D13.4
Gothenburg: Demonstration Results

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SUMMARY SHEET

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Abstract	The Gothenburg demonstration team was committed to implement and test three technological innovations (TIs) within EBSF_2, namely: • New energy-efficient heating solution for electric buses (TIGot1); • Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2); • Attractiveness of innovative bus stop (incl. indoor) and interaction between bus and bus stop design (TIGot3) The first section of this report describes the demo site and the technical innovations that have been developed and tested. The second part describes the test set up, the data collection and analyses, while the third part describes the results obtained. EBSF_2 tests have shown that the electric buses and re-designed bus stops are very popular among the travellers as well as the bus drivers. Perhaps equally as important the activities have shown that the electric bus line as a whole is very well liked, not just for the technical innovations but also for competent drivers and focus on maintenance and comfort. Finally, the project has demonstrated significant energy savings that can be achieved from heat pump technology and more carefully designed insulation, in a standard size electric bus.
Keywords	Bus System; Electric Bus; Bus Stop Design; Indoor Bus Stop; Heating System; Innovation.

INTERNAL DISTRIBUTION

Participant N°	Participant organisation name	Country
1 Coordinator	Union Internationale des Transports Publics - UITP	Belgium
2	Régie Autonome des Transports Parisiens - RATP	France
3	Iveco France SA - IVECO	France
4	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. - FRAUNHOFER	Germany
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ACRONYMS

EBSF – European Bus system of the Future

KPI – Key Performance Indicator

ITxPT – Information Technology for Public Transport

PTA – Public Transit Authority

PTO – Public Transit Operator4

TI – Technological Innovation

VO – Validation Objective

INDEX

INDEX OF FIGURES

INDEX OF TABLES

1 Executive Summary

The Gothenburg demonstration team has implemented and tested three (3) technological innovations (TIs), listed below according to the name and coding agreed with the EBSF_2 evaluation team and described in the following sections, namely:

- New energy-efficient heating solution for electric buses (TIGot1).
  In an electric driven vehicle the on-board energy consumption for heating is of higher importance compared to a diesel or hybrid driven vehicle, since there is much less surplus heat due to the high efficiency of the system.TIGot1 has tested the efficiency of a heating solution for electric buses that is driven by electricity and biofuels instead of diesel.
- Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2)
  A new driveline means the possibility to create new vehicle design. Four fully electric buses and seven plug-in hybrid buses (for comparison) that operate a new bus line in Gothenburg, line 55, have been demonstrated and evaluated.
- Attractiveness of innovative bus stop designs (incl. indoor) and interaction between bus and bus stop designs (TIGot3).
  Electrification offers new opportunities for creating innovative solutions for the interface between public transport and the urban environment, in terms of new types of bus stops, including an indoor stop.

TIGot1 belongs to the EBSF_2 topical area “Energy Strategy and Auxiliaries”, TIGot2 to “Vehicle Design and TIGot 3 to “Interface between Bus and Urban infrastructure”.

The team has shown a 60% decrease in the energy consumption for heating by installing an air-to-air heat pump, added insulation in key areas, and updated control systems. This equals a 17% reducton in overall energy use for an electric bus under normal operating conditions in Gothenburg.

In terms of attractivness of buses and bus stops the fully electric bus line that has been implemented in Gothenburg has proven to be very popular with the travellers, as well as the drivers. Key benefits are the silent, low vibration, comfortable and well kept buses; the competent and friendly bus drivers; and the innovative and welcoming bus stops. Not the least people with reduced mobility stated that the buses and bus stops were easily accessible and declared it “the best bus ever”. Nevertheless some issues were found, not the least in terms of how to integrate the bus stops better in the city. The project clearly has shown that in order for bus stops to become something more than just a place to wait, both placement in the city and the cooperation of the surrounding businesses are of vital importance.

2 Introduction

The European Bus Systems of the Future 2 (EBSF 2) is an Innovation Action co-funded by the European Union within the Horizon 2020 Research and Innovation programme and coordinated by UITP – the International Association of Public Transport. The project, which runs between May 2015 and April 2018, capitalizes on the results of the previous EBSF project (2008-2013) and, as the former, aims to develop a new generation of urban bus systems by means of new vehicle technologies and infrastructures in combination with operational best practices, and test them in operating scenarios within several European bus networks.

The need for more cost-effective and energy efficient bus systems has led to the identification of a set of technological innovations (TIs) and strategies with a strong potential to optimize mainly energy and thermal management of buses (in particular auxiliaries such as climate systems), green driver (eco driving) assistance systems, intelligent garage and maintenance processes, IT standard equipment and services. Moreover, to effectively address the need to move quickly from laboratory research to actual innovation of the bus fleets in operation in Europe, the technologies to be tested have been selected according to their technological maturity (and not only because of their potential) in order to ensure a short step to commercialisation once the project ends. The use of simulators and prototypes has been conceived as a preliminary step for the validation of the innovations in real operational scenarios, performed within the project as well, or as a necessary task to prove the potential of more futuristic solutions currently implemented at early stage of development (e.g. modular bus).

2.1 Scope of deliverable

Thus, EBSF 2 aims to test, evaluate and validate innovative technological solutions and/or strategies for urban and sub urban bus systems through demonstrations in real service. The ultimate goal is to improve the efficiency of operations mainly in terms of costs and energy consumption but also to increase the modal share of bus services by improving the image of the bus for the users.

Six key research areas have been identified to have the highest potential to impact:

- Energy Strategy and Auxiliaries;
- Green Driver Assistance Systems;
- IT Standards introduction in existing fleet;
- Vehicle Design (capacity, accessibility, modularity);
- Intelligent Garage and predictive maintenance; and
- Interface between Bus and Urban infrastructure

These areas are to be further investigated in demonstrations in altogether 12 demonstration sites of which Gothenburg is one. The Gothenburg demonstration addresses three of the aforementioned key research areas for innovation, namely (i) energy strategies and auxiliaries, (ii) vehicle design, and (iii) interface between bus and urban infrastructure.

This deliverable, D13.4 - Gothenburg: Results**,** provides a description of the innovations demonstrated, how they were implementated, relevant validation objectives, data collected, and results achieved.

2.2 Organisation of deliverable

The deliverable is organised as follows:

The first section describes the demo site and the technical innovations that have been developed and tested. The second part describes the test set up, the data collection and analyses, while the third part describes the results obtained. The deliverable ends with a short description of the demo demonstration activities and the partner contribution.

3 Demo overview

The Gothenburg demonstration team has implemented and tested three (3) technological innovations (TIs), listed below according to the name and coding agreed with the EBSF_2 evaluation team and described in the following sections, namely:

- New energy-efficient heating solution for electric buses (TIGot1)
- Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2)
- Attractiveness of innovative bus stop designs (incl. indoor) and interaction between bus and bus stop designs (TIGot3)

3.1 A new energy-efficient heating solution for electric buses (TI-1)

In an electric driven vehicle the on-board energy consumption for heating is substantially higher compared to a diesel or hybrid driven vehicle. The technical innovation concerns the innovation topic Energy Strategy and Auxiliaries. More specifically it involves *a new energy-efficient heating solution for electric buses* that is driven by electricity and biofuels instead of diesel.

3.1.1 Goals

The goal is to improve the efficiency of heating by 30% in fully electric buses.

3.1.2 Test scenarios

The demonstration includes i) simulations, ii) tests in controlled environment, and iii) test under real operational conditions. The overall test design is choosen to be able to, as much as possible, negate the effects of passengers and weather to the climate in the bus. Simulations include an analysis on what the largest heat loss sources are. For the tests in controlled environment, a comparison was made between a vehicle equipped with the existing heating system and a vehicle equipped with the new heating system. These tests were done on instrumented vehicles in a controlled environment and withouth any people in the bus (althoug simulated by adding a separate heat source). For the test under real operational conditions, the same approach was applied, hence the evaluation compared energy use in a vehicle equipped with the existing heating system and a vehicle equipped with the new heating system. The field trial involved two electric buses, operating the new electric bus line in Gothenburg, (line 55) under normal trafic conditions.

3.1.3 Description of the no “EBSF_2 scenario vs “EBSF_2 scenario”

The two vehicles used in the test have basically the same geometry and dimension. However, the driveline, heating system and other important design features are different in the two buses. The principle in the heating systems in the Electric Hybrid Bus is based on conventional auxiliary heater and in the Electric Bus a complete new system together with a number of energy saving features is applied.

	7900 Electric Hybrid Bus Current Design	7900 Electric Bus Improved Design	Comments
LxWxH [mm]	12000x2550x3300	12000x2550x3300	
Auxiliary heater [kW]	30 (fuel)	7 (600VDC) + 16 (fuel)	HVO
Heat Pump	-	Reverse AC function	
Design	-	Improved heat insulation	
Heat management	-	Improved control system	

Table 1 - The test buses

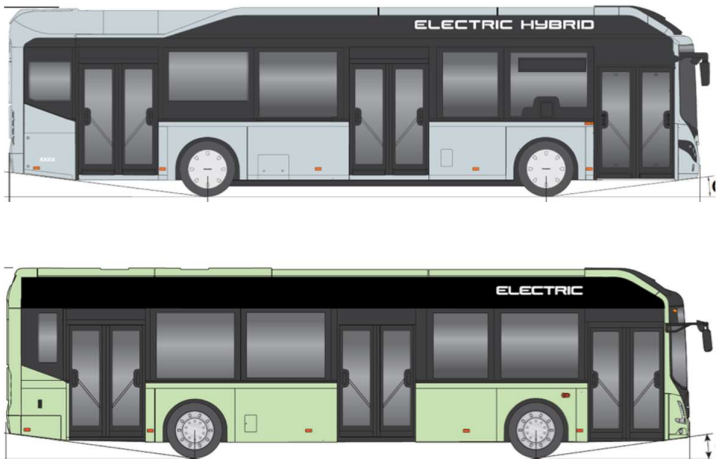


Figure 1 - The test buses

Heat pump

The main innovative energy saving component in the heating system is the roof mounted air to air heat pump and integrated air condition unit. To utilize the heat pump process where Coefficient Of Performance (COP) around 3 can be obtained under certain conditions will make considerably energy saving. The heated air from the heat pump is transferred through channels in the roof and distributed along the bus through air vents. In addition, the auxiliary heater will add extra useful heating power to the defroster and convectors when needed.

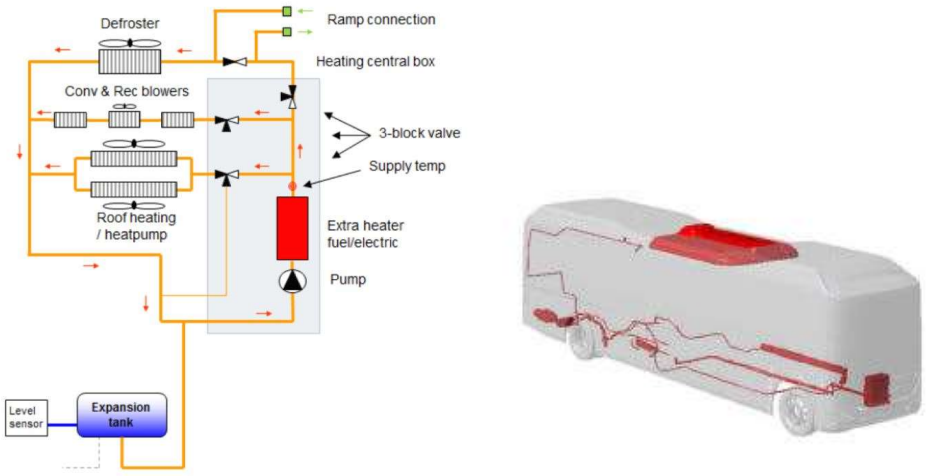


Figure 2 - Heating system in Electric Bus

Improved insulation

There are mainly three areas where the heat insulation is improved. Different insulation material is used with the thermal conductivity around 0.04 W / (mK) with the thickness 10-20 mm.

