Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Testing innovations for increased energy efficiency of electric buses: evidence from the EBSF_2 project

Michele Tozzi[a]*, MariaVittoria Corazza[b], Umberto Guida[a], Antonio Musso[b]

[a]International Association of Public Transport - UITP, Rue Sainte-Marie 6, 1080 Brussels, Belgium
[b]Sapienza University of Rome, Via Eudossiana 18, 00184 Rome, Italy

---

Abstract

EBSF_2 is a three-year research project which came to an end in April 2018. The project was led by the International Association of Public Transport and funded by the European Union with the aim of increasing attractiveness and efficiency of urban bus systems. Real-life demonstrations in 12 cities addressed diverse areas for innovations, but for several test sites the main goal was to deploy and test solutions for increased energy efficiency of urban bus fleets. Optimize the energy management, lower the energy needed for on-board auxiliaries, including heating, ventilation and air conditioning systems, and thus minimizing the impact on the total energy consumption of electric buses and their operation, were the tasks to be accomplished.

The paper describes how the topic energy efficiency was addressed within the EBSF_2 demonstrators. The assessment methodology designed to measure the performance variations in each demonstrator and cross-case is presented, together with the testing scenarios and the main results achieved in four demonstrators impacting the energy efficiency domain.

© 2018 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Energy Efficiency; Electro Mobility; Thermal Management; Auxiliaries.

1. Introduction

The European Bus System of the Future 2 (EBSF_2) is an Innovation Action funded by the European Union within the Horizon 2020 Research and Innovation programme and coordinated by UITP – the International Association of Public Transport. Coherently with the results of the previous EBSF (2008-2013), EBSF_2 (2015-2018) combined the efforts of 42 European bus stakeholders to optimize the efficiency of urban bus systems, improve the reliability of operations and raise the image of the bus for the users.

EBSF_2 combined experiments with research as it relied on demonstrators, i.e. innovative technologies have been

---

* Corresponding author. Tel.: +32-2-7880129
E-mail address: Michele.tozzi@uitp.org

2352-1465 © 2018 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

tested on vehicles operating in European bus networks and evaluated through a methodology to assess the soundness of the innovations and their affordability. More specifically, the project consortium has identified six research areas with the highest potential to produce breakthrough changes in the existing bus scenario, namely:

- Energy Strategy and Auxiliaries,
- Green Driver Assistance Systems,
- IT Standards Introduction in Existing Fleet,
- Vehicle Design (in terms of capacity, accessibility, and modularity),
- Intelligent Garage and Predictive Maintenance,
- Interface between the Bus and Urban Infrastructure.

The theoretical vision behind the six research areas is that innovation for buses is a multi-comprehensive concept, involving the study of requirements and performance of vehicles, infrastructures and operations by investigating the needs of all the relevant actors involved (i.e., passengers, operators, drivers, manufacturers, etc.).

In three years' time, about 30 technological innovations (TI) have been deployed and tested by the local demonstration teams in 12 urban areas across Europe, namely: Barcelona, Dresden, Gothenburg, Helsinki, Lyons, London, Madrid, Paris area, Paris city, Ravenna, San Sebastian and Stuttgart. The solutions are very different and so are the results achieved, but energy efficiency is behind the majority of them. One of the key objectives of the project was to optimize the energy used for on-board auxiliaries and thermal management, with a focus on electrically-powered buses where this task is even more important, in comparison to conventional diesel buses, due to its impact on the operating range. Currently, auxiliaries account for 15% to 25% of the total energy budget of an Internal Combustion Engine (ICE) bus, but they can rise up to 50% in the case of electric propulsion with no excess heat energy to exploit. Thus, against a background of limited energy resources in traction batteries, the use of highly efficient components and on-board sub-systems as well as intelligent thermal management (e.g. reducing the heat loss via interior and exterior design solutions and insulation) are a major prerequisite to reduce the overall vehicle's consumption. In addition, increased reliability of the auxiliary components is leading to lower vehicle's operational costs (maintenance costs, vehicles' non-operational time) as well as achieving acceptable operating ranges. Many solutions for new buses, especially electric buses, can be also adapted for retrofitting of buses already in operation.

Energy management strategies exploited within EBSF_2 are based on both real-time and anticipation of the near future operating profile. This predictive component is based on schedule, the vehicle's en-route position, street geometry and topography, and enables more adaptive and higher-level system control than traditional real-time but algorithm-based control.

