From lab to real operation: ASSURED use cases and city demos

Enabling the upscale of electric fleets

About ASSURED

Coordinated by VUB (Vrije Universiteit Brussel), the EU-funded project ASSURED aims to boost the electrification of urban commercial vehicles and their integration with high-power fast charging infrastructure. The project has developed and tested high-power solutions for full-size, urban, heavy-duty applications. The aim is that each of these solutions are interoperable and standardised, which means they will be able to charge various types of vehicles. This enables operators to mix and match different brands of vehicles and chargers, making the integration of e-vehicles into the public transport network easier and cheaper.

During the project, electric buses, trucks, and vans tested different types of charging solutions, including different types of pantographs, plug-in and wireless charging. Another element which ASSURED has investigated is the stability of the energy supply, essential for future use when a larger number of vehicles will rely on the charging infrastructure.

Tests and demonstrations

To enable the interoperability and standardisation of electric vehicles and chargers, ASSURED has developed and tested solutions for public transport electric buses, trucks, and delivery vans. These solutions are known as the ASSURED innovations:

- Interoperable high-power charging, up to 600 kW
- Charger-vehicle interoperability and standardisation
- Smart tools for fleet level optimisation
- Innovative energy storage system and charging management strategies

These solutions were first tested in controlled conditions in various test sites across Europe (the use cases) and later in the project, tested in real life through demos in five European cities.

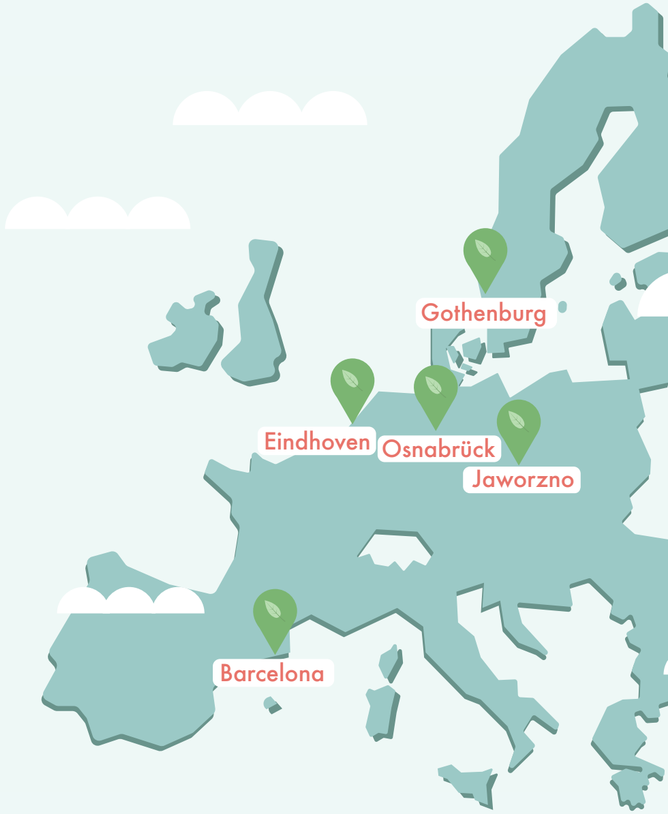
In this brochure, we summarise the activities for each use case and city demonstration. We explain which technologies and vehicles were tested, what the key results were, and ultimately how the tests have contributed to achieving project goals.

The ASSURED use cases

The use cases describe the baseline vehicles adapted and modified to comply with the technical requirements of the ASSURED solutions, and to fulfil the needs of the end users at the demonstration cities. Before entering the demo operation, the vehicles were verified at control sites and test tracks, to ensure the adaptations could fulfil the operational requirements.

The ASSURED demo cities

After testing the vehicles and charging solutions in controlled conditions, they were demonstrated in five European cities: Gothenburg (Sweden), Barcelona (Spain), Osnabrück (Germany), Eindhoven (the Netherlands), and Jaworzno (Poland). The vehicles and chargers were integrated into the public transport network and tested in real operation.



Use case 1

Testing superfast conductive charging for electric buses

Description

Led by IVECO Altra/Heuliez Bus, and supported by ABB and VUB, the starting point of this use case was a battery electric bus without fast charging and medium power transfer capability.

From the baseline vehicle, the use case developed two electric buses with superfast charging for infrastructure-mounted pantograph and roof-mounted pantograph technologies for urban transport.

Based on the exploitation specifications, the battery life cycle and TCO (Total Cost of Ownership), the main objectives were, first, to optimise the chemistry and dimensioning of the battery, and second, to enable opportunity charging with power up to 450 kW. This reduced charging time, improving service availability and enhancing the electrical range of the vehicle.