- Air channels in roof
  Insulation is improved inside the air channels outer wall area in order to decrease heat loss of the air flowing in the roof air channels. In addition the distributed heated air will keep a more even temperature throughout the bus improving the thermal comfort.
- Lower part of side walls
  Insulation foam is added inside the outer side panels in lower part of side walls close to where radiators are located. The inside surfaces of side panels are then covered with insulation reducing direct heat loss from radiators. It will also reduce cold draft in floor area improving comfort.
- Floor area
  As was found in the simulation, the heat convection in the floor is quite big and insulation is added from underneath the floor in order to decrease heat loss.

Improved control system

The control strategy is to use the most energy efficient way to keep comfortable indoor climate in the bus. The system will automatically use the different heat sources and heat distributers to reach inside set temp and to avoid cold drafts.

In order to control the heating system a number of temperature sensors are installed in the system and around the bus. This will give valuable feedback to the control system which is combining and balancing the temperature values in order to take decision when/how to activate/deactivate different components in the heating system.

The heating system is controlling air and liquid based heat distribution as well as fans and blowers. The needed air and liquid temperatures in the heating system are based on set temp, actual temperature and ambient temperature. To keep the temperature on right level will secure heating function as well as reduce heat loss and keep comfortable climate.

3.2 Attractiveness and efficiency of innovative external and internal design of electric buses (TI-2)

A new driveline means a possibility to create new vehicle designs. The technical innovation concerns the EBSF_2 innovation topic “Vehicle Design”. More specifically it involves the attractiveness and efficiency of innovative external and internal design of electric buses.
The new vehicles to be demonstrated and evaluated include four fully electric buses and seven plug-in hybrid buses (for comparison) that operate the new bus line, line 55. The electric buses have a total length of 10,5 m (compared to 12 m), low floor, a large double doors in the middle of the vehicle to facilitate access/exit, an open layout with an extended number of folding seats to increase flexibility during peak hours, a modern colour scheme and WiFi onboard.

3.2.1 Goals

The objective is to demonstrate a new, more efficient and flexible solution (fully electric buses) and compare this with a more traditional design (hybrid buses). The overall aim of the technical innovation is to increase the attractiveness of public transport, increase passengers’ perceived quality of the service, and improve passengers’ satisfaction with PT in general and bus systems in particular. Related goals are to speed up boarding/alighting operations and hence reduce dwell times; improve flexibility; improve onboard travel comfort; and reduce noise and air emissions. Speeding up boarding/alighting is partly a consequence of the new bus design, partly the interplay between bus design and bus stop design (see also TI-3).

The goals are to be achieved by the particulars of an electric bus (i.e. lack of noise from engine and lack of emissions) as well as the particular design of the specific electric buses introduced on line 55 in Gothenburg (the large double doors, the open layout, the folding seats, the modern colour scheme).

3.2.2 Description of the no “EBSF_2 scenario vs “EBSF_2 scenario

The bus fleet in Gothenburg consist primarily of diesel fuelled buses, but there are an increasing amount of diesel-electric hybrid buses.

Line 16 (the control line), one of the “stombuss” lines, are run with 20 diesel fuelled buses. All are double articulated buses with a comfort capacity of 120 passengers. Otherwise they have traditional, standard design, externally and internally regarding the design of doors, the interior layout and overall interior design (see Figure 3 and Figure 4)

Figure 3 - An example of the buses along line 16.

Figure 4 - Interior design of the standard bus.

The new fully electric buses come with new features (see Figure 5). The fully electric bus has a total length of approx. 10,5 m with a total capacity of maximum 85 passengers, two large double doors, low-floor, and flexible/folding seats to increase accessibility, as well as new and light interior design and WiFi onboard. The electric hybrid with a total capacity of 71 passengers has a similar colour scheme but is fiited with three doors (one in the front, one in the middle, and one in the rear part of the bus) and a more traditional interior layout.

Figure 5 - The exterior design of the new electric bus.

Figure 6 - The interior design of the new electric bus.

3.3 Attractiveness of innovative bus stop designs and interaction between bus and bus stop (TI-3)

Electrification offers new opportunities for creating innovative solutions for the interface between public transport and the urban environment, in terms of new types of bus stops. The innovation concerns the topic Interface Bus-Urban Infrastructure. More specifically it involves the attractiveness of innovative bus designs and interaction between bus and bus stop design including an indoor stop.

The new bus line 55 passes altogether 16 bus stops of which five have a new design. One of these is an indoor bus stop, located at Lindholmen university campus. It forms an extension to an existing building in which is located e.g. a cafeteria and teaching facilities. Also other bus stops have a new design, including a shelter which is larger in size than the standard

ones and which are equipped with new information features (in terms of touch monitors), free wifi, USB-charging, and a small table.

3.3.1 Goals

A main goal of the demonstration is to investigate how the interface between the urban infrastructure and the bus can be improved from different perspectives. The redesign of bus stops and the new buses are expected to contribute to more efficient boarding/alighting but there are also more overriding goals related to satisfaction and in the long run, demand.
A second goal is to demonstrate the feasibility of an 'indoor' bus stop for increased attractiveness of bus systems in particular while solving technical challenges including charging and climate. The demonstration will allow for a comparison between traditional bus stops and indoor bus stops, which provide improved shelter for travellers waiting fot the bus but more fundamentally the intention is to create a shared space for PT and other urban activities, reducing the distance between PT and for instance school or work and hereby changing the perception of a bus stop: from "bus stop" (a place where the bus stops) to a space for activities including travel.

3.3.2 Description of the no "EBSF_2 scenario vs "EBSF_2 scenario"

The control is line 16 and its altogether 22 bus stops. These are equipped with one or two JC Decaux standard shelters equipped with information (including realtime information).

Figure 7 - Example of bus stop along line 16.

Figure 8 - Example of shelter provided along line 16.

The new electric bus line has altogether 16 bus stops. Five of these have a new design including bus shelter, furniture, and information. All five new bus stops are equipped with free WiFi, and USB charging. The two bus stops at Götaplatsen and the one at Chalmersplatsen are of the design shown in Figure 9. They are larger than the standard shelters and designed with more wood to make them more attractive. There are also large touch monitors providing information on the bus route, a table and wooden sofas. In the Götaplatsen shelters these sofas are electrically heated during wintertime. The indoor bus stop (Figure 10) is located at Lindholmen where it forms an extension to an existing building in which is located a cafeteria

and teaching facilities. The building is situated in a context of university buildings, office buildings, a science park, and restaurants. Close by are also found new apartment buildings. Regarding the indoor bus stop the intention is to create a shared space for PT and other urban activities, reducing the distance between PT and e.g. school or work but also change the perception of a bus stop: from “bus stop” (a place where the bus stops) to a space for activities including travel. Charging of the electric buses takes place at the indoor stop at Lindhomen and at an outdoor stop close to Johanneberg Science Park. The Johanneberg Science Park stop, finally, has a shelter that is designed to be particullary quiet, and has a book swapping shelf.

Figure 9- Example of new bus stop along line 55.

Figure 10 – The indoor bus stop

4 Demo execution

In this chapter the preparatory activities and the data collection are presented for the three technical innovations.

4.1 TIGot1

4.1.1 Preparatory activities

In order to calculate and to get the overall picture of needed heat power a complete bus simulation model was built up. The model is based on global geometry and dimensions together with material properties. The numerical values come from drawings, specifications and empirical heat transfer data from handbooks. The model is global and gives understanding for the overall heat transfer during operation. It does not take into consideration heat loss effects in local areas. Energy balance at steady state condition is considered where the heat transfer is done through thermal convection and conduction.

The new improved heating system was installed in an electric driven city bus running on line 55. The bus started operation in December 2016.

4.1.2 Data collection

Different methods have been used to validate the improvement of the new heating system. Both theoretical and practical studies and testing have been carried out as well as valuable input from vehicles in operation. The tests of the new HVAC in actual traffic started in December 2016.

Real Operational Trial

For the TIGot1 the Volvo 7900 Electric Hybrid is used as the reference bus and the 7900 Electric as the improved EBSF2 bus. The two buses have been in operation on line 55 for more than one year and experiences from a large number of trips are collected and give valuable information about functionality and reliability of the heating system.

Testing in Climate Chamber

To determine the effect of the improved design and the new heating system, measurements on two comparable buses in climate chamber have been done. Testing and measurement in climate chamber is a way to have control of all functions independently of external disturbances and different operational behaviour. One of the buses has current design and the other one has improved design including new heating system. By comparing results from the measurements the improved heating energy consumption is determined.

The test setup is done in the same way for the two buses and same equipment for collecting data is used. The target is to eliminate all errors related to technique and procedure to get

clean reliable results. Heating from passengers is simulated by adding constant 2000 W from electric radiators inside the buses. Otherwise, all possible heating sources except the ones who are target for the measurement are switched off. It means that for the Electric Hybrid Bus only the auxiliary heater is operating and the heat from the engine is switched off. For the Electric Bus, the heat pump is the main heat source together with “minor” auxiliary heating for the defroster. Both buses heating systems in the test are working in the same respective way as in real operation together with recirculation fans that are distributing the heat throughout the cabin.

The day before the test the buses are parked in the climate chamber to get an overall stable temperature of 12 °C. During the test the ambient is set to 5 °C and cabin set temp to 19 °C. After some time steady state condition is reached. This test scenario is also likely the normal scenario during real operation where the buses, after duty, are parked in garage or close together outside heated up by electric ramp heater before next day’s operation.

After the steady state condition is reached, the pre-defined test cycle, including all doors opening and closing sequence is starting up. During the test cycle the power consumption for heating is measured as well as temperatures in a number of control positions. The test cycle for each test is around one hour where data is collected and average value for heat power consumption is calculated.

In the tests the effect of sun heat radiation is not taken into consideration and the wind speed around the bus is zero.

4.2 TIGot2

4.2.1 Preparatory activities

Most of the preparatory activities was done before the official start of the project as the demo is part of the ElectriCity project, which started spring 2013, but launched the bus line 15 June 2015. A bus line with 3 fully electric (4 fully electric buses by the end of the project) and 8 plug-in hybrid electric buses has been implemented.

In order to assess the attractiveness and use of this bus line and the specific new technology introduced in the test buses a questionnaire to be distributed on the test buses, as well as on the control bus line has been designed. Furthermore, interview guides for the interviews with passengers as well as drivers have been designed and developed.

4.2.2 Data collection

The attractiveness and use of the bus line, including vehicles, have been investigated by registration of the number of passengers that use the new line; interviews with a sample of passengers on board the different buses, and on board questionnaires. Furthermore performance data such as dwell times, average speeds, etc. has been collected as part of Västtrafik’s continuous quality assurance programme.