Heating, ventilation and air conditioning (HVAC) are an important area for improvement in both ICE and battery-powered buses due to their high power needs. A combination of measures can increase the efficiency of air conditioning units as well as reduce heat loss via the interior and exterior design of buses. Effective circulation of air could also help maintain a comfortable temperature inside the bus with less energy input. Fresh air is required to control moisture/condensation on window surfaces which is imperative especially during snowy winter conditions.

Furthermore, solutions related to the bus stop event, such as controlled door openings for less heat exchange or a totally indoors bus stop, although specifically designed to improve operations or attractiveness, can have positive consequences in terms of energy savings. The design of bus doors may serve as case in point: within the EBSF project, prototypes with larger door blades or with a fifth door were respectively tested in Gothenburg and Budapest with the primary aim to speed up boarding and alighting operations. The possibility of reducing the overall fuel consumption due to the consequent shortened dwell time at stops resulted to be not negligible (Corazza et al. 2016a). Within EBSF_2, the feasibility of an 'indoor' bus stop has been demonstrated in Gothenburg, for increased attractiveness of the bus system while solving technical challenges associated with maintaining a comfortable climate. The test showed that the technology works and that the intended benefits for the passengers are there, even though no assessment in terms of potential energy savings has been performed. As a consequence, this papers focuses on the 4 EBSF_2 demonstrators impacting the project's research area Energy

Strategy and Auxiliaries for electric buses.

2. Developing and testing innovations for energy and auxiliaries management

Within EBSF_2, diverse energy management strategies have been testing since mid-2015 with different implementation plans at each demo site. Focus is on the efficiency of the auxiliaries and sub-systems on-board as well as on (active and passive) thermal management to lower the energy needed for passenger cabin heating, ventilation and cooling. Table 1 shows the demo sites actively involved in the test on Energy Strategy and Auxiliaries and provide a short description of the solutions deployed and tested by site, which are further detailed in section 4.

Table 1 – Scope of demonstrations on Energy Strategy and Auxiliaries

Test site	*Solution deployed and tested - definition*	*Solutions deployed and tested - explanation*	*Test-bus propulsion technology*
Barcelona	Intelligent Energy Management	An intelligent energy management system that anticipates the energy demand of auxiliaries and optimise the energy flow between them and the energy storage unit has been developed and tested.	Electric
	Thermal Management	Solutions to optimise operation mode and management of HVAC components have been investigated. Modifications were applied to the climate and thermal management system at two levels: • Simplification of the HVAC system, by using only one compressor and redesigning the two circuits turning into a single one. • Optimization of the ECU (Electronic Control Unit) system software.	Electric
Gothenburg	New Energy-Efficient Heating Solution	A new heating system to reduce energy consumption was developed within the project. This new system is driven by electricity and bio-fuel. The main innovative energy saving component in the heating system is the roof mounted air to air heat pump and integrated air condition unit. Utilizing the heat pump process where Coefficient Of Performance around 3 can be obtained under certain conditions, results in 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.	Electric
Helsinki	Adaptive Control for Auxiliaries	A real-time optimized control for auxiliaries has been studied. This system is based on an innovative adaptation scheme that uses real-time data collection from the bus together with the real-time en-route position, traffic situation and characteristics of the line ahead to determine the optimum use of the auxiliaries. A back-office system collects all the data on-line, processes it, and feeds the bus with optimised use profiles in real time.	Electric
Stuttgart	Innovative HVAC for Battery-Only Buses	An innovative HVAC system for city buses was designed to reduce energy consumption compared to conventional belt-driven systems while providing an acceptable level of comfort for passengers. The new solution is equipped with heat pump technology and an electrically-driven refrigerant compressor.	Diesel modified to simulate an electric bus

The variety of demo sites allowed the comparison of results achieved in different physical environments, hereby providing an evident added value, since climate conditions, topography, bus infrastructures and operational requirements are variables of utmost importance for the validation of the results and eventually their transferability in comparable contexts. Together the solutions are aimed at improving the efficiency of auxiliaries and optimising the thermal management in new generation full-electric buses.