Testing in Osnabrück

Trondheim was the first experience in the field (not in the framework of the ASSURED project), where the bus operated in real conditions to validate that opportunity charging is a consistent solution to extend the vehicle autonomy, offering more flexibility to bus operators.

The testing in Osnabrück took place in March and April 2021 and was part of the ASSURED demonstration. The objective was to demonstrate the vehicle and charging capability for infrastructure-mounted technology.

Key outcomes

The use case delivered two final vehicles:

- HB GX 437E 18m urban electric bus with superfast charging capability and roof-mounted pantograph technology, and 20 h zero-emission range 450 km with superfast charging at the bus terminal/last stop. The charging time for the vehicle proved to be less than 20 minutes (for 70 km superfast charging), with a minimised impact on the power grid.
- HB GX 437E 18m urban electric bus with superfast charging capability and infrastructure-mounted pantograph technology, 20 h zero-emission range 300 km with superfast charging at bus terminal/last stop. Charging time was less than five minutes (for 12 km superfast charging).

Ultimately, the use case saw standardised superfast charging to guarantee interoperability, with successful real operation demonstrations in Trondheim and Groningen (not in the scope of the ASSURED project) and Osnabrück.

Use case specifications

Baseline vehicle

GX437E e-bus with infrastructure-mounted pantograph, and without superfast charging.

Final vehicles

Vehicle 1

Heuliez GX 437 18m, roof-mounted pantograph

Urban e-bus with superfast charging (< 20 min), regular electric drive range 450 km and up to 70 km between charging stations, and power transfer capability > 400 kW superfast charge.

Vehicle 2

Heuliez GX 437 18m, infrastructure-mounted pantograph

Urban e-bus with superfast charging (< 5 min) and regular electric drive range 300 km and up to 12 km between charging stations, with a power transfer capability > 400 kW superfast charge.

Duration

Tests in Osnabrück took place over two months, in March and April 2021.

Use case 2

Superfast opportunity and depot conductive charging

Description

Led by Volvo, and in partnership with ABB, this use case transformed two existing hybrid bus models into full electric buses for demonstration of a high-capacity bus line during peak hour operations, with superfast charging. The aim was to increase transport efficiency combined with the benefits of electric powertrains, like zero-emissions and lower noise levels.

In addition, the use case demonstrated efficient charging technologies and infrastructure to support interoperability of different bus types, with the goal of developing flexible charging options for the same vehicle and support different operational scenarios in city bus traffic.

Lessons learned

Charging interoperability is key for electrification. Infrastructure-mounted pantograph technology has been delivered by several bus OEMs and charging suppliers to more than 30 cities in Europe. Volvo foresees that charging infrastructure will continue to be essential for electrification of cities.

Key outcomes

The use case delivered three final vehicles that were demonstrated in Gothenburg in October 2020:

- 1 x Volvo 7900 E-Bus 12m, modified with roof-mounted pantograph, CCS and AC plug charging.
- 2 x Volvo 7900 E-Articulated Bus 18m full electric buses, modified with superfast opportunity charging, and equipped with infrastructure-mounted pantograph technology, and combined with CCS and AC plug charging. The charging power was upgraded from 290 kW to 450 kW.

The upgrades performed in this use case enabled higher interoperability of both bus models, by providing charging with ACD both infrastructure-mounted and roof-mounted, as well as CCS.

Use case specifications

Vehicle 1

Volvo 7900E/EA 18.7m

- Passenger capacity: 150
- Weight: 21,000 kg
- Storable energy: 282 - 564k Wh
- Nominal charging power: 660 V

Vehicle 2

Volvo 7900E 12m electric bus

- Passenger capacity: 100
- Weight: 13,150 kg
- Storable energy: 282 - 564k kWh
- Nominal charging power: 660 V

Capabilities

- Range and charging times depend on battery configuration, topography, load, climate and drive cycle.
- Volvo offers useable energy contracts to guarantee a certain amount of available energy the whole contract period.