On board questionnaires have been distributed on five occasions with altogether 1350 questionnaires collected on bus 55 and the same amount on the control (line 16). Furthermore, two sets of on board interviews (N=20+28) has been conducted with passengers, one set of on-board interviews with passengers with reduced mobility (N=9), as well as two sets of interviews with the bus drivers (N=10+12).

4.3 TIGot3

4.3.1 Preparatory activities

Five new bus stops have been built, one of them an indoors bus stop. As with TIGot2, questionnares and interview guides have been designed and developed. Furthermore, a new method of assessing buit invironements, as the indoors bus stop, based on naming of different parts of the environment as well as semantic differential scales has been developed, and a series of co-design workshops have been organised (two on a proposed new bus stop at Johanneberg Science Park and one on the interior design of the indoors bus stop).

4.3.2 Data collection

The attractiveness and use of the bus stops have been investigated by interviews with a sample of passengers on board the different buses, and on board questionnaires. Furthermore, performance data such as dwell times, number of people who board the buses at a particular stop, etc. has been collected as part of Västtrafik's continuous quality assurance programme.

On board questionnaires have been distributed on five occasions with altogether 1350 questionnaires collected on bus 55 and the same amount on the control (line 16). Furthermore, two sets of on board interviews (N=20+28) has been conducted with passengers, and one set of on-board interviews with passengers with reduced mobility (N=9).

For the bus stops in particular, a number of additional studies have been conducted. They include structured observations, interviews on the indoors bus stop using a newly developed technique (N=10), as well as a co-design workshop where passengers (N=12) on the bus line were invited to re-design the interior of the indoors bus stop to make it more attractive. Furthermore two Co-design workshops on requirements for a proposed new bus stop at Johanneberg Science Park has been conducted (N=12+12) with people working at the science park as well as people living in the neighbourhood participated.

5 Demo results

In this chapter the results of the different tests are presented.

5.1 TIGot1

5.1.1 Simulation of Heat Transfer

As been described earlier a simulation model has been developed in the project to investigate the heat loss. The results (figure 11) showed that the main heat transfer is in the floor due to its big area and relatively poor insulation. Compared to the roof (which has a similar area to the floor), the difference in insulation is really apparent. Therefore the floor was one of the main areas that were improved before the trials with the real bus.

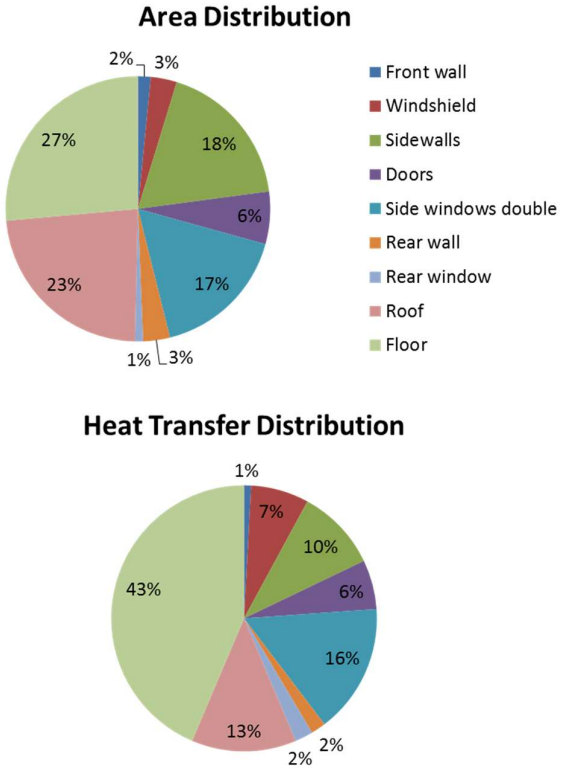


Fig 11 Distribution of area and heat transfer

5.1.2 Results in real traffic

From line 55 a number of observations have been done together with measured values of energy consumption. These resulted in a big variation of heat energy consumption between different trips, due to different operational conditions. E.g. adjustment and use of the heating system, traffic situation, number and degree of passengers' exchange, door opening

sequence, specific traffic situation, different ambient climate etc. The conclusion is that in order to compare the performance and efficiency of the heating systems in the two buses and to get reliable results a more stable condition is needed. The decision was therefore made to do measurements in a climate chamber.

5.1.3 Results from Climate chamber tests

The energy supply to the test buses is transferred through electricity and fuel and then transformed into heat energy transferred by air and liquid. During the test, both vehicles outer and inner climate is the same but the principles of heating up the cabin is different. In order to determine the energy usage, the electric supply current and voltage and flow of supplied fuel is measured throughout the whole test cycle. From the measured values the average total power supply during the steady state condition in the test is calculated. The test cycle corresponds to condition during city bus operation.

Power consumption during the test is presented with numerical values and graph (Table 2 and Figure 12).

	Electric Hybrid Bus Current Design Power [kW]	**Electric Bus Improved Design Power [kW]**	**Comments**
HVAC roof unit	0,064	0,312	
Aux heater	6,385	-	
Heat Pump – 600V	-	1,853	
Aux heater – 600V	-	0,308	
Convector fans	0,02	0,02	
Defroster fan	0,02	0,02	
Coolant pump	0,128	0,128	
Total	6,617	2,641	
Reduction		60%	

Table 2: Power consumption

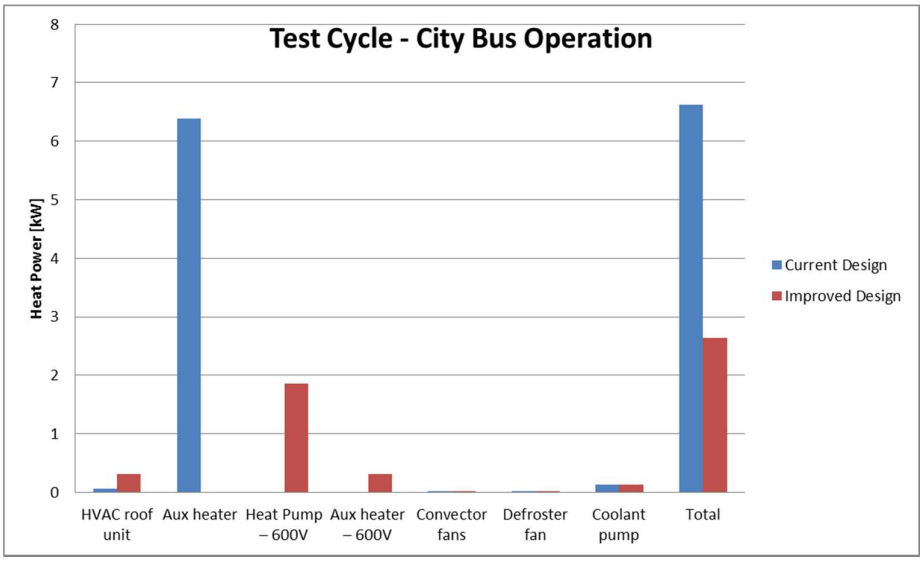


Fig 12 Test Results

The reduction in heat power consumption is 60% and it seems that the new heating system is well fitted to the operational conditions.

In order to visualize the temperature gradients and identify thermal performance, a camera with infrared energy detection technology is used. Thermal images are taken from outside the buses and high temperature areas are found with potential heat losses (Figure 13).

Fig 13 Thermal image from IR-camera

5.1.4 Operational Energy Saving on line 55

In order to measure the operational improvements in terms of energy saving for the new innovation, the results from measurement in climate chamber together with operational conditions in line 55 are combined.

The power and energy added to the heating system in terms of electricity and HVO fuel are:

7900 Electric Hybrid Bus	7900 Electric Bus	Comments
6,617 kW	2,641 kW	Added Heating Power Climate Chamber Test
0,39 kWh/km	0,15 kWh/km	Added Heating Energy Bus operating on Line 55, average speed 17 km/h

Table 3: Power added to the heating system

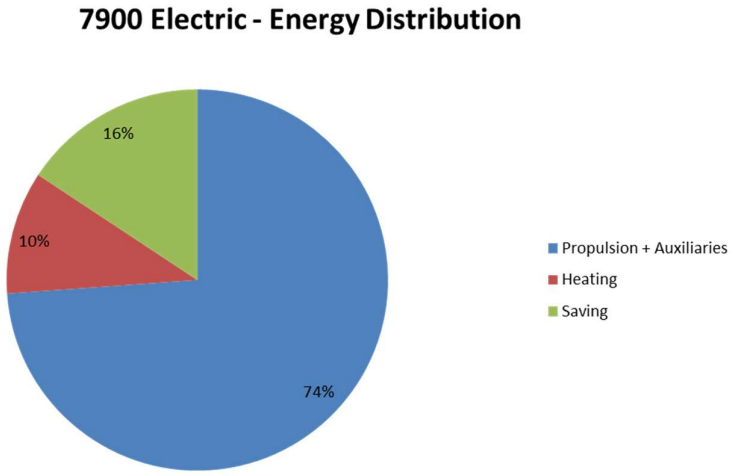


Figure 14: Energy distribution for the new bus

The major part of the energy is used for propulsion (and some auxiliaries) of the bus. However, quite a big overall energy saving (16%) is achieved for the 7900 Electric Bus with improved design (Figure 14).

5.1.5 Potential further improvements

During the work in the project a number of reflections have been done and thus also ideas for improvements of future products. Based on common sense in combination with new

technology tools several steps toward more energy efficient heating system and climate control can be achieved. Below are some ideas to keep in mind when developing new buses.

- **Using of excess heat:**
  In an electrical drive line in a Bus the temperature of electrical components is controlled by liquid cooling system. The excess heat from this could be transferred into the heating system adding heat energy.
- **Geometry, Design and Insulation:**
  The temperature is normally highest close to heat sources and thus also temperature difference to the environment which will increase heat loss potential. In order to transfer the heat throughout the bus in an efficient way it is very important to reduce direct heat losses in channels, hoses and pipes where the heat energy is distributed. This can be done with choice of geometry and design and using of right material and insulation.
- **Sealing:**
  Sealing should be done properly in order to avoid leakage of air and thus heat energy. E.g. sealing around doors, hatches etc.
- **Cold bridges:**
  Cold bridges should be avoided. I.e. outer surface material with high thermal conductivity should not be in direct contact with inner surfaces. This will result in local heat transfer and heat losses.

5.2 TIGot2

The travellers were found to be very pleased with the service on line 55. 75% of the adult travellers in the interview studies regarded it superior to all other buses and bus services. The remaining found it equally good. Various reasons were cited for this superiority, often pertaining to the electric drive or the interior features. Although highly appreciated, these features still seem to have negligible influence when choosing a bus service to travel with.

The most common reason to choose service 55 is an attractive route. On second place comes the random effect of the bus being the first to arrive when parts of the route are shared. After that follows the fact that the 55 usually is less crowded than service 16, with which the 55 share significant parts of the route. Only after these totally dominating reasons come others related to the bus itself, such as electric drive and a perceived quiet and calm journey. Other minor reasons include a perceived faster trip, better timeliness, friendly bus drivers, high comfort, and experiencing the bus as fresh or safe. This indicates that the new features of the Electric Concept Bus are indeed highly appreciated and significant factors in why the bus and the service are regarded superior to others. When it comes to down choosing a bus service, basic needs such as getting to the right place and getting there in time, however, seems to have most influence. This is not unexpected, as the basic needs have to be fulfilled before other enhancing needs are of any use. These findings are supported by travellers asking for Electric Concept Buses to be implemented on other bus services, or questioning why the 55 does not run on weekends or during summer. They appreciate the bus, but want it to run when and where they need it.

