant number of zero emission buses in the coming years. After 2025 only new zero emission vehicles are allowed to be taken into operation in their region.

RET needs to renew its entire bus fleet for the new concession period starting in December 2019. The fleet has over 250 buses, mostly conventional fossil fuel buses, that need to be replaced by cleaner versions. The challenge RET faces is to introduce zero emission (e)-buses successfully on a large scale. At the time the RUGGEDISED proposal was drafted (2016), the aim was to start with 6 and grow up to 40 zero emission buses. Now over two years later RET has six so-called 'specials' running, which can operate in zero emission mode, consisting of four hybrid buses and two hydrogen buses. More importantly on 13 July 2018 the company has awarded a contract to purchase 55 to 105 fully electric buses from VDL. The actual contract was signed on 23 August 2018.

The introduction of the buses has been structured in six phases, of which the first four (ZERO 1 to ZERO 4) address the deployment and the introduction of 24 opportunity charging stations, 50 overnight charging stations and 265 battery electric buses. The phases ZERO 1 and ZERO 2 are relevant for RUGGEDISED and cover all overnight and opportunity charging stations and 105 electric uses.

Although the market for e-buses and charging infrastructure is maturing, there was still a strong wish to mitigate the risk of underperformance with more conventional technologies in the first phases of transition. Realizing opportunity charging infrastructure and overnight charging in the depots remains a challenge due to stakeholder demands and grid issues. Important recommendations at the moment is to take into account different technical performance scenarios and work with extra vehicles in the system, at least in the starting phases.



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1. Introduction

The Metropolitan Region Rotterdam The Hague (MRDH) is the public transport authority in the region in which the public transport company RET operates. RET is MRDH's concessionary for public transport in the city of Rotterdam and its periphery. For many citizens public passenger transport is essential to travel from home to work, for business and leisure purposes. Buses, metro, trams, railways and all other means of public transport in the region constitute key elements in the daily transport of persons. As the region also deals with air quality issues and congestion, public transport is also very important in that sense. On average public transport use has seen a continuous growth of more than 3 percent per year in the last ten years.

With other Dutch transport authorities, MRDH has developed a nation-wide concept for sustainable public transport. This includes the decision to introduce zero emission public transport on a large scale by 2025. The Dutch public transport authorities have signed an agreement to introduce about 5.000 zero emission public transport buses all over the Netherlands from 2025 to 2030. To effectively pursue this aim, it is necessary for MRDH and RET to introduce a significant number of zero emission buses in the coming years. After 2025 only new zero emission vehicles are allowed to be taken into operation in their region.

1.1 RET and its journey to zero emission bus transport

RET operates a multimodal public transport junction in the Heart of South, key area in the RUGGEDISED project. The route network in the south contains 2 metro lines, over 30 buslines and on a yearly basis over 12 million passengers use both metro and bus. Because RET sees itself as a socially responsible company it has the ambition and goals to make its public transport operation more sustainable. The past few years the company has done several pilot projects to see what type of zero emission buses were best suited for the local transport conditions in Rotterdam. Now the time has come that the company needs to renew its entire bus fleet for the new concession period starting in December 2019. The fleet consists of more than 250 buses mostly conventional fossil fuel buses that need to be replaced by cleaner versions.

1.2 Introduction zero emission buses

The challenge RET faces is to introduce zero emission (e)-buses successfully on a large scale. At the time the RUGGEDISED proposal was drafted (2016) the aim was to start with 6 and grow up to 40 zero emission buses. At the same time the reliability of service should be guaranteed at all times. We expected that battery-electric buses would form a significant part of the new bus fleet.

Now over two years later RET has six so-called 'specials' running, which can operate in zero emission mode, consisting of four hybrid buses and two hydrogen buses. More importantly on 13 July 2018 the company has awarded a contract to purchase 55 to 105 fully electric buses from VDL. The actual contract was signed on 23 August 2018.