Charging

Three different charging systems available

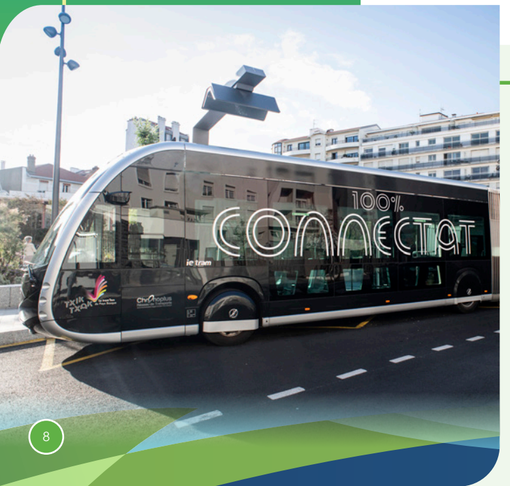
- Infrastructure-mounted pantograph technology up to 450 kW.
- Roof-mounted pantograph technology up to 450 kW.
- CCS Combo 2 up to 150 kW.

Duration

The buses were tested from February 2018 until February 2020.

Use case 3

Testing interoperability for a higher operating frequency



Description

The aim of the Irizar-Jema use case was to test interoperability by managing a fleet of 18 buses with different charging strategies and realise improved energy efficiency to achieve a higher operating frequency. Taking place in the cities of Bayonne and Biarritz (France), the use case also developed smart charging strategies to adapt the required power from the grid to the vehicle charging power demand.

Key outcomes

Charging of the vehicles was conducted with roof-mounted pantograph technology: 600 kW superfast Type B charging stations have been used at the end of the line and 50 kW chargers have been installed in the depots.

Starting operation in September 2019 and still ongoing in 2022, the complete fleet of 18 vehicles has been operating in the French cities with a frequency of 10 minutes and the chargers have been operating successfully for years. The expected operating frequency has been achieved. Superfast charging processes of less than five minutes were performed in the line and overnight charging processes at the depot.

Moreover, the depot chargers have been using a fleet management tool to minimise the peak consumption when all the vehicles are charging at the same time. The power is limited to 500 kW, even if all the depot chargers would be able to consume 900 kW.

In summary, a more energy-efficient bus and a more cost-effective operation were the results of the use case.

Irizar Jema Irizar Group

Lessons learned

By focusing on interoperability, superfast charging and fleet management tools, different aspects of fleet upscaling were tested. This resulted in multiple benefits: not only is there a reduction of investment in charging infrastructure and operating costs for the City Line operator, there is also reduction of power needs from the grid.

In short, superfast charging and energy efficiency lead to a high availability of buses which also leads to higher operating frequencies with the same amount of vehicles.

Use case specifications

Vehicle

IRIZAR ie tram, full electric (Irizar ieTram model) 18m

- Passenger capacity: 155
- Empty weight: 18,700 kg
- Drivetrain size: Electric – 235 kW, 2300 Nm

Capabilities

- Daily electric range: 250-300 km
- Possible daily fully electric operation time: continuously as it is charged every 1h at the end of the line
- Effective electric driving range: vehicle is %100 electric

Charging

- Roof-mounted pantograph
- Charging power: 600 kW
- Battery capacity: 120 kWh

Duration

Operations started in September 2019 and are ongoing in 2022, in Bayonne and Biarritz.

Use case 4

Optimising charging management strategies

Description

This use case, led by VDL Bus & Coach, aimed to test the charging protocol developed in the ASSURED project in a controlled environment, and update the current serial fast charging technology.

Two buses with different charging technologies were tested: the VDL Citea SLE-129 Electric, which is equipped with charge bars to accommodate charging with the infrastructure mounted pantograph, and the VDL Citea SLF-120 Electric, with a roof mounted pantograph.

Testing of both vehicles took place at the testing facilities of project partner Idiada in Spain.

Lessons learned

No major challenges were encountered during the tests of the vehicles. Considering the use case was the first one to launch testing at the facilities of project partner Idiada (in Spain), some small start-up issues arose yet these were quickly solved by the teams involved.

Key outcomes

The two buses were modified, and their Vehicle Charging Control Unit (VCCU) and high-voltage vehicle system streamlined. Superfast charging software and interfaces were paired with an optimised charging strategy for two ACD concepts.

For both the VDL Citea SLE-129 Electric and the VDL Citea SLF-120 Electric, this use case proved that they can be charged using different chargers by using the charging protocol developed in the ASSURED project. This means that superfast charging software and interfaces were paired with an optimised charging strategy for two ACD concepts.

Finalisation of this use case took place during the city demonstrations in Osnabrück and Barcelona in Spring 2021.