A majority of travellers in the questionnaires seem to choose service 55 due to environmental concern and the trend is found stable over time. This is interesting, as the interview study shows that only a small share choose the service due to environmental concern, although most find it advantageous. The questionnaires specifically ask travellers if the increased sustainability makes them more likely to choose service 55, while this study made the travellers come up with own reasons why they choose the service. Specifically asking leading questions if sustainability is important will however lead to more travellers giving affirmative answers; either influenced to think about it or believing that they should give a positive answer. It seems that the questionnaires actually measure the amount of travellers not finding the sustainability aspect negative, instead of those actually thinking of it when selecting a service to travel with.

5.2.1 Interior

The test bus is widely believed to have fewer seats than other buses, and this is the most commonly cited negative aspect of it. This desire for more seats is however not reflected in criticising the large open area. Travellers instead want an elongated version of the bus to support more seats, as well as to allow them to move away from disturbing co-travellers.

Nevertheless, many travellers in the questionnaires indicate that the buses on service 55 have enough space. The trend is increasing, and the shares are often higher than for the 16. This is interesting, as the small size is the most common complaint about the Electric Concept Bus. However, the 55 has fewer travellers than the 16, and it is often mentioned to be able to contain many travellers in a small space due to the open layout. These results could therefore indicate that smart layout is more important than the length of the bus.

Statistics from Västtrafik show that the buses are most often not overcrowded. The average maximal occupancy per trip is 67,2%, and the average occupancy over all bus stops and trips is 38,6%, compared to 89,0% and 58,8% for service 16 within the same zone. 18 trips (12%) during the day have an average maximal occupancy at 99% or more. These include all morning trips bound for Lindholmen between 7:23 and 8:33. On the other hand, 34,9% of all trips at Service 16 in the same area have an average maximal occupancy of 99% or above. An average 317 travellers per day, or 6,6%, enter a bus with occupancy at 100% or above, compared to 22,6% on line 16. This means that a large majority will not enter an overcrowded bus, which is in line with the travellers' beliefs.

The large open area (Figure 15) is highly appreciated for allowing travellers to get past others fast when disembarking, as well as making the bus feel more open and spacious. It is also regarded advantageous for placing prams and wheelchairs without blocking other travellers' paths. Some parents however mention that the pram department decrees placing the pram so that the baby faces the door, if not to block the foldable seats. This means that the adult cannot sit down and watch the child.

Some travellers report that they get confused by the open area when entering the bus for the first time. Crowds covering the foldable seats have led travellers to believe that the bus has no seats at all, before spotting the rear or front end. This can be a particularly negative experience for elderly travellers, who risk falling and hurting themselves if they stand when the bus is driving. The problem however solely applies to first-time travellers.

Figure 15: The double doors and the large floor area of the fully electric bus

5.2.2 Seating

The bus has numerous foldable seats and foldable seats are generally less appreciated than permanent. This may be due to the extra effort of folding out the seat, the risk of having to give it up and stand if the bus gets crowded, or distrusting the quality of the seats. Some travellers specifically mention that they dislike travelling while seated on the side.

Travellers have diverse opinions regarding the comfort of the seats. Some find the permanent seats more comfortable than on other buses, although many others find them less so. This could likely arise from the travellers' different frames of reference. The foldable seats are generally regarded more comfortable than foldable seats on other buses but less comfortable than permanent seats. The appreciation emanates from the backrest that is folded out with the seat and the soft headrest on the rails behind. Shorter travellers can however not reach either backrest or headrest if they want to keep their feet on the ground.

The permanent seats have varying amounts of space around them. The two front-facing seats right behind the doors are regarded to be very tight. Travellers find little space for their feet, partially due to the glass wall in front going all the way down to the floor. The two front-facing seats on the opposite side are instead regarded to be spacious. Many seats are found rather close to the walls, but especially those in the frontal four-seat complex marked with a disabled sign.

The seats are described to be in very good shape, and the travellers have never seen them broken, dirty, sticky or scribbled on. The daily service at Volvo is likely a contributing factor to this, but the drivers' good overview and the bus not running at nights may be explanations as well.

5.2.3 Doors: getting on and off

Travellers appreciate the concept of two large doors in the middle of the bus. It is regarded to allow fast embarking and disembarking for a large number of travellers in a short time. No traveller expressed any need for more doors in the front or back. Moreover, the risk of getting hit by a door was perceived to be smaller than on other buses, as the doors open outwards.

Almost every traveller answering the questionnaires believe that the bus is easy to get on and off, with the shares being either 99% or 100%. The study highlights the large doors for fast and easy embarking and disembarking, the large open space where travellers could pass each other, as well as the low floor as the main reasons. The share is somewhat higher than for service 16, although surprisingly similar. The 16 is regularly mentioned to be vastly inferior regarding boarding and alighting in the study. Respondents of the questionnaire are however not comparing the buses, only judging them separately. Service 16 is indeed run by buses with many doors, although not found as efficient as the two doors of the Electric Concept Bus.

Raw data from Västtrafik's October 2017-measurements was used to obtain average dwell times. Dwell times for the hybrids and the Electric Concept Buses were calculated separately, and compared using a 95% confidence level. Dwell times for service 16 at mutual stops was calculated and compared with the 55 averages. The results are summarised in a table below. Statistically significant differences are marked in colour, with red indicating longer dwell times and green shorter. Comparisons are between electric-hybrid and 55-16 (Table 4).

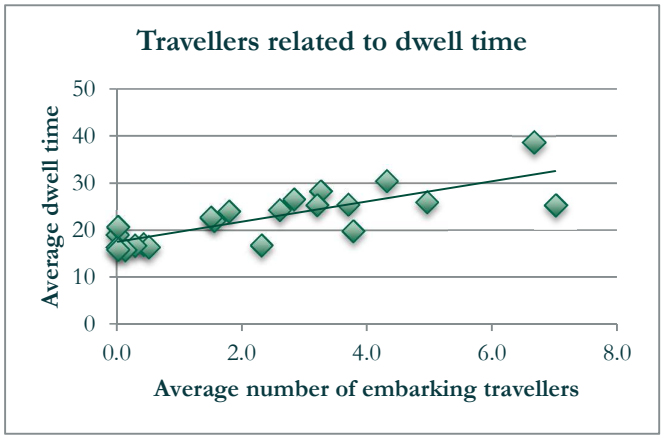
Dwell times [s] at bus stops	Electric	Hybrid	Service55	Service16
1.Sven Hultins plats A				
2.Chalmersplatsen A	17.5	16.3		
3.Kapellplatsen E	21.0	19.2	19.6	34.1*
4.Götaplatsen A	26.1	24.9		
5.Valand C	25.8	26.0		
6.Kungsportsplatsen C	24.5	23.7		
7.Brunnsparken B	30.5	30.4	30.4	34.9*
8.Lilla Bommen B	21.3	22.3		
9.Frihamnsporten B	18.9	19.1	19.0	15.7
10.Pumpgatan B	15.7	14.5	14.8	15.6
11.Regnbågsgatan D	17.8	16.7	17.0	21.1

Dwell times [s] at bus stops	Electric	Hybrid	Service55	Service16
12.Lindholmen D	22.1	19.9	20.4	26.7
13.Teknikgatan A				
1.Teknikgatan A				
2.Lindholmsplatsen A	29.1	25.2		
3.Regnbågsgatan B	27.8	24.2	25.1	25.3
4.Pumpgatan A	17.4	16.1	16.4	15.6
5.Frihamnsporten A	16.3	17.0	16.8	16.7
6.Lilla Bommen A	28.1	28.3		
7.Brunnsparken A	39.9	38.2	38.5	33.68*
8.Kungsportsplatsen D	24.6	25.6		
9.Valand D	24.4	24.2		
10.Götaplatsen B	22.5	22.8		
11.Ålandsgatan B	16.8	15.4		
12.Chalmers Tvärgata B	17.3	15.3		
13.Sven Hultins plats A				
Stops at the same gate			18.8	21.0
All mutual bus stops	23.8	23.0	23.8	26.7
*Different gate				

Table 4: Dwell times at the different bus stops along line 55 and 16

Service 55 has significantly shorter dwell times than service 16 when comparing the mutual stops as a group. The 16 however has significantly shorter dwell times at Frihamnsporten towards Lindholmen and Brunnsparken towards Johanneberg. The overall results are not surprising. More travellers enter the 16 through multiple doors, and the drivers find it difficult to obtain an overview of the bus. The closeness sensors in the doors cause drivers to force-close them if travellers are standing close, making all doors open and close again. The longer dwell times may influence travellers to believe that the 16 is slower than the 55, as idle waiting at a bus stop is likely found more disturbing than travelling.

The Electric Concept Buses however have significantly longer dwell times than the hybrids on 8 specific stops, as well as overall. This is interesting, as the large doors in the middle are praised for allowing large amounts of travellers to enter and exit the bus simultaneously. The drivers indeed believe that the Electric Concept Bus needs to stop shorter times than other buses. There is however a strong positive correlation between the amount of travellers entering the bus and the dwell time on the 55, whereas no correlation between the amount exiting the bus and the dwell time can be found. This indicates that the number of travellers boarding the bus and finding a place to stand or sit is the main issue in increasing the dwell time. The Electric Concept Bus has much better possibilities for the driver to get an overview of the bus, given the live-view monitor in the drivers' compartment. It is therefore possible that the drivers on the Electric Concept Buses wait with starting the bus until everybody really is seated and thereby increasing the dwell time. Both drivers and travellers agree that the drivers actually do wait with starting the 55 for being considerate towards the travellers.

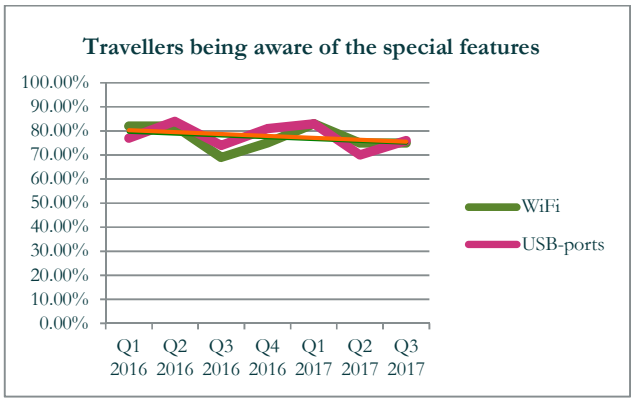


The large windows are found to make the bus appear lighter, as well as providing a good view of the exterior. Some travellers however want large windows to come with sun curtains, as they are more likely to give direct access to the sun. Others want to open the windows, either to let cool air in or bad odours out. This desire may be coupled with the initial air condition problems that some travellers still mention as a negative trait of the bus.