Another important aspect of the introduction of the electric buses and of the RUGGEDISED project is that the reliability of ICT bus scheduling software had to become smarter. Planning a large number of e-buses introduces new variables that the current software cannot deal with. We are well on our way in the development of the special MINBUS planning software module for e-buses. RET has also started to simulate the effects on the logistic operations with help of the Erasmus University Rotterdam. In a PhD research project the university will help us to further explore the effects of the logistic variables and real time response capability.



Picture above: RET CEO and VDL directors sign the contract for the first 55 electric buses

The buses will start operation in Rotterdam, Schiedam and Vlaardingen in December 2019. This is the first step (20%) in the transition to a complete zero emission bus fleet.



Picture above: Prototype electric bus at Kick-off meeting at RET head office

2. Methods and results

RET has developed a strategy to systematically introduce zero emission buses in its transport network. The introduction of 55 battery electric buses, of the respective charging-infrastructure and of about 110 hybrid-buses is a first step towards the full implementation of complete zero emission public passenger transport in our network.

This introduction does not only affect Rotterdam, but also neighboring municipalities. It is also an example for other regions, for instance The Hague and the province South Holland. The 55 buses are in addition to the 6 special buses RET already has in operation.

2.1 Implementation plan

Figure 1 below shows the current RET implementation plan for a zero emission bus fleet. The introduction is structured in six phases, of which the first four (ZERO 1 to ZERO 4) address the deployment and the introduction of 24 opportunity charging stations, 50 overnight charging stations and 265 battery electric buses. Battery electric buses are buses that are driven by an electric motor and get their energy from onboard batteries. Opportunity charging means the buses will be charged rapidly at strategic points along the bus route. With overnight charging the batteries are charged more slowly overnight at the depot.

The phases ZERO 1 and ZERO 2 cover all overnight and opportunity charging stations and 105 electric buses. The first 74 charging stations mentioned above will be realised in the ZERO 1 and 2 phases. After these phases more charging points will be added gradually.

The phases ZERO 3 and ZERO 4 address the rollout of another 160 electric buses from 2025 to 2034. By 2030 the bus fleet will exclusively exist of battery electric buses.

In the meantime the phases 5 and 6 will support the transition from diesel to electric buses by complementing the electric bus fleet by 110 Hybrid buses and 40 EURO VI diesel-powered buses. This is necessary to ensure an optimal service should the electric buses not function as foreseen.



Figure 1 Timeline introduction zero emission buses RET - Rotterdam

2.2 Key objectives of the first transition phases

The first two phases of the full shift to electric buses are relevant for the RUGGEDISED project. Key objectives include the following:

- Initiation of the full shift from fossil to alternative fuels and power trains regarding public bus transport;
- The introduction of 105 electric buses covering the bus network between important nodes in the transport network, for example from Rotterdam The Hague Airport, via Central Station and Zuidplein (Heart of south station) to several destinations in the harbour (Waalhaven, Heijplaat / RDM Campus and Pernis);
- Expanding the emission free zones in the area of Rotterdam and beyond;
- Increased zero emission co-modality;
- Grid balancing via overnight chargers.

The following table summarizes the main outputs, outcomes and key performance indicators. A dedicated programme manager is in charge of the activities.

Output	Outcome	KPIs
105 BEBs	Covering the bus network between important nodes in the transport network.	<ul style="list-style-type: none"> ➤ Number of vehicles operating; ➤ Number of passengers transported; ➤ Kilometres travelled until 2025.
24 Opportunity Chargers	Charge on demand while operating	<ul style="list-style-type: none"> ➤ 24+50 chargers operating; ➤ Energy dispensed.
50 Overnight Chargers	Basic and regular charging is most economical	
Depot	Bus smart charging and overnight parking enabled	<ul style="list-style-type: none"> ➤ Number of charging sessions at the depot.
Energy management system	Most economic charging enabled	<ul style="list-style-type: none"> ➤ Number of successful charging sessions; ➤ Lower bus downtime.
Qualified staff	Staff is able to operate system and vehicles	<ul style="list-style-type: none"> ➤ Lower Bus downtime; ➤ Lower incident rate.