3. The assessment methodology

As for any other solution tested within EBSF_2, the assessment is focused on a classical before-vs-during-the-implementation comparison of results, with Key Performance Indicators (KPIs) measuring the performance variations in each case study and cross-case (as already extensively reported in Corazza et al. 2016b, Corazza et al. 2016c). In this way, the benefits of each innovation are evaluated by means of performance variation between the control scenario, i.e. the situation preceding the implementation of the TI, and the scenario resulting from the activities to implement it, at each demonstrator site.

To achieve a more accurate assessment, quantitative Performance Targets (PTs) have been introduced to evaluate, at the end of the project, whether the achieved results, thus each performance variation, met the expectations. PT values have been set according to the evaluators and demonstrator leaders' expertise. Each target stems from specific Validation Objectives (VOs), initially set by the evaluators to ensure consistency with the EBSF_2 overall vision, and translate them into clear and measurable achievements. The rationale for introducing such Performance Targets relies on the need to assess whether the initially supposed technological maturity of the innovations can be corroborated by actual performance improvements, strong enough to ensure them a "life after" and reduce the gap prior to their commercialisation following the end of the project.

Consequently, each selected KPI is associated to a specific PT, which in turn is linked to a specific VO as shown in Table 2 for the KPI "Energy demand for HVAC system".

Table 2 – Extract from Validation Objective, Performance Targets and KPIs for Priority Topic "Energy strategy and auxiliaries" (Cascajo et al. 2016)

		PT – Performance Targets		
VO – Validation Objective	*KPI*	*Barcelona: Thermal Management*	*Gothenburg: New energy-efficient heating solution for electric buses*	*Stuttgart: Innovative HVAC system for battery-only buses*
Improving the energy efficiency of specific components (HVAC)	Energy demand for HVAC system	10-15%	25-30%	30%

The EBSF_2 evaluation framework has been completed by a measurement plan. The definition of an appropriate measurement methodology was necessary to provide the demonstration teams with directions on how to collect the data needed for the evaluation, so to ensure comparability between the different sites.

Based on the results of the technical evaluation, a financial and economic analysis has been also performed by comparing the short term costs of the TI within the project with the long term impacts, and drawing conclusions on the prospective impacts resulting from the adoption of innovative bus solutions.

The last step of the evaluation process has seen the involvement of bus stakeholders external to the consortium, experienced in solutions or strategies which represent an innovation in the bus system domain. The selected stakeholders were willing to investigate the replication of the EBSF_2 innovations in their own bus network and they participated in a transferability exercise which produced a customised roadmap in a form of a tailored action plan to maximize transferability potentials.

3.1. The test scenarios

A test scenario describes the environment in which the EBSF_2 demonstrations take place. It includes the entire set of conditions under which the technological innovation are developed and implemented or, in other words, the detailed description of what is going to be tested, when, where and how. As the innovative solutions are very different, 4 categories of testing processes have been identified:

a) simulations,
b) tests in controlled environment,
c) tests under real operational conditions,
d) assessment of technological concepts, code of practice and specifications.

In order to have a proper comparison, the "no EBSF_2 scenario" and the "EBSF_2 scenario" can be tailored to the different combination of circumstances which may apply to each innovation and/or demonstration site (Figure 1).

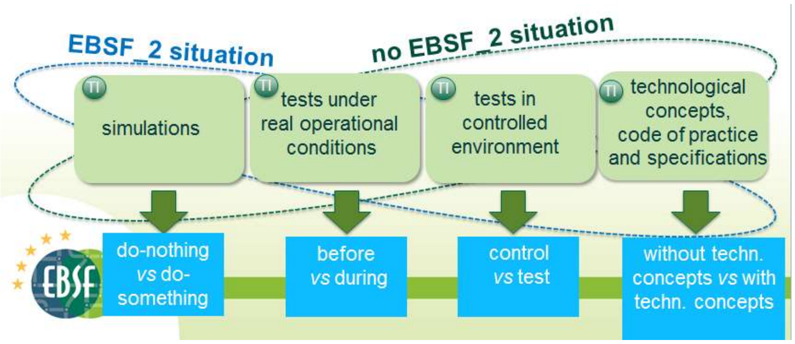

Fig. 1 – The test scenarios

More specifically, the “no EBSF_2 scenario” contemplates the following options:
For innovations to be tested in controlled environment or under real operational conditions

- *before vs during*: the assessment is performed through a comparison between the reference scenario (before) and the EBSF_2 situation (during).
- *control vs test*: the assessment is based on a comparison between the control scenario (during EBSF_2 and with a control vehicle/line/fleet) and the EBSF_2 situation.