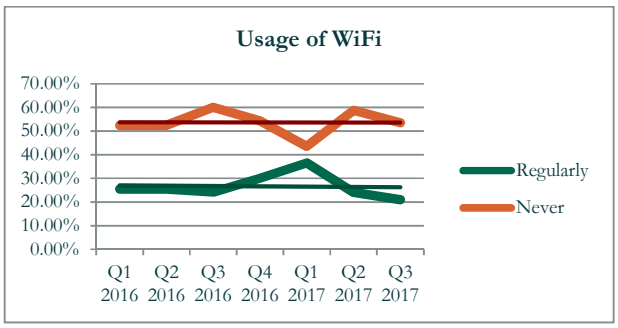
5.2.4 WiFi and charging stations

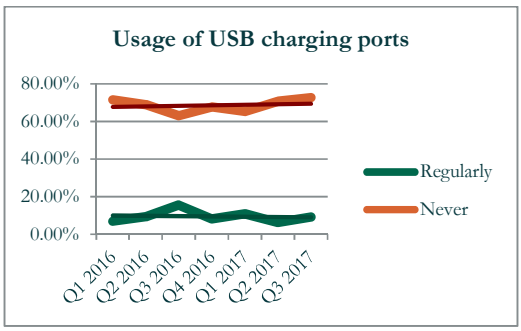
Most travellers hardly ever use the on-board WiFi or the USB-charging ports, but usually find it positive that the features exist. A majority of the interviewees do however not mention them at all. USB-ports are regarded unspecial as they can be found on other buses as well, and WiFi is found too abundant to surprise anyone. One traveller speculated that few were aware of the WiFi's existence, due to the only symbol being placed on the exterior of the bus.

Awareness of the USB charging ports and WiFi has fluctuated, but have a somewhat decreasing trend. It was suggested in the study that the single WiFi symbol on the outside might not be enough to inform all travellers. The fact that the USB-ports are rather discrete and not present beside each seat could make them go unnoticed. The initially higher awareness may be related to initial campaigns promoting these features or a somewhat different traveller clientele. It seems that more travellers have found the bus during the period it has been in use, without necessarily being informed about all the features of the bus.

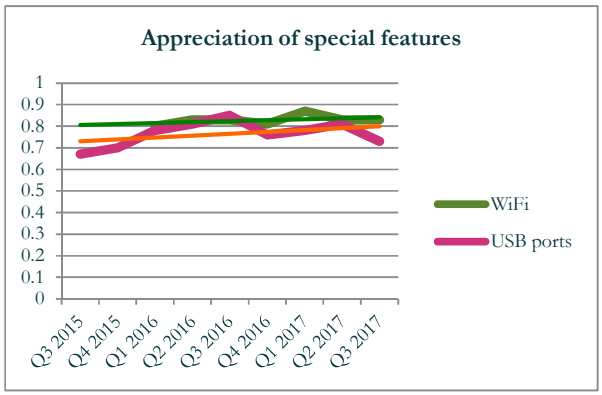


The share of travellers using WiFi and USB-ports are expressed in percentage of the total amount of travellers, instead of the share of travellers aware of them as is done in the questionnaire reports. A minority regularly use the WiFi, but the share seems constant over time. Travellers find it unnecessary to connect to a WiFi network for a short ride, especially as most of them have large data subscription plans. Others do not use their phones at all during travel, especially older travellers.





USB-ports are used even less than the WiFi, although rather constant. The study shows that travellers find it cumbersome to fetch their charging cables if they have one, and will often not plug in their mobile phone for a short journey. Others do not use them beacuse the seats beside the outlets are all taken.



WiFi and USB-ports are however widely appreciated, despite the low usage. The appreciation even seems to have increased over time. The study indicates that travellers find USB charging ports a good backup solution in case they run out of battery. WiFi is likely more neutrally appreciated, as indicated by comments that WiFi ‘always is nice’.

5.2.5 The monitors

The front monitor proclaiming stops to come is appreciated for showing connecting services at interchange points, which is found to reduce stress and help the travellers to plan. Some find the monitor's position unintuitive, as they are usually placed elsewhere. The white background helps some travellers to read clearly, while others find the text smaller than other monitors and thereby significantly harder to read.

The monitors on the sideways slant between roof and wall are rarely watched, as they are hard to see when seated. Many travellers have never noticed them at all. The front side monitors can be spotted from the frontal four-seat complex, but are partly covered by the upper rails. Travellers often suggest other placements for these monitors, such as above the doors or in the middle. Moreover, the sideways bus stop monitors have even smaller text than the front, and some of them do not show connecting services.

5.2.6 Stopping the bus

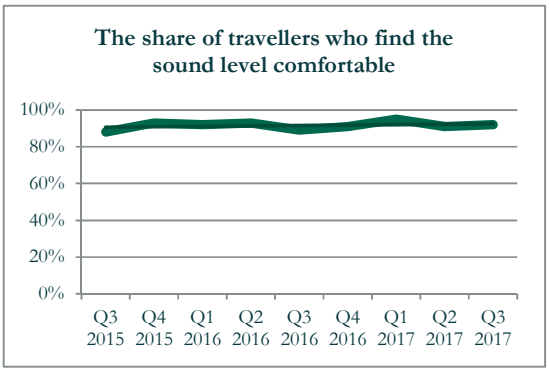
Travellers find the bus easy to stop, and believe that it has more stop buttons than other buses. The buttons are found comfortable to press due to the smooth rounded surface. The stop sign proclaiming "next stop" is regarded amusingly retro by some, while others question the use of the English word "next".

5.2.7 Colouring

Every subjected traveller acknowledged the light-green colour as something new about the bus, and all but one appreciated it. It was generally believed to be 'nice', either calm or happy as well as making the bus appear lighter. The unique colour also made it possible to spot and identify the bus from a distance. The interior was found to have a good and comfortable contrast between the green and grey. Some travellers mentioned the connection to sustainability or found it well fitting in a city with many trees, while others believed the colour to be yellow.

5.2.8 Electric drive

Most travellers are aware of service 55 being traversed with electric buses. Many are however not aware of the hybrids and sometimes express distain when being informed about them. The sound level is the most commonly mentioned factor pertaining to the electric drive, and travellers find the quiet journey a main advantage. It helps them to relax and reduces their stress level. A few travellers are however uncomfortable with talking in the silent bus as they find that others can hear them too clearly. The environmental aspect of electric drive is mentioned as well, but more rarely than the sound level. Remarkably few travellers mention the absence of exhaust fumes. Most parts of the route are however shared with diesel buses contaminating the air, making the effect of a few electric buses hard to notice.



Looking at the questionnaire results, the sound level is found comfortable by an overwhelming majority of the travellers, far larger than on other buses. The trend seems to be constant. Travellers in the study agree and attribute the comfortable sound level to a decreased engine sound. The sound level is appreciated, as it implies a more calm and relaxed journey. The small minority not finding the sound level comfortable likely find the bus too quiet. Some travellers were actually found reluctant to speak on the bus, as they could be overheard by others.

5.2.9 Travel time, perceived speed, routing, etc.

Many travellers regard the 55 to be faster than other comparable services, despite the official schedule proclaiming the opposite. Some travellers attribute this to the route not passing through Nordstan and the interior at Brunnsparken and thereby avoiding the delaying jams often found to occur there. Student travellers express dismay over the early time at which the service ceases to run in the evenings, whereas those outside academia disapprove of it only being active during semesters and weekdays.

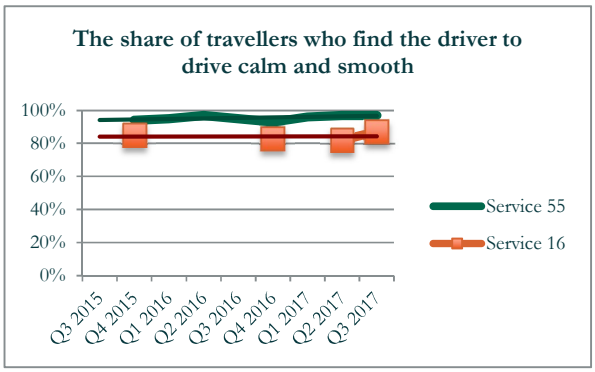
Many travellers express desire for the bus service to take a more attractive route, despite traversing the middle of the city. Such comments can be interpreted as a desire for Electric Concept Buses on other services where the travellers use to go. Others find it remarkable that the bus traverses different stops in different directions and some have even waited to take it in one direction at stops where it only traverses the opposite.

Service 55 takes longer time between the campuses than the 16, just as the official schedule pronounces. The difference is not very large, about 1,5 minutes, but still large enough to possibly be noticed by travellers. Many travellers however still believe the 55 to be faster. The 16 has a larger standard deviation of the total time than the 55, and the significant speed drop of the 16 in Brunnsparken makes the speed more fluctuating. The 16 runs on a longer route than the 55, and has no large time buffer between each trip as the 55. This makes it more prone to delays. It could simply be the 16's commonly occurring delays that make travellers assume that the service runs slower. Travellers may think that the bus is late because it has been slow, while it in fact just has a much smaller time buffer and the small delays are compounded during the day.

It is however important to note that service 55 runs a total route back and forth that is 13.9 km, while service 16 only runs 12.6 km in the same area. The average speed over the route between the campuses is therefore 18.4 km/h for the 55, and 18.0 for the 16, if the dwell times are included. The difference is not significant but it shows that the shorter dwell times make it at par with the 16. It is actually the longer route that makes the 55 somewhat slower between the campuses.

5.2.10 Drivers and driving style

The drivers are generally found more friendly and helpful on line 55 than on other services. They are found to drive smoothly and continuously inform travellers during disturbances. Travellers appreciate that the drivers do not start the bus until everybody is seated and that they allow time to talk to travellers. This is found to affect the mood on the bus in a positive and relaxed direction. It is however made possible due to a ten-minute time buffer between the trips at the end stops, while charging only takes about 5 minutes.



Looking at questionnaire results, the driving style of the 55 is more appreciated than the 16's, and the share of travellers believing so may be increasing. This is widely mentioned in the study and is mainly attributed to the slow, smooth acceleration and deceleration. The bus supports this on its own, but the carefully selected drivers are very important as well. The study comparison suggests that the drivers are more aware of the travellers' situation in the present, which could explain the slight rise. The share of travellers finding the bus driver to behave well as well as finding them careful when people are to get off are equally high. They are however equal to service 16, which is rather surprising. Travellers mention that the drivers on the 55 stop closer to the sidewalk than on other services and always wait for the travellers to get seated before starting. They are indeed often mentioned to be nicer and gentler than drivers on other services. However, the perception may be diminished by the enclosed drivers' compartment of the Electric Concept Buses, which is found to make the drivers appear more separated from travellers.

Many travellers acknowledge the drivers' centre position and enclosing, but often regard it insignificant to them. Some actually find it positive, as they believe the drivers to get less disturbed and more focused on the driving. Others however believe that it makes communication more difficult and are often afraid to knock the door and interrupt the driver.

5.2.11 Children on the bus

Children seem to enjoy the colouring of the bus as well as the paintings on fabric and glass reminiscent of a city. Many of them however find the journey somewhat boring, as they cannot see out of the high windows when seated at the foldable seats. This led them to suggest either introducing touchscreens with games or lowering the windows.

The seats were too high for the children to have their feet on the ground while still sitting comfortably. This leads to problems staying put on the seat when the bus brakes or turns.

Two children sitting on foldable seats in the pram department were found holding onto the pram belt to avoid falling, since the rails were too high up. This was however regarded an acceptable solution, and the children requested such belts at all seats.

5.2.12 The buses from the perspective of passengers with reduced mobility

The travellers with reduced mobility seem to be very pleased with the electric bus. All but one interviewee regarded it superior to all other buses, and the last believed it to be equally good. The main cited reasons for superiority were the softer driving style, the open interior layout, the low floor, the existence of foldable seats in the handicap department and the brighter interior.