Figure 2 Results overview

2.3 Tendering process

The tender procedures for the e-buses and infrastructure were in line with European and Dutch legislation for public procurement. All supply, works and service items of the project are subject to tendering procedures described in directive 2014/25/EU on procurement of entities operation in water, energy, transport and postal services sectors. The tendering procedure started early 2017.

RET set up a team to prepare the procurement. The procurement department entrusted a dedicated senior procurement officer to lead the process alongside the programme manager. The officer was involved in the procurement of previous buses such as the hydrogen buses.

Other team members came from the departments Fleet management, Fleet Services, Strategy (R&O), Infrastructure management, Legal and Finance.

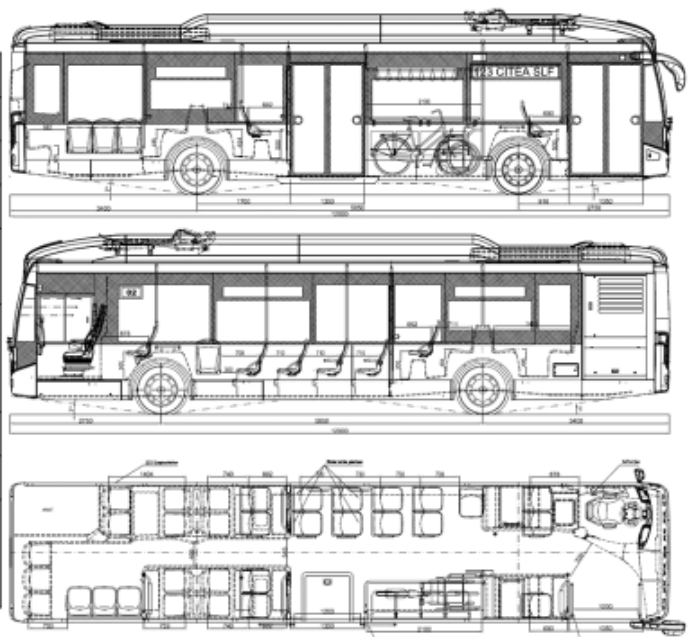
The procurement process contained the following phases:

	Phase	Description	Duration
0	Preparation	Combine all the information, team discussions and work on concluding the need assessment and specific requirements based on previous experience, studies and knowledge of relevant departments.	About 6 months in 2016 and 2017
1	Market consultation	European publication that RET will consult the market. RET uses this phase to fine tune its needs assessment and scope.	About 3 weeks in Q1 2018
2	Requirements / Terms of reference	Finalize requirements / Terms of Reference.	30 days Q1 2018
3	Pre-qualification and selection	Dialogue with possible suppliers / consortia and selection of the shortlist of possible suppliers.	2 weeks Q2 2018
4	Bidding phase	The exact requirements/Terms of Reference will be disclosed in a tender dossier for the remaining parties with information on what RET expects, how RET decides, planning of the remaining process etc. RET uses Commerce Hub to this effect.	45 days Q2 2018
5	Final phase / contracting	The offers of the parties will be received and assessed. Parties will be asked to make their best and final offers.	3 weeks Q3 2018

The contract was awarded to the Dutch company VDL and was signed on 23 August 2018 for the first 55 buses and charging infrastructure with an option for another 50 buses in 2021.