Use case specifications

Vehicle 1

VDL Citea SLE-129 Electric

- 12.9m low entry
- Passenger capacity: 60
- Empty weight: 14,500 kg

Vehicle 2

VDL Citea SLF-120 Electric

- 12m low floor
- Passenger capacity: 72
- Empty weight: 14,500 kg

Capabilities

VDL Citea SLE-129 Electric

- Maximum electric driving range single charge: 200 - 300 km
- Possible daily fully electric operation time: up to 24 hours with opportunity charging
- Effective electric driving range: depending on charging strategy (vehicle is 100% electric)

VDL Citea SLF-120 Electric

- Maximum electric driving range single charge: 80 – 130 km
- Possible daily fully electric operation time: up to 24 hours with opportunity charging
- Effective electric driving range: depending on charging strategy (vehicle is 100% electric)

Charging

VDL Citea SLE-129 Electric

- Infrastructure mounted pantograph
- Battery capacity: 288 kWh
- Nominal charging power: 420 kW

VDL Citea SLF-120 Electric

- Roof mounted pantograph
- Battery capacity: 127 kWh
- Nominal charging power: 300 kW

Duration

Both vehicles were tested in Spring 2021.

Use case 5

Superfast charging of refuse collection truck

Description

For this use case, partners MAN, IAV and ABB aimed to demonstrate the optimisation in terms of energy consumption of one electric truck for garbage collection operations.

The use case included one Battery Electric Vehicle (BEV) garbage collection truck with a high-efficient drivetrain being tested in the city of Munich, during usual daily use.

While real-life testing will kick off in 2022, testing in controlled conditions was done in December 2021 and some preliminary outcomes were found.

Expected outcomes

When the refuse collection truck will be tested, the following outcomes are expected:

- Zero emissions during refuse collection operation in inner-city areas
- Low emissions during transport of garbage to recycling ground in suburban areas
- Fully integrated and optimised energy and recuperation management
- Pure electrical driving range of at least 50 km
- Low noise during operation
- Electrical charging capability up to 150 kW based on CCS type 2 charging interface
- Energy efficient auxiliary units for maximised driving range

Key outcomes

A BEV truck medium duty with highly efficient drivetrain was developed for this use case. In December 2021, tests were done on MAN's test track, bringing the following results:

- 0.6 – 1.5 kWh/km energy consumption in driving (strongly dependent on driving profile)
- 69 – 145 km electric driving range (dependent on driving profile and SoC limits)
- 2 – 6 hours electric driving time (dependent on driving profile and SoC limits)
- Up to 50% reduction of energy consumption for cabin heating by using heat pump
- Range extender operation: up to 4.5 kWh electric energy per kg natural gas with emission of 0.63 kg CO2 / kWh

Use case specifications

Vehicle

MAN TGM 6x2/4

- Weight: 27,000 kg
- Payload: ~ 10.5 tons

Capabilities

- Electric drivetrain 250 kW peak
- Range extender (REX) module with CNG engine, 50 kW charging power
- 22 kg CNG tank
- Zero emission in full electric mode, REX with EUROVI
- Heat pump refrigerant: CO_2) for heating/cooling/ air conditioning

Charging

- DC Charging
- Battery capacity: 148 kWh
- Nominal charging power: Up to 150 kW

Duration

Operations started in September 2019 and are ongoing in 2022.

Use case 6

Superfast charging of Volvo electric truck

Description

This use case, led by Volvo, demonstrated zero-emission and low-noise off-peak operation of an electric urban truck, which shared fast-charging facilities with electric buses. The truck's battery size was chosen based on the availability of fast charging infrastructure and the opportunity of fast charging interoperability between buses and trucks.

The aim was to demonstrate the competitiveness of TCO for electric delivery trucks and to minimise the environmental impact of CO_2, regulated emissions and noise.

Testing in Gothenburg

Interoperability for this use case was demonstrated in the city of Gothenburg, alongside use case 2 (superfast opportunity and depot conductive charging). Testing was done across a wide range of vehicle types and charging technologies: between city buses and urban trucks, with alternative depot charging technologies, with different charging powers, and different infrastructure, mounted pantograph solutions.

Key outcomes

The demonstration vehicle was a Volvo FL Electric, modified to include high-power AC and DC CCS2 charging.

The demonstrator truck, the Volvo Modified FL Electric, was equipped with the latest battery technology, to include high-power AC and DC CCS2 charging.

Flexibility and scalability in the battery system enabled balancing between peak traffic range requirements, charging opportunities and vehicle load capacity to maximise the utilisation of the energy storage system and enabling more customised and optimised offers to the vehicle customers.

A new battery cooling and traction voltage system were included to allow for a more flexible and scalable battery system. The architecture for the control system is designed to reduce the impact of integrating future battery cell and module upgrades in the battery system.