All but one traveller would chose the 55 over service 16 even if they had to wait for it a while, while the last would chose the bus arriving first. This suggests that travellers with reduced mobility are even more positive towards the Electric Concept Bus than others. The reactions could however partly be explained by novelty measures, as none of the travellers with reduced mobility had used service 55 before. This also means that they have never travelled with one of the hybrids. The Electric Concept Bus is generally more appreciated than the hybrids and provides more features for those with reduced mobility, which means that the travellers have an incomplete perception of the service that covers only the most positive aspects.

Experiences

The bus is regarded to look accessible already from the outside, providing immediate trust that it could be used. The large doors, low floor, kindly looking colour as well as the quiet and smooth arrival at the bus stop were factors behind this.

Driver and driving style

The bus was almost unanimously regarded to sport a softer ride than all other bus services, which made it possible for the travellers to stand up or even move around during travel. The travellers noted that the driver does not start driving until everybody is seated, and found this positive from a safety point-of-view. It was also mentioned that the 55 stops much closer to the sidewalk than other services, which makes boarding possible at all times.

Travellers with reduced mobility often need to communicate with the driver and find the enclosed driver compartment troublesome. They cannot ask questions from the outside, as the windows are not possible to open. Many do not want to board and go all the way to the driver just to get an answer, especially not if they need help with the ramp. It is problematic to start a communication from the inside as well, as the travellers must reach the door to the drivers' compartment and knock on it. The driver then has to stop the bus and turn around to

be able to talk. The design of the divers' compartment is found to be non-inviting, giving affordance not to knock and bother the driver.

Interior layout

The large open area is highly appreciated, as it provides much space for prams and wheelchairs while still allowing other wheelchairs or walkers to pass them by. The wheelchair corral was easy to reach even during rush hour, and travellers with walkers could sit down with their aid in front of them without obstructing others.

Seating

Many travellers with reduced mobility have problems to reach the rear seats due to the small upward step and the narrow passageway in which a walker cannot fit. This is found unfortunate, as many travellers could otherwise have used the seats not exactly above the wheels. The foldable seats were easier to reach, although some travellers found them unsteady. Travellers appreciate their close proximity to the door, as it allows them to enter or exit without having to worry about disrupting the bus or not getting there in time.

The foldable seats in the wheelchair department were very well received, as they allow non-disabled friends to sit next to those riding a wheelchair. Travellers with walkers or canes appreciated them as well and found them somewhat reserved for them. This allowed them to safely claim a seat close to the door without having to worry about giving it up later. One traveller with a walker had never been able to sit in a bus before the journey with the Electric Concept Bus.

The seats of four seat-complex in the front of the bus are marked with a disabled symbol, but are often not used for that purpose. The space between the opposing seats is not large enough to allow travellers to have their walkers in front of them. The height of the seats is found to be way too low to allow safe and easy rising, up to the extent that some travellers actually left their walkers unattended and used the high seats above the wheels.

The wheelchair area

The wheelchair area is located straight across the door and consists of foldable seats and a corral. Wheelchair travellers found the corral wider and easier to enter than on other buses, and the placement close to the door was regarded to make disembarking less stressful. Both side rails are permanent with a height comfortable to hold. None of the side rails have to be folded in or out during travel, as often is the case on other buses. This allowed faster entry and exit and was very appreciated.

The decreed backwards position during travel is regarded to increase safety, although giving a diminished experience of the journey. One traveller expressed fear that no crash tests had been done with wheelchairs. The corral is not equipped with any form of seatbelt, which is mainly found advantageous. Many travellers believe such belts to be unprotective and feel forced to use them although nobody else on the bus does. A few however miss the seatbelts and their ability to prevent rolling for wheelchair travellers with uncalibrated brakes. One

wheelchair traveller had to hold the rails at all time and could thereby not use a mobile phone during travel.

The stop button is located behind the back of travellers seated in the corral and was almost impossible to reach. The blue disabled stop button was even further behind them, and travellers pointed out that an ideal placement would be above the USB-outlets in front of them. None of the monitors could be seen from the wheelchair department; especially not the one proclaiming stops to come. As the windows also were too high up to allow a good view of the exterior, many travellers had a hard time knowing where they were or when to get off. They commonly desired a monitor that could be seen when facing either backwards or sideways in the open area.

Use of other areas

The Electric Concept Bus was found to allow several wheelchairs to travel at once, which was regarded a major improvement over other buses. Two wheelchairs could fit beside the corral and at least one more could fit in front of the door. These placements were regarded somewhat less safe, but still provided enough safety to use them. The placement just outside the corral was used by one wheelchair traveller during a full trip. It proved to work, but the rail was too high to be held comfortably, and the view out of the windows was even less than in the corral.

Most travellers with reduced mobility prefer to sit close to the door, but other seats as regularly used as well. Using other seats could however lead to problems in signalling to get off, as the blue disabled stop buttons only occur at a few places.

The monitors

The stop monitors were found misplaced for all travellers not facing front. Travellers seated sideways could sometimes see them if they twisted their body, but not all of them were able to do so. The side monitors suffered from glare when observed from below, and darkened when watched from the side. Travellers therefore often desired more monitors at relevant places.

WiFi and mobile charging

Some wheelchair users did not want to hold their phones while travelling, as they used their hands for other purposes. It was therefore often impossible to use the USB-ports, and some travellers suggested shelves below the outlets where phones could be placed.

Ticket machine

Several travellers with reduced mobility have obtained special cards that allow them to travel without having to pay or even show their card. This does however not apply to all, including many elderly travellers that have to pay during peak hours. Travellers fear that they will not

be able to walk up to the ticket machine and thereafter find a seat before the bus starts to run. Suggestions regarding machines where the card could be shown when boarding or when seated were common. Although one ticket machine is placed close to the wheelchair department, it cannot be used properly from the corral since it is facing outwards.

Doors and windows

The windows cannot provide a good view of the exterior, as they start rather high up. The hammer for breaking the glass can likewise not be reached by most travellers with reduced mobility. As travellers with reduced mobility prefer not to move around when seated, they find the lack of sun curtains more disturbing than other travellers.

The wide doors allow many travellers to enter and exit at the same time, even when a traveller with reduced mobility is going in or out. This is found important for the travellers, as it allows them to enter or exit without having to feel any stress or sense of disrupting others. Wheelchair users could however only barely reach both side rails of a door when heaving themselves up, and would often try to use one only. All subjected travellers in a manual wheelchair managed to do so, but it might be difficult for some. It is however likely that most travellers not using the ramp would be able to do so. The travellers with reduced mobility appreciate that the doors open outwards, as this makes it much more unlikely to get hit by a door.

Rails

Travellers regularly use the rails to move around and find them more abundant than in other buses, while still not obstructing the way for wheelchairs. The side rails of the doors were far between, but the increased height distribution could make boarding easier. Many travellers who regularly use rails to board however found it unnecessary on the Electric Concept Bus due to the low floor.

The ramp

A majority of travellers with reduced mobility do not want to use a ramp. It makes them feel stigmatised, standing out as a person that cannot function as everybody else. The low floor was therefore a highly regarded part of the Electric Concept Bus. Travellers with severely reduced mobility reluctantly accept the ramp, although often preferring a ramp that they could control on their own. A few are however afraid that such a ramp would be more prone to break.

The ramp used in the Electric Concept Bus reminisced traveller of similar ramps where the opening handles tend to gets stuck from assembled dirt. This is however likely less of a problem in the daily-maintained Electric Concept Buses. The incline of the ramp was found small enough to allow easy boarding, and a small elevation at the end prevents wheelchairs from sliding off at high speed. Travellers however find it unfortunate that only the front door is

equipped with a ramp in case one door breaks. Indeed, the front door is often more difficult for drivers to open, as well as more prone to break.

Height of the bus

No traveller had ever witnessed a bus as low as the Electric Concept Bus, and the low height was universally praised. The incline arising when tilting the bus down to a bus stop was small enough not to interfere with the travellers on the bus. Several travellers desired an increased tilt so that the bus could get flush to the ground. One idle bus at the indoor bus stop was encountered untitled, which led to problems when boarding. The bus driver had likely forgotten to tilt it when parking, as no traveller with reduced mobility was on-board the bus when it arrived.

5.2.13 Drivers' perspective

Numerous issues were raised during the interviews with drivers, and these are divided into different categories. These concern Overall Opinions, Working Environment, Handling the Bus in Traffic, Design of the Bus and Societal Issues and development of electric buses. There is a slight overlap between the categories, especially Working Environment and Handling the Bus in Traffic, but the latter is focused on actual driving and issues directly related to that, while the former concern more static issues.

Overall opinions

All subjected drivers were remarkably pleased with the Electric Concept Buses and the ElectriCity project. The buses were regarded superior to every other bus they know of, including the electric hybrids. While the overall comments had a very positive tone, drivers easily mentioned certain negative issues and aspects of the bus.

No driver could however mention any negative sides of the ElectriCity project as a whole. It was regarded a forerunner project making an impact on the environment and gaining publicity for the city. Most drivers spontaneously mentioned that they were proud to be a part of it. A few negative sides of the working environment could somehow be attributed to the project, even though the drivers did not. Issues regarding the buses and the service are often regarded to be separate from the project, and it is hard to know what the drivers actually attribute to the project and what they know about it. This could be a reason for the absence of negative criticism of the project.

All drivers taking part in the project have specially applied to be a part of it, and have thereafter chosen to stay. The interviewed drivers may therefore not be representative for the bus driver profession as a whole. They could constitute the enthusiasts who really appreciate the project and every part of it.

Working environment

All but one driver find the Electric Concept Buses' working environment superior to other buses, and the remaining one found it at par with others. The main cited reasons for the superiority are a lower sound level, an expanded field-of-view from the driving compartment and a softer drive. There were however several aspects of the driving environment unanimously regarded as less attractive.

Sound level

All drivers spontaneously mentioned the reduced sound level as one of the main benefits. The low amount of noise makes the drivers less irritable and less stressed, as well as allowing them to uphold a positive approach and a high vigilance. Many believe that it makes them less tired as well, which in turn makes them safer in traffic and gives them a more meaningful spare time. The low ambient sound level also allows the drivers to listen to music while driving and many would indeed do this, as it makes them even more positive and less tired. Drivers also find it easier to detect other sounds in the bus, despite being seated in an enclosed compartment. Communication with the traffic control is likewise easier for both ends, as the voices are not covered in noise.

Other sounds were however regularly mentioned to be far louder than in other buses. For example, the fan system was found to have a high sound level already at the lowest step, as well as lacking the stepless regulation in other buses. An extra fan system will automatically start if the temperature rises above 18°C, and this is found even louder totally impossible to control. It is worth to note that the sound level of these features may well be at par with other buses and are only made more apparent by the lower overall noise. As all drivers find the sound level to be much more comfortable in the Electric Concept Buses than in other buses, it can be assumed that these sounds are less of an issue than the overall motor noise. Many drivers still express a desire for electric buses to be completely silent, and want the other noises to be lowered as well.

Fumes

Some drivers mention the lack of fumes in the bus as a contributor to a better working environment. They found the amount of bad odours in the drivers' compartment to be lower than on other buses and that this allowed for a more pleasant driving experience. The buses however traverse a route where non-electric buses occur as well and the air will still contain some fumes. The electric drive may provide some explanation to this phenomenon, but the enclosed driving compartment and the distance from the door may well contribute as well. It could also be the effect of placebo, as it may be found a rather odd aspect to mention. It could emanate from information campaigns or even earlier interviews regarding emissions that have made the drivers more aware.