For innovations to be tested through simulation

- *do-nothing vs do-something*: simulations provide quantitative and qualitative outcomes to compare a prospective situation without the implementation of the innovation (do-nothing scenario) and the same situation with the implementation of the innovation (do-something scenario). The do-something scenario defines the EBSF_2 situation.

For innovations within the test category “assessment of technological concepts, code of practice and specifications”

- *without technological concepts vs with technological concepts*: being this category based on innovations which have no factual demonstrator, stakeholders involved in the local demo activities are asked to provide a qualitative assessment on how the demo site can develop without and with the considered technological concepts. The qualitative assessment is achieved by means of a specific questionnaire.

For what concerns the innovations associated to the priority topic Energy Strategies and Auxiliaries, the comparison between the reference scenario and the EBSF_2 scenario is based on the assessment of either *before vs during* or *control vs test* performance. This means that these innovations are assessed according to actual tests outcomes, either within usual operations or in a controlled environment, or even both. As an example, Table 3 shows the testing scenarios which apply to Barcelona and Gothenburg.

Table 3 - The EBSF_2 testing scenarios: examples of Barcelona and Gothenburg demonstrators

	Barcelona		*Gothenburg*
Test Category	*Intelligent Energy Management*	*Thermal Management*	*New Energy-Efficient Heating Solution for Electric Buses*
Tests under real operational conditions	Before/During	Control/Test	Control/Test
Tests in controlled environment		Before/During	Control/Test
Simulation			do-nothing vs do-something
Test Features			
Vehicles involved (units)	2/2	2	1/1
Lines involved (units)	2/2	2	1/1
Routes involved (units)	2/2	2	-

4. The demonstrators

4.1. Barcelona

Barcelona is one of the bus networks selected for testing and validating technological solutions for increased efficiency of fully electric buses. Two 12-metre electric buses were already operating within the TMB fleet as part of the ZeEUS project (Figure 2). The results achieved within ZeEUS have paved the way for more efficient operations to be achieved in EBSF_2 thanks to a multitasking demonstrator that deployed two technological innovations: an energy predictive system, to reduce the energy consumptions of the on-board auxiliaries, and solutions to increase the efficiency of climate system and thermal management, including the reduction of maintenance and service costs of the A/C unit.

Figure 2 – Barcelona demonstration: the test bus.

The former was planned to deliver up to 20% energy saving, using a ’self-learning‘ approach (i.e., by learning and predicting energy demands in order to optimise the management of energy flows between the auxiliary systems and the energy storage unit). The logic behind this is that urban bus driving cycles on specific routes are usually similar, then it may be possible to successfully implement an intelligent and adaptive system that optimizes energy requirements. The fact that frequent loading and discharging of energy to and from the storage system increases the consumption and the energy demand for cooling system supports this. In addition, auxiliaries on full electric buses are powered and run independently of driving styles. The deployed predictive system collects several parameters (including the bus position and the driving style) and sends them to the self-learning algorithm. This in turn revises the parameters of, for example, the steering pump and the air compressor, helping the vehicles to function more efficiently.

In addition, solutions were tested to minimize energy consumption for thermal management in warm conditions. Savings were achieved by introducing innovations related to the operation mode and management of components like compressors, condenser fan motors and evaporator blowers and their regulation by the Electronic Control Unit system. The target was to optimize the consumption thanks to a better software regulation.

4.2. Gothenburg

In an electrically driven vehicle the on-board energy consumption for heating is substantially higher compared to a diesel or hybrid driven vehicle. The technical innovation deployed and tested in Gothenburg involved a new energy-efficient heating solution for electric buses that is driven by electricity and biofuels instead of diesel.

The demonstration has included simulation, laboratory tests and tests under real operational conditions. A complete bus simulation model was built to get the overall picture of needed heat power and heat transfer during operation. The model is based on global geometry and dimensions together with material properties. 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 without any people in the bus (passengers were simulated by adding a separate heat source). Also tests in a heat chamber were performed to investigate on what the largest heat loss sources are and a camera with infrared energy detection technology was used to visualize the temperature gradients and identify thermal performance (Figure 3). For the test under real operational conditions, the same approach was applied, hence the evaluation compared the 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 recently-opened electric bus line in Gothenburg (line 55) under normal traffic conditions.