Use case specifications

Vehicle

Volvo Modified FL Electric

- Maximum load: 16,700 kg

Capabilities

- Maximum electric driving range fully charged: Dependent on mission profile and environment
- Duration of full overnight charging in depot: 1-10h depending on charging method used and grid load

Charging

- Technology/contact type: CCS2 DC/AC Type 2
- Charging power range: 150 kW DC CCS2, to 22 kW AC CCS2
- Battery capacity: 4 x 50 kWh
- Nominal charging power: 660 V

Duration

The vehicle was tested in Gothenburg, in Spring 2021.

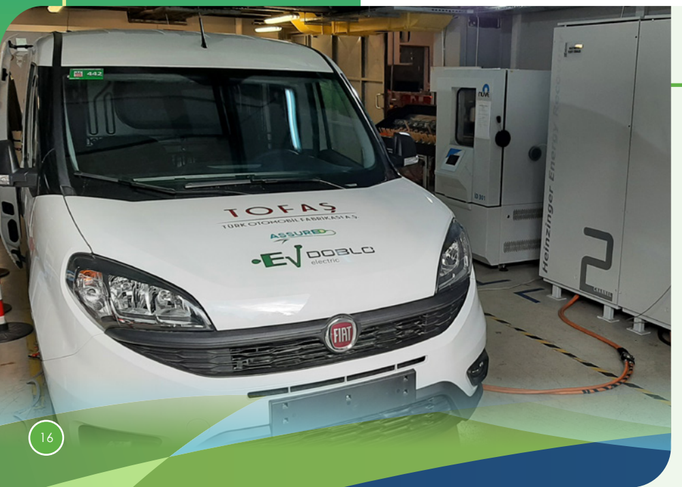
Use case 7

Fast wireless charging of electric van

Description

This use case, led by Tofas and supported by PoliTO, aimed to demonstrate a light duty vehicle that can fast-charge wirelessly while being parked, at pickup or delivery locations, or while being stopped at a traffic light.

A new electric and electronic system, new thermal system, new battery system, and drive-train were also tested in the adapted vehicle. The vehicle tested was a battery electric van.



Key outcomes

Tests enabled the lightweight van (a Fiat Doblo Cargo) to wirelessly charge up to 100 kW in less than five minutes. Tests also revealed that noise and emission pollution was zero, with five minutes wireless charging providing approximately a 40 km range for the customer. The time for opportunity charging was up to 12 minutes.

Lessons learned

By enabling fast and easy wireless high power inductive charging, TOFAS' competitiveness was increased by introducing new wireless charge technology to the LCV electric vehicles market that will also reduce TCO of customers.

Use case specifications

Vehicle

FIAT DOBLO Cargo Electric

- Size: 4756x1832x1880 (LxWxH)
- Weight: 1,917 kg
- Drivetrain size: 83 kW (234`0 Nm)

Capabilities

- Maximum electric driving range fully charged: ~220km
- Effective electric driving range: ~180km

Charging

- Charging technology: Inductive Wireless High Power Charging
- Battery capacity: ~40kwh
- Wireless Power Transfer Charging Power Output: 105kW

Duration & Location

Tests were originally planned to be held at the Turin tram station, but were ultimately conducted at TOFAS' premises due to COVID-19, in early October 2021. The Wireless Power Transfer Unit (WPT) test was made in the laboratories of Politecnico di Torino (Polytechnic University of Turin), from February to May 2021.

Demo city
Gothenburg

Testing interoperability of e-bus, e-truck and e-car charging

Description

The goal of the Gothenburg demonstration led by Volvo was to display different vehicles using same charging technology and standards.

The work performed supported the demonstration of the management of a high-capacity bus line during peak hour operation, with superfast power transfer reaching a high level of transport efficiency combined with zero emissions and low noise.

It also demonstrated competitiveness of TCO for the complete bus system including environmental benefits.

The Gothenburg Demo Launch Event held on 20th October 2020 showcased efficient charging technologies and infrastructure to support the TCO, and interoperability between different versions of buses, trucks and cars.

We need innovative mobility solutions that can be tested and deployed in environments in the EU – ASSURED is an important manifestation of our commitment to the Green Deal.

Patrick Anthony Child,
Deputy Director-General
at DG Research and Innovation
During the Gothenburg demo launch

Timeline

The demonstration was planned, tested and verified during 2018-2020.

- 2018: Start of realisation of demo vehicles
- October 2020: Gothenburg Demo event
- Operation on route from 2018 to 2020

Key outcomes

In the city of Gothenburg, the two articulated buses operated for approximately two years on Line 16, with 60,000 km per bus per year (average in Gothenburg city traffic). Feedback from passengers, bus drivers, city and operator were very positive.