General specifications

Brand and Type	VDL Citea SLF-120E
LxBxH	12,0 x 2,55 x 3,39 mtr
Wheel base	5,850 mtr
Draaicirkel	21,176 mtr
Weight empty and max	13.540 en 19.400 kg
Capacity	32 chairs, 4 folding chairs, 37 standing places. Total 69 passengers
E-motor	153kW from Siemens
Battery pack	216kWh
Charing	Via pantograph on roof: 50kW in depot 300kW at fast charger



3. Discussion and Conclusions

You could argue that RET should introduce zero emission bus transport in one big bang and replace all buses in a shorter period of time. We have chosen to transform the entire fleet in phases and to guarantee service by keeping diesel and hybrid buses in operation in addition to the new battery electric buses. Although the market for e-buses and charging infrastructure is maturing, there was still a strong wish to mitigate the risk of underperformance with more conventional technologies in the first phases of transition. This is why we also use hybrid and diesel buses in addition to the 55 e-buses to replace 50 diesel buses. In the current approach we also keep the option open to work with other suppliers of buses and charging infrastructure in every new implementation phase starting from phase ZERO 2.

Furthermore relying on an opportunity charging network in addition to overnight charging could be viewed as a very expensive solution. It may not sufficiently utilise overnight low carbon electricity. RET acknowledges that this solution is more expensive than a solution that utilises overnight charging more. This was a deliberate choice. RET wants to charge the vehicles at central points in the network during break times of the drivers. The bus must be charged within 12 minutes and after which the bus can drive another 100 km or more. In addition to short breaks the drivers also have longer breaks at these central points after which they drive relatively long distances without charging opportunities (ca 200 km). Fast opportunity charging at central points with a large power output also adds flexibility to RET's operation. Occasional route changes or changes in schedules will be less of a problem with RET's charging solution.

With this approach we believe the technical risks are relatively low and mostly lie with the supplier. For instance the fast charging solution requires excellent thermal management and the use of innovative materials to accommodate in all weather conditions. The selected supplier are confident their products can manage the conditions in Rotterdam. The challenge RET faces now is to get the charging infrastructure in place in a relatively short period of time. Luckily we will use our own rail energy infrastructure to feed most of the charging points and where this is not possible the net operator does not foresee any problems. After procurement of the charging infrastructure, placing the equipment for opportunity charging at end stops of bus lines has proven to be a major challenge for us. Municipalities want to minimize visible charging installations in the open space. Pillars and equipment boxes have a large impact, both spatial and for connection to the grid. It takes time to find the exact spots where both the municipality and technicians can agree on.

4. Recommendations

Although we are still in the starting phase of implementation of the zero emission vehicles, there are some recommendations we could give to organisations with similar plans.

- Re-charging of the buses during service hours (opportunity charging) takes extra time compared to diesel powered buses that have energy available for the whole day. It is recommended to add extra vehicles into the system up to 10 percent. For RET 55 electric buses will replace 50 diesel vehicles, in order to provide the same level of service.
- Because the range of the buses directly relates to the energy consumption, it is recommended to calculate the range, number of charging spots and charging time needed

for different levels of energy consumption. For example for standard buses not only at 1,0 kWh/km, but also at 1,4 and 1,8 kWh/km, or even more.

- The adaptation of depots, for placing the overnight charging equipment, takes time and space. Be aware a temporary spot for overnight parking of the vehicles might be necessary.

5. Risk Register

In the table below we have indicated some of the important risks we took into account for the introduction of zero emission buses. This is hardly a complete summary, but gives an indication of issues that might occur during the implementation proces.

Risk	What is the risk	Level of risk	Solutions to overcome the risk
	Early choices versus (not yet) existing standards	high	System phase ZERO 1 will run on its own; systems ZERO 2, 3 and 4 will adapt existing standards.
	Charging spots not be accepted nor available on time	low	Communicate early with neighbours and municipalities of bus end stops, to avoid “not in my backyard” approach. Pay extra attention to advantages of zero emission versus Diesel emissions.
	Early choices no longer sufficient because of technical developments	medium	Approach foresees introduction in batches, so developments can be adapted in second and further batches.

6. References

- REMETBUS2 Connecting Europe Facility project:
<https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2017-nl-tm-0060-w>

7. Acknowledgment

- RET project team implementation zero emission bus transport
- Theo Konijnendijk – coordinator innovation and product development RET

Appendix List

none



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