Figure 3 – Gothenburg demonstration: the test in the heat chamber for investigations on heat loss

The two vehicles used in the tests have basically the same geometry and dimension. However, the driveline, heating system and other important design features are different in the two buses. The heating system in the electric hybrid bus is based on conventional auxiliary heater while in the electric bus a complete new system together with a number of energy saving features is applied. It consists of a new heat pump and integrated air conditioner on the roof of the vehicle. Utilizing the heat pump process where Coefficient Of Performance around 3 can be obtained under certain conditions, results in 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 coolant liquid is to be heated using a combination of a 16kW capacity sourced from bio-fuel along with 7kW electrical heating while driving and 9.2kW electrical heating in the depot. Key to the improved performance is pre-heating the bus in the depot, either electrically or by hot water.

4.3. Helsinki

The Adaptive Control for Auxiliaries addressed the energy use of on-board auxiliaries in order to minimise their part in total energy consumption of an electric bus and its operation. The idea is to run auxiliary systems in a maximal way during regenerative braking of the vehicle. In this way the energy flowing from the powertrain can be used directly in the auxiliary systems, and it is not pushed to the battery. Using this approach, the saving comes from the decreased battery losses during the charging in the regeneration phase, and during the recharging, when the energy is taken from the battery to run the auxiliaries. On the other hand, the adaptive auxiliary control is used to decrease the energy consumption on-board directly by using auxiliary systems less or in a different way, when the traffic situation and driving program are known beforehand.

Originally, this solution was planned to be demonstrated with commercial battery-electric buses in real revenue service within an existing bus line. For various causes the schedule of the demonstration in Helsinki Metropolitan area was delayed, and due to this reason the demonstration in real revenue traffic was not possible. As an alternative, the effect of the technological innovation has been evaluated using computer simulation and using the collected data from the buses as an input to the simulation model. The data collection system was set up during autumn 2017, and it gathered reference data of the real-world traffic of bus line 23 in Helsinki. This data was used as a starting point for the simulation and the evaluation.

4.4. Stuttgart

Within the Stuttgart demonstration, an innovative HVAC system for electric driven city buses was deployed and tested. Aim of this demo was to show a reduction in the energy used for HVAC in the amount of 30 % compared to a conventional belt-driven HVAC system (in average, on yearly basis). The test vehicle (Figure 4) is a conventional diesel bus modified to simulate an electric bus with an adaptable high voltage battery. The conventional HVAC system was replaced by an almost completely new HVAC system designed for an electric bus, including for example an electric driven, hermetic refrigerant compressor as well as an on-roof heat pump system. The heating system and diesel engine were completely separated and a high voltage system was implemented. Instead of a high voltage battery, a power set was installed in the rear of the bus within a modified ski case. For cooling of the diesel engine as well as the generator of the power set, a separate on roof cooling unit was implemented.

Figure 4 – Stuttgart demonstration: the test bus

To compensate for additional weight in the rear of the vehicle due to the power set and the extra on roof cooling unit, and do not endanger driving stability, one ton of inert mass was integrated in the area of the center axle. To ensure that both vehicles perform with the same total weight within the test campaigns, the reference vehicle was equipped with an extra weight, too.

Determination of the refrigerant compressor's power consumption was given special attention within this demo. For the test vehicle with its electrically driven compressor, the power consumption was shown on the CAN bus trace of the power inverter, which could be logged. However, for the reference vehicle with its conventionally belt-driven compressor, the power consumption had to be calculated as a product of speed and torque. Therefore, a special feature was custom-built: a torque-measuring device was integrated into the magnetic clutch of the compressor. This measuring system was supplemented by a contact-free sensor telemetry system.

5. Main results achieved

Overall, within EBSF_2, solutions that can reduce the energy demand in HVAC system on-board e-buses between 11 – 60% have been successfully tested in different climate and operative conditions (Table 4). This decrease can be translated in a lower gross energy use per bus and per km up to 9%.

Table 4 – Energy savings achieved according to common KPIs.