Today, Gothenburg has over 175 full electric buses in operation, and Volvo's first electric trucks FL/FE where launched 2020.

Lessons learned

The demo in Gothenburg proved that industry standard is a must; customer unique demands is not feasible. Furthermore, multi-brand usage enables completion of business case, lower TCO, scale of economy, lower development cost, and the future use of components will be lower.

Finally, standards should be implemented, but there should not be too many different standards with one technology. Standardisation cannot be a slow process.

Volvo believes that the charging solutions tested will co-exist for a foreseeable future. Charging on route requires pantograph charging, which type depends much on the city and regional preference.

Demo in brief

Volvo demonstrated three buses, 1 truck and 1 car in Gothenburg:

- 2 x 18.75m Volvo 7900EA high-capacity articulated full electric buses
- 1 x 12m Volvo 7900E full electric city bus
- 1 Volvo FL Fridge truck, GCW 16 ton, fully electric.
- 1 car Polestar 2, fully electric.

Charging

- Bus: Inverted pantograph ABB (max 300 kW) and Siemens (max 300 kW)
- Bus: roof-mounted pantograph ABB with Schunk Pantograph 150 kW
- Truck: DC CCS2 Heliox (25 kW), ABB (150 kW)
- Car: AC CCS2 11KW

Partners

Volvo, ABB, Heliox and Siemens.

Demo city
Osnabrück

Testing interoperability of buses and chargers

> ***As operators, we learn a lot from the OEMs. At the same time, we are happy to pass on our rich experience in operating electric buses. Only by uniting different interests and knowledge in our sector we can move forward with the large-scale uptake of clean vehicles.***
>
> Joachim Kossow, Deputy Manager Operations at Stadtwerke Osnabrück

Description

With electric buses being in regular use since 2019, Stadtwerke Osnabrück can count on much experience with e-buses. Late December 2021, 62 articulated buses are running on five lines in the city. In total, the city of Osnabrück serves more than 20 million customers each year, with increasing numbers post COVID.

In Spring 2021, the ASSURED demo tested the interoperability with four different electric bus types and two different chargers. Both the infrastructure and the protocols behind it played an important role.

Scientific partners from across Europe participated in the demo, to get profound results that can be transferred to other cities and use cases too.

Timeline

- October 2020: Arrival of the first bus and commissioning of the first charging station
- February 2021: all buses and chargers arrive in Osnabrück
- March - April 2021: set up of all buses and chargers, and demo testing
- May 2021: Dismantling of the chargers and return of the buses

Key outcomes

- Daily operations of the buses during 60 days
- More than 4,000 electric km driven
- Satisfied customers that got familiar with new buses and technologies
- Stable and safe operations, despite the challenging COVID situation

Future plans

Stadtwerke Osnabrück AG will continue its path to fully electrify the public road transport. As of 2025 there should be no more fossil fuel driven buses on the roads of Osnabrück. The results and experiences from the ASSURED project will definitely make the way more smoothly as interoperability will be more achievable in the upcoming years.

Lessons learned

The main takeaway from the ASSURED demo concerns interoperability and interpretation of the norms by the different bus OEMs and charger suppliers. It took a great effort of every partner involved to get the buses up and running and the charging up to speed. We learned to adapt to different (technical) challenges and together achieve a positive demo project.

Considering ASSURED's project character, there was not a 'one-key' solution. Yet, as long as everyone involved is committed to give the best performance possible, a project like ASSURED can only be successful and significantly support greener and more sustainable public transport and cities.

Demo in brief

Vehicles
- Heuliez Bus GX 437 full electric (18m)
- Irizar ie tram (18m)
- Volvo 7900 electric (12m)
- VDL Citea SLE-129 Electric (12m)

Charging
- Infrastructure-mounted pantograph
- Chargers from Heliox and ABB on each end of the route to get experience on the interoperability of the system

Timeline
- March 2021 – April 2021

Integration with network
- Lengths of lines: 6 km
- Total km driven/vehicle/day: approximately 80 km
- All buses were added to an existing bus route and tested under real-life conditions

Partners
Partners such as FRAUNHOFER, IDIADA, ENGIE and TNO participated in the scientific monitoring and to secure results.

Demo city
Eindhoven

From E-Mobility to I-Mobility

Description

As part of the Green Deal launched by the Dutch government in 2016, and in cooperation with bus operator Hermes, VDL Bus & Coach, leader of the Eindhoven demonstration, introduced more than 60 vehicles to the existing fleet of 43 articulated electric buses.