Driver placement

The drivers are placed in an enclosed compartment, as well as in the centre rather than to the left. Some drivers found it hard to separate these two issues when discussing their working environment, but where encouraged to try.

The central placement was a cause of division between the drivers. All of them found it hard to cope with in the beginning, forcing them to obtain new reference points and develop new strategies on how to drive. Some learned to master it quickly, while others struggled for months or indeed up until this very day. Certain drivers still lose their placement on the road, and hit objects with the protruding side mirrors. Narrow bus stops or bad weather are issues found to make central driving harder. Some drivers therefore experience that they have less control when driving Electric Concept Buses and that they have to focus more when doing so. Switching between the different bus types, as well as between left-hand drive on cars and Electric Concept buses, was found an issue as well. The switch from central drive to left-hand drive was regarded more difficult than the opposite.

Central placement was preferred by a small majority of the drivers who could select one of the two. Several drivers could however not choose which one they preferred. Central placement is found to significantly increase the field-of-view in all angles, making the drivers more aware of the traffic situation and thereby driving safer with less effort. The view towards the right is especially expanded, as the drivers find it possible to look backwards and see through all the windows of the bus. This was used when leaving Lindholmen for Teknikgatan, where the drivers have to cross a traffic island to get into an ordinary lane. Only the Electric Concept Buses provide enough sight to do this safely, while hybrids must cross the traffic island by chance.

The drivers are seated on top of the front axis in the Electric Concept Bus. This is found to give a more comfortable and less bumpy drive, although less compliant with the travellers journey. Travellers are mainly seated in the wide gap between the axes, and experience a much less comfortable ride. The drivers try to adapt to this by driving even more careful and cautious, but find it difficult to judge exactly how they should drive and which consequences it will give. The result is that the travellers get a less gentle ride than what the drivers actually want to give them.

Enclosed driving position

The enclosed drivers' compartment is far less appreciated than the central drive. The drivers could think up some advantages of it, but find them insignificant compared to the reduced communication. All travellers enter behind the drivers, without getting eye contact with them when they board. Some drivers describe that the travellers do not even look at them when passing them on the outside. They blame this on the physical separation, and believe that it makes them look as though they do not want to communicate.

Travellers are described to only knock on the door if they have a really important question, which has made all small-talk disappear. To answer a traveller, the drivers must brake the bus, shift to neutral gear, activate the handbrake, turn the seat and open the door. This is found to be too complicated. No communication can take place during driving and drivers find it significantly harder to intervene if an unpleasant situation should arise on the bus.

There are a few advantages arising from the enclosed compartment. It allows the drivers to listen to music without disturbing others, as well as choosing a temperature separate from the rest of the bus. It can make them more focused on driving, as well as protected from violence in the bus. Moreover, travellers cannot stand beside the drivers and block their line of sight. Drivers describe that they sometimes have to reprimand travellers tens of times each day about this in other buses, which drains them of energy.

Vibration

Some drivers mention the Electric Concept Bus to have a reduced amount of vibrations, making the drive more comfortable and less harmful for their bodies. The hybrids were found inferior as the vibrating diesel engine could start at any time. Drivers sometimes mention their placement above the axis in conjunction to vibrations.

Mental working environment

Most drivers find service 55 to provide a much less hectic atmosphere overall. The small intimate workforce is mentioned as one reason, as well as the 10-minute gap between each trip. The gap exists to allow recharging the bus but makes a great time buffer as the bus can get fully charged in 5 minutes and will sustain two trips back and forth without charging. The drivers argue that they can afford to wait longer on the bus stops and allow everybody to get seated, as well as not having to worry that traffic jams will affect the entire day's schedule. The gap allows drivers to stand up or walk for a while and will thereby help preventing back pain. It can also allow them to grab coffee or tea at Lindholmen when they like.

Some drivers argue that the relaxed mood affects the travellers as well. All drivers find the travellers on service 55 to be more calm and understanding than other travellers and that this affects them positively. Some drivers note that the travellers must be pleased with the bus and the journey, or else they will show off their anger to the driver.

Handling the bus in traffic

The drivers generally find the Electric Concept Buses easy to handle in traffic, although some still struggle with the sideways positioning. Most find the handling equally easy to other buses, although the increased field-of-view is found to provide safer handling. There are however specific situations in which the bus differs from others. Some drivers find the Electric Concept Buses superior to hybrids when having to stop close to a sidewalk. The hybrids are regarded to protrude further out from the wheels, which make them more likely to hit an edge. The wide span between the axes of the Electric Concept Bus is often mentioned

to decrease the turning radius and allow sharper turns. This is regarded advantageous, although demanding another driving style. The low floor makes it impossible to cross sidewalks without damaging the underneath of the bus, which some drivers find problematic in case they have to divert from the ordinary route.

A few drivers experience the electric motor to be very strong and spouting such a rapid acceleration that it is hard to sport a soft ride. Other drivers however find the electric bus to naturally support a smoother drive. This is interesting, but an explanation may be found in the software. One driver actually argued that the built-in software has been changed and that the initial rapid acceleration has been toned down. This may well be the case and could make drivers believe that the initial problems still exist, only that they have learned how to cope with them.

Several drivers acknowledge problems with staying still uphill. Electric Concept Buses are found to roll backwards in a slope if not constantly accelerating or if the driver presses a hold-button reserved for bus stops to keep it still. Braking the rolling bus is regarded to give a hard uncomfortable stop, while rolling forward at low speed leads to a stuttering drive. This problem is never encountered with the hybrid buses and is found problematic.

Driving aid systems

The buses are equipped with several driving aid systems aimed at helping the drivers. Zone Management caps the speed in certain areas and prevents diesel operation for the hybrids. The drivers appreciate this feature, as it allows them to focus less on the speedometer. It is rather common for drivers to forget about current speed or speed limit when driving and this feature helps them to stay safe. There are however a few issues in the current implementation. The speed cap above the draws of the Göta Älv Bridge is said to protrude further out on the sides, making it impossible to accelerate when other vehicles expect the bus to do so.

Surprisingly few drivers mention the Pedestrian Detection system, which is aimed to give a warning if somebody steps out in front of the bus. Drivers instead request various pedestrian safety systems, such as exterior airbags, ringing sounds when the bus starts or a device counteracting the low floor that could crush a pedestrian getting hit. The amount of suggestions in this area is rather astonishing. It suggests that the system in place is not sufficient, not working or somehow shut off. The system should benefit from a separate investigation.

Special features of the Electric Concept Bus

The Electric Concept Bus has a few special features not usually present in buses. Some of these are used during driving and affect the driving situation. One feature concerns locking the foldable seats and thereby preventing travellers from opening them. The reasoning behind this is that travellers should stand during high-traffic to allow more people on the bus.

This feature is however met with mixed reception. A few drivers will indeed lock the seats in high-traffic, while others would never do it. It is found difficult to judge exactly when the bus is getting too crowded, and most seats are often already in use at that moment. The seats also show no indication of being locked and some drivers find it confusing for the travellers. They argue that travellers will not understand why the seats sometimes can be opened and sometimes not and believe that this will affect their trust in the bus. Drivers also disapprove of the seats being locked as a standard when the bus starts in the morning or after a restart. It is not uncommon for drivers to forget about unlocking the seats, even though they would want them to be usable.

Many drivers mention the extra lights that the Electric Concept Bus is equipped with. Some use them only rarely, while others regard it a nice way to show off the bus. It is sometimes argued that the extra lights can make travellers more happy. One of the extra lights is placed low on the exterior side of the bus and is aimed at showing when the bus will turn. Drivers will however sometimes use it to light up sidewalk edges during dark hours.

A monitor in the drivers' compartment shows a live video feed of the bus interior. This allows drivers to see when all travellers are seated or have disembarked, and it is found a major improvement over other buses. Some drivers indeed mention that accidents do occur in other buses due to insufficient overview. They however find that the monitor could still be improved by increased resolution or using another camera in which the entire bus could be seen.

The doors have no closeness sensors on the inside and this is highly appreciated. Drivers describe that all other buses, including the hybrids, are equipped with sensors that prevent the doors from closing if somebody is too close to them. This regularly leads to only a few doors getting closed when the driver presses the buttons, and force-closing therefore has to be used. Force-closing the doors will however open all the doors that have become closed, and drivers describe a pulse of opening and closing doors going through the bus. The Electric Concept Bus only uses sensors at the edges of the doors to prevent travellers from getting stuck and drivers find this to give them much more control over the doors.

Travellers

Most drivers find contact with travellers to be very important. The enclosed compartment and impractical microphone however makes them more separated than on other buses. Drivers describe that they tend to greet all travellers and help everyone in need when driving the hybrids, whereas travellers on the Electric Concept Buses instead help each other.

All drivers are very fond of the travellers on service 55 and regard them to be the best travellers possible. It is sometimes believed that travelling with the 55 is an active choice, leading to a specific and more pleased clientele. Some drivers believe that the relaxed mood

on the bus and their own positive attitude affects the travellers as well. It is often mentioned that nobody would start driving unless everybody is seated and that they always want to help those with reduced mobility to get on or off.

Although the interaction between driver and traveller is limited due to the enclosed driver compartment, travellers still tend to ask questions. Drivers point out that younger travellers often ask about the route, whereas older ask about the technology. Indeed, several drivers mention that the most common question nowadays is whether the bus is bound for Hjalmar Brantingsplatsen. The amount of technical questions and spontaneous comments has decreased significantly over time and now almost solely occurs at the end stations, although very rarely there as well. It is however worth to note that no driver has ever heard any negative comments. A few travellers have become disappointed when they learn about hybrids being used on the service as well, but that is about all.

Design of the bus

Certain aspects of the bus have no direct influence on the drivers' working environment or the ability to drive the bus. Drivers however still mention such issues, both in terms of what exists today and what they desire to have in a bus.

Many drivers appreciate the Electric Concept Bus' open interior. They find it to provide space for many travellers, as well as allowing faster embarking and disembarking. The two large doors are regarded important factors in this as well, and their central placement makes it easier to see all travellers on the move. The large size of the doors is believed to reduce dwell time at bus stops, but increase the amount of cold air entering the bus. Some driver find the sound of an opening door to be remarkably loud, but this is likely an effect of the reduced engine volume. The bus is shorter than regular buses but drivers find this to be mitigated by the open layout, concentration of doors to the centre, design of the doors and the large axis span. Some drivers however still find that the Electric Concept Bus easily gets crowded, and would want an elongated version.

Many drivers mention the on-board WiFi and the USB charging ports, not only as positive aspects for travellers but also as feature they use themselves. Many drivers recount that although these features are used every day, the amount of travellers actually using them are very low. Indeed, most drivers initially believed that they would be used to a much higher extent, and that they would find lost mobile phones on the bus each day. They speculate that the reasons behind may be that travellers do not bring charging cables, do not see the outlets or are seated elsewhere in the bus or simply find the journey too short to charge their phones.

Desired features

Drivers mention that children cannot sit safely on the bus, and request special children seats or convertible seats that can work for children as well. Others ask for seats with adjustable

height to fit other travellers as well. Some drivers ask for a rear-view camera that can help them to reverse the bus, and others desire a dashboard camera in case something happens. A few drivers actually use their mobile phones to film every journey today to be on the safe side.