Test site	*Solution deployed and tested definition*	*KPI - Energy demand for HVAC system*	*KPI - Energy consumption per vehicle and km*	*KPI - Average energy demand by auxiliaries*
Barcelona	Intelligent Energy Management	--	-2.9%	-57%
	Thermal Management	-11.5%	-2.9%	--
Gothenburg	New Energy-Efficient Heating Solution	-60%	--	--
Helsinki	Adaptive Control for Auxiliaries	--	-1%	-3%
Stuttgart	Innovative HVAC for Battery-Only Buses	-35-45%	-9.1%	

In Barcelona, the 2 test buses have been equipped with a device, specifically implemented for this demo, which can communicate with the vehicle's CAN bus and the back-office located at Fraunhofer IVI in Dresden. A software running on the modules allowed collecting data (mainly about the steering pump and e-compressor vehicle components) that is red from the vehicle's CAN-Bus.

Introducing the advanced energy management system - able to anticipate energy demands of auxiliaries - delivered an average energy saving of about 57%; in particular efficiency was improved by 35% on the air compressor and 76% in the steering pump. In addition, during the tests it was achieved an 11.5% increase of the efficiency of climate system during summer time (no winter campaigns have been conducted). This improvement was the result of the modification of the system at two levels:

- simplification of the system, with the application of an HVAC using a single circuit and only one compressor, thus reducing the weight over the roof of the vehicle;
- optimization of the Electronic Control Unit (ECU) system's software.

Also, the temperature inside the bus was more homogeneous with the new system. This was a consequence of a better regulation of the compressor, not only due to the software improvements but also due to the reduction of the number of compressors in the system. A reduction of the maintenance costs was also registered as a consequence of the simplification of the system.

In Gothenburg, results show that the overall reduction in heat power consumption is about 60% thanks to the new heating system, which proved to be well fitted to the operational conditions. The investigations on the heat loss led to improved insulation, by using material with thermal conductivity around 0.04 W / (mK) and thickness of 10-20 mm. in three areas of the bus:

- Air channels in the 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 the lower part of side walls, close to the radiators' location. 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.

The air-to-air heat pump, the added insulation in key areas and the updated control systems resulted in a 17% reduction in overall energy use for an electric bus under normal operating conditions in Gothenburg. Moreover, passengers' perception of ride comfort has been improved by 12.2% (the score given has changed from 8.2 to 9.2, in a 1-10 scale), and their perception of thermal climate on-board by 8.7%. Both situations are very important as passengers now feel more satisfied with the service.

In Helsinki, data collection of the electric bus energy usage showed that there is potential in the adaptive control of auxiliary systems, which can decrease the total energy consumption up to 1 %. When auxiliary systems are run in a maximal way during regenerative braking of the vehicle, energy flowing from the powertrain can be used directly in the auxiliary systems, and it is not pushed back to the battery with battery losses.

Within the Stuttgart demonstration, the innovative HVAC system for electric city buses was demonstrated in total five test campaigns: winter, spring, summer and autumn 2017, and an additional campaign in January 2018, due to a relatively warm winter season in 2017. Data collected to determine performance and energy consumption of the test and reference vehicles, includes electrical current consumption of pumps/blowers, run-time of heaters, duration of door opening times, power consumption of refrigerant compressors, etc.
The new system showed an excellent behaviour in terms of energy consumption. Depending on the season, the energy used for heating, ventilation and air conditioning could be reduced in the amount of up to 35 - 45 % compared to the conventional system. These significant improvements in energy efficiency were achieved by both innovative technology in terms of hardware and new routines for the control system.

Acknowledgements

The EBSF_2 project has received funding from the European Union Horizon 2020 Research and Innovation programme under grant agreement N° 636300. The authors wish to thank all the EBSF_2 partners and especially the partners involved in the demonstration of Barcelona, Gothenburg, Helsinki and Stuttgart.

References

Cascajo, R. et al. 2016. EBSF_2 Deliverable 2.3 Report on Evaluation Framework, restricted document

Corazza, M. V. et al. 2016a. From EBSF to EBSF_2: A Compelling Agenda for the Bus of the Future. A decade of research for more attractive and sustainable buses, in: Martirano, L., et al., Proceedings of the 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEIC), pp. 621 – 626

Corazza, M. V., et al. 2016b. A new generation of buses to support more sustainable urban transport policies: A path towards “greener” awareness among bus stakeholders in Europe. Research in Transportation Economics, 55, pp. 20 – 29 .

Corazza, M. V. et al. 2016c. A European vision for more environmentally friendly buses, in: Transportation Research Part D: Transport and Environment, Vol. 45, 6, pp. 48-63

Gasparini, P. 2015. ZeEUS Deliverable 27.1 - Cagliari: Demo Description and Implementation Plan, December 2015, restricted document