The objective was to demonstrate that future operation of e-buses and charging can be scaled up in a smart and cost-effective way.

This plan had various complexities, including the time frame of the upscaling and to achieve one integrated fleet, instead of two separate fleets.

The original fleet was put into service in 2016, as one of the earliest e-bus fleets in Europe. The second phase will be implemented during 2022, exactly five years after start of operation. In this timeframe many improvements have and will be made in both technology and operational excellence.

> ***Together with VDL we are running a unique operation in Eindhoven. Over the past few years, many other European operators and cities have visited Eindhoven to see everything for themselves and to see that the future of e-mobility in public transport started here. We have acquired a great deal of knowledge and experience with the reliable VDL Citea buses on the basis of the many millions of electrically driven kilometres.***
>
> Martijn Mentink,
> Executive Vice President of Hermes

Key outcomes

- The 43 articulated electric VDL Citea buses (2016) have covered about 400,000 km each
- The running fleet of electric buses will be expanded with 60 to 65 electric 12m buses, replacing existing 12m Euro 5 EEV diesel buses (2008)
- The new buses will be both 12m Low Floor (city operation) and 12m Low Entry (intercity operation)
- The new 12m electric buses will be the first of the New Generation Citea Electric buses. These are designed to reduce energy consumption (compared to the first generation Electric Citea) with up to 30%.

Lessons learned

Technology is developing fast. Therefore the current battery and driveline technology is able to provide all the performance to electrify the demanding European public transport. The rapid pace in which many EU member states invest in zero emission public transport is also promising.

However, due to this rapid pace, new challenges arise: the electricity grid is not able to cope with the number and size of the power connections needed to power these new fleets of vehicles.

Vehicles and chargers are therefore being adapted to this. They become more intelligent and, based on vehicle performance data, are able to be fully integrated into the digital infrastructure of fleet management and energy management.

We are moving from E-Mobility to I-Mobility.

Future plans

Electrifying mobility does not only enable cleaner transport. The digital architecture of the electric vehicles also enables smarter mobility. Continuous data exchange between vehicles and IT back office systems enable a steep learning curve.

An integrated digital twin of the vehicle into the IT systems will then unlock new features and operational possibilities in terms of autonomous functions, operational excellence and passenger comfort.

Demo in brief

Vehicle
- > 60 VDL New Generation Citea, 12m Low Floor and 12m Low Entry buses

Charging
- Battery electric
- Roof-mounted pantograph

Timeline
- In operation 2016 – present
- 2nd phase implemented during 2022

Integration with network
- All buses ran standard daily operation

Partners
VDL Bus & Coach, Heliox, Scholt, ENEXIS.

Demo city
Barcelona

Showcasing interoperability bus-charger with roof-mounted pantograph tech

Description

The goal of the ASSURED Barcelona demonstration led by TMB was to showcase interoperability of buses and chargers with roof-mounted pantograph technology. With this purpose, two ASSURED vehicles (VDL, Irizar) and three chargers (ABB, Heliox, Jema) were tested by TMB in real operation, and fully integrated in TMB fleet. Before integrated in real operation, the buses were first tested at the facilities of TMB and ASSURED partner IDIADA.

Our active participation in ASSURED fits within the objective of positioning TMB and the Barcelona metropolis as benchmarks in innovation and leaders in sustainable mobility. At TMB we are on the road to the electrification of urban bus transport, and this means not only new types of vehicles but also charging and management infrastructures, in and outside depots. We have the challenge of promoting advanced, efficient and fully interoperable charging technologies to provide a flexible and efficient service to citizens.

Gerardo Lertxundi, CEO of TMB

Key outcomes

Interoperability between the ASSURED buses and chargers was successfully demonstrated. Furthermore, the Barcelona demo has proven the validity of the *ASSURED 1.0 Interoperability Reference*, developed and tested within the project, which enabled full interoperability between buses and chargers independently of brand in real operating conditions.

Timeline

The Barcelona demo took place from the beginning to the end of March 2021. Preparation (civil works for the installation of charging infrastructure, delivery and commissioning of the vehicles, etc.) and finalisation (dismantling, decommissioning, and delivery of the vehicles, etc.) tasks were performed before and after this period. The testing of the ASSURED buses took place over the 5-6 weeks in real operating conditions.

Lessons learned

The benefits of interoperable charging for TMB are manifold:

- It allows TMB to choose the best option in each tender without entering vendor lock-ins.
- It opens the possibility to share the opportunity chargers on route with other vehicles, e.g., waste collection trucks or other utility vehicles.
- Charging all the vehicles with the same charging system and protocol simplifies the maintenance.