Defibrillators and reachable first-aids kits are regularly asked for, as the present first-aid kit is only possible to open with a square key never brought on the bus. Others desire plastic gloves for cleaning or replacement bags for the litter box, or even a toolbox in case the bus breaks.

Societal issues and development of electric buses

The drivers provided input on the overall consequences of electric buses, both regarding the present situation and in case the electric bus network is extended. All subjected drivers have a very positive attitude towards electric buses as a phenomenon and envision a near future in which they are more abundant or even standard. Some drivers could not provide any negative aspects of an extended electric bus network, although others had a more realistic outlook.

All of the drivers believe electric buses to contribute to society as a whole. They regularly mention their role in achieving a quiet urban environment and find electric buses to harmonise with the citizens and their activities. Some drivers acknowledge that pedestrians may find it harder to notice silent buses and believe audial or visual signals to be necessary in preventing accidents. Others take a more cynical stance and believe that certain pedestrians never will look around in traffic no matter what. No driver mentioned any issue for pedestrians with reduced vision.

The absence of combustion fumes is widely mentioned as a positive effect of electric buses. Many drivers believe electric buses to play a vital role in making the air more clean and the environment less toxic. Some even believe that the electric buses will improve the society's overall health situation. It is interesting to note that only a few drivers mention reduced emissions from a global standpoint, as a mean to reduce global warming. These issues may be too large to grasp or discuss, or seem too far away from a small-scale bus project in a northern city. It could however also be regarded too obvious to even mention.

Expansion of electric bus system

Many drivers believe that electric buses could completely alter public transport and what it stands for. Some of them envision a future where travellers can take an elevator from their flat to a bus stop, and go with the bus trough Nordstan or Sahlgrenska to the exact point they are going. One driver found this especially advantageous for elderly and those hard of walking and believed that Färdtjänst could be abolished with such a system in place. It is hard to know if these envisions are the drivers own concoctions or if they reflect visualisations done by Västtrafik. Either way, it still serves to illustrate that the drivers see a lot of potential in the subject.

Charging is regarded to be the most challenging issue in an expansion of the electric bus network. This is hardly surprising, as the main problems with the buses of today are all related to charging. Drivers stress the importance of charging stations that continuously keep working without breaking down. The fact that numerous charging stations have to be built around the cities is found to be logistically and monetary challenging.

The large time buffer between the trips at the 55 is regarded essential in every expansion to assure time for charging even if the bus is belated. Drivers note that this increased idle time will mean an increased number of buses to uphold the same frequency of service. There is a fear that the generous time buffers will be stripped away in an expansion and some drivers note that fully charged backup buses will in that case be necessary on each end station, if a battery-swapping system is not conjured.

5.3 TIGot3

Four special bus stops have been built along the route of the 55, including an indoor bus stop at on of the end stations. Several travellers recall visiting one of these stops, although the indoor bus stop was the one most commonly remembered.

5.3.1 The indoor bus stop

All interviewees appreciate the indoor bus stop, and use strongly positive words to describe it. The two most enjoyed features are the provided shelter during wintertime or bad weather as well as the possibility to board and secure a seat at waiting bus at all times. This proves to be a somewhat oxymoronic combination, as the ubiquitous boarding renders the indoor waiting area unnecessary. Travellers state that they rarely ever use the indoor facilities, and instead prefer indoor bus stops in the middle of routes where they actually may have to wait for a bus.

While the bus is often entered at the indoor bus stop, most travellers choose to exit at the stop before. This is because of the long route the bus has to take between the two nearby stops. Some travellers will also board the bus at the stop just outside the indoor bus stop, as it is a closer walk from the main interchange point.

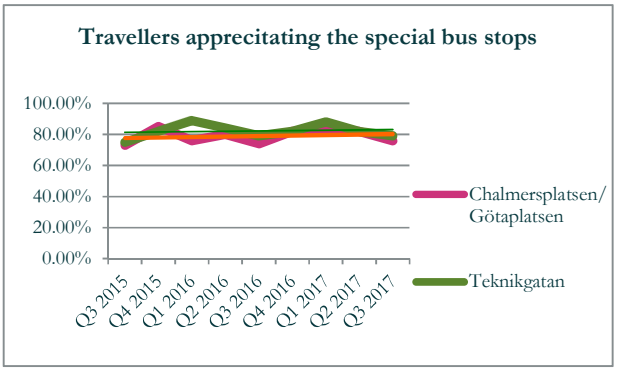
The indoor bus stop is often described as ‘comfy’, nice and clean. It is regarded to be a safe waiting place during dark hours, as it is light, furnished and has a size that makes it neither claustrophobic nor desolated. The bus stop is often mentioned to be silent, as the buses are mostly idling and surrounding sounds are not let in. The lack of exhaust fumes was however not mentioned at all, even though some travellers were probed for it. This may indicate that the travellers see the stop more as a bus storage where the buses can be boarded, rather than a busy place where they actually travel and could emit fumes. Some compare the stop to indoor waiting areas with buses standing right outside. The fact that such areas rarely smell could contribute to not noticing the lack of fumes it in this case.

The departure monitor is regarded hard to find and many regular travellers are not aware of its existence. It is regarded small compared to the other screens in the bus stop and some travellers find it unnecessary to use a regular monitor with rows for many different services when this stop only is traversed by the 55. Travellers commonly ask for an easy-to-read departure monitor outside the bus stop, so they can know on forehand if they should enter the shelter or not.

The café is appreciated but none of the subjected traveller has ever used it in conjunction to the bus. The same reasoning applies to the chairs. One traveller mentioned the electric outlets in the chairs, but only when probed for positive aspects of the stop while watching the chairs. The large interactive information screen suffers from similar issues, although it is also

regarded messy and containing too much information to be of any use. Travellers want the map on the screen to show their current location, the route, and a live feed of where the buses are at the moment. Other information is regarded unnecessary.

The small book exchange is likewise found a good idea that is not really used. It reminds some travellers of the indoor library stop that was used as a gimmick in the introduction of the 55. Many travellers find this an even better example of an indoor bus stop, as it allowed the stop to become something more than a mere stop; a place where the travellers actually may want to go.



Looking at the questionnaire results we find that the indoor bus stop is appreciated by most travellers, and the trend is rather constant. The interview study reasserts this, and finds the total sheltering from weather, the cosy-looking interior and the possibility to board the bus at all times to be the main appreciators. The contradiction between a large furnished indoor bus stop and a bus that can be boarded at all times is a reason why it is not fully appreciated. Some travellers find it unnecessary, and would prefer such bus stops in the middle of a route where they actually could be used for waiting.

The Co-design workshop focussing on the interior design of the indoors bus stop confirmed findings from observations and on-board interviews in that the location of the bus stop really didn't suit itself to make an area that was used as something completely different than a place to wait for the bus and work therefor focussed on making the interior more "indoors-like" and consequently to stand out more.

Figure 16: The Co-design workshop at the bus stop.

The result of the workshop was presented to a interior decorator who developed the solutions into something possible to execute in cooperation with Chalmersfastigheter. The new design was implemented March 2018 and proved to be more indoor-like, more pleasant to be in, and better held together (negating the garage + living room feeling).

Figure 17: The redesigned interior of the indoors bus stop

Figure 18: Sofas, greenery, information

Figure 19: Seating area

5.3.2 The bus stop at Sven Hultins plats

Many travellers have frequented the other end station as well, but few have noticed anything particular about it. They board the bus directly and never enter the inconspicuous shelter. Only one traveller had used the book-swapping pedestal, while another one believed it to be a vending machine for tickets. The sound-insulating properties of the shelter are not mentioned, partly because of the low noise from an idling electric bus, but mainly because it is not entered.

5.3.3 The bus stops at Chalmersplatsen and Götaplatsen

Several travellers recall waiting in one of the semi-enclosed bus stops, although often not able to recall any differences from regular shelters. The shelters are mentioned to look more windproof than other bus stops without actually being that. Some travellers recall the heated seats at Götaplatsen, and find this very positive during wintertime.

The shelters are found difficult to exit even with small crowds in them, as the large centre pillar blocks the way. The departure screen is hard to see, as it is placed at one location within the shelter. The touchscreen for searching travel instructions very is rarely used. Travellers who use to search for such instructions do it on their smartphone and those without a smartphone are not used to do such searches at all. It is moreover found to have low usability. The interface returns to the first screen before travellers finish searching, and this return seems to be based on total interaction time instead of time since it was last touched.

The observations studies at the various bus stops showed that the Götaplatsen one was the bus stop that succeeded the best in achieving the integration between the city and the bus system the best. It is interesting to note that this was not as much a result of the actual design of the shelter, as its location within the city. Since it is located on an open space in front of the city library the whole area (including the library itself) was used as a waiting space, and at the same time one can argue that the bus stop was used as an extension of the library with people reading they recently borrowed books on the bus stop. In contrast, the other new bus stops (for project reasons) were located somewhat off the beaten path and therefor had little chance of being an integrated part of city life.

Figure 20: The Götaplatsen bus stop

5.4 Demo showcase

The Gothenburg demo was showcased in January 2018. About 30 people from the city of Gothenburg as well as from different parts of Europe showed up. During the Demo showcase all three TIs were presented, TIGot1 by Volvo Bus and TIGot2 and TIGot3 by Chalmers. After lunch, Keolis and Volvo Bus had organised an extra fully electric bus to take us to the indoors bus stop at Lindholmen. On board were three of the regular chauffeurs of line 55 giving ample opportunity do ask any questions about the demonstration bus line and relative benefits and drawbacks of the bus line from a chauffeur's perspective. After a quick stop at the bus stop where representatives from Chalmersfastigheter who owns and operates the bus stop gave a presentation on how it is to own and operate an indoors bus stop, we all returned to the city centre.

Figure 21: Some of the participants at the Demo Showcase

6 Partners' contribution

The following partners have contributed to completion of the deliverable as specified below.

Institution/Company	Sections	Description of the partner contribution
Chalmers University of Technology	All	A draft version of the deliverable, including all chapters and sections, as well as updates based on input from partners (below) as well as from the work on KPIs etc. within WP2.
Chalmers Fastigheter	TI-3	Contribution to content regarding TI-3. Review of content
Volvo Bus Corporation	TI-1	Contribution to content regarding TI-1. Review of content
Västtrafik	TI-2	Contribution to content regarding TI-2. Review of content
UITP	All	Review of content Quality check

7 Conclusions

The Gothenburg activities in EBSF2 has shown that the electric buses and re-designed bus stops are very popular among the travellers as well as the bus drivers. Perhaps equally as important the activities have shown that the electric bus line as a whole is very well liked, not just for the technical innovations but also for competent drivers and focus on maintenance and comfort.
The good reactions to the bus line has convinced the public transport provider to continue with its plans to further electrify their bus lines, the second line opening summer of 2018. Some details such as USB charging ports in the buses have already been installed in all buses during the duration of the project.

In terms of interaction between bus and urban infrastructure, the project has show that indoor bus stops are indeed a viable option that is well liked by the public. However, the placement of said bus stop has been demonstrated to be of vital importance to reach the added value necessary for such a big investment.

Finally, the project has demonstrated the very large energy savings that can be achieved from installing heat pump technology and more carefully designed insulation, in our case a 60% reduction in energy use for heating, which leads to a 17% reduction in total energy consumption for a standard size electric bus.

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