In future tenders for e-vehicles and chargers, TMB will include the requirement of a certification by a third party that validates compliance with the *ASSURED 1.1 Interoperability Reference*.

Future plans

TMB is committed to the reduction of emissions in the TMB bus service by introducing clean bus technologies. The fleet renewal plans started back in 2010 and until 2030 foresee the full replacement of diesel buses with a major share of natural gas and battery buses, with a progressive introduction of fuel cell hydrogen buses as of 2022.

Main actions in this sense are the acquisition of 618 buses of different sizes (midi, standard, articulated, double decker): 46 hydrogen, 332 electric, 216 CNG hybrid and 24 hybrid, with the corresponding e-bus charging and power/fuel supply infrastructure.

Demo in brief

Vehicles
- Irizar ieTram (18m)
- VDL Citea SLF-120 Electric (12m)

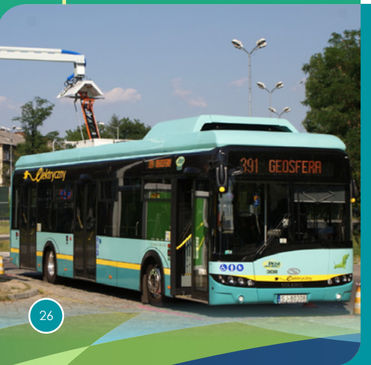
Charging
Three chargers equipped with roof-mounted pantograph technology were tested:
- ABB and Heliox, installed at the TMB Triangle depot
- Jema, installed on Carrer del Cisell, Sants-Montjuïc district, at one of the terminals of the H16 line.

Integration with network
- All buses ran standard daily operation

Partners
TMB, Irizar, VDL Bus & Coach, Heliox, Jema, ABB

Demo city
Jaworzno

Smart charging management & improved efficiency



In 2030, PKM will achieve its electrification target, namely50 e-buses, of the total 70 buses, and 55 vehicles driven daily. Diesel vehicles only perform short services to support operation during peak times, covering a small number of km per day.

Description

During the demo in Poland, bus operator PKM tested 23 electric buses of three different sizes (8.9m, 12m, and 18m) in terms of optimsed charging strategies. The demo was based on the development of the baseline e-buses in order to optimise the operational cost, with the main aim to switch public transportation from internal combustion engine vehicles (ICEVs) to electric ones, minimising CO2 emissions.

The goal of the demo was to optimise the vehicle operation process, including the power consumption, and provide an improved version of the baseline vehicle.

The e-buses were equipped with standard charging solutions, namely plug-in charging with Combined Charging System Type 2 (CCS2, Combo 2) and roof-mounted pantograph. To minimise the consumed energy, optimal battery packs were installed in the e-buses, also minimising the total cost of ownership. These battery packs need to be charged frequently and therefore 12 pantograph chargers were dispersed in Jaworzno along the e-buses routes.

Timeline

Data were collected between October 2020 and March 2021 and some sample data were processed and analysed to study the technical and economic operations of the e-bus fleet.

Key outcomes

Thanks to the data analysis PKM was able to optimise its charging strategies. There was less daily charging, which had a direct impact on increasing the service life of traction batteries. Replacements were less frequent, which enabled lower costs. Also, the e-bus charging grid was redesigned in order to increase the amount of charging at night, which resulted in a reduction of electricity consumption costs.

Overall, the demo resulted in operational cost reduction compared to the baseline vehicle. The conducted research allowed PKM to increase the efficiency of e-bus transport by increasing the reliability, reducing the number of recharging and scheduling charging at nighttime.

Lessons learned

PKM obtained the necessary knowledge and experience that allowed to develop the e-bus fleet and charging grid in a most effective way. At the same time, PKM has defined and solved problems related to the utilisation of the e-buses in the area of timetables, vehicle operation, and charging infrastructure.

From OEM (Solaris) side, the demo proved that e-bus energy consumption depends on the e-bus load (number of passengers) and the internal equipment consumption of the bus, which varies from one season to another based on the weather conditions.

Demo in brief

Vehicles
- Urbino 8.9m Low Entry electric
- Urbino 12m Low Floor electric
- Articulated Urbino 18m electric

Charging
- Plug-in charging with a Combined Charging System (CCS2) connector
- Roof-mounted pantograph

Timeline
October 2020 – March 2021

Integration with network
- All buses ran standard daily operation

Partners
PKM, SOLARIS, VUB

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769850.