Report Electric Mobility Europe

Trolley Systems 4 Smart Cities *Created project report on Monday February 01, 2021 21:40:56*

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^ 0 Report summary

Electric mobility has become an increasingly important topic for public transport in cities. In this context, trolley bus systems have established themselves as a modern and emission-free alternative to diesel buses. The infrastructure investments have so far required a corresponding traffic volume for the environmentally friendly systems to be viable from an economic point of view. In addition to track guidance on the overhead line, infrastructure elements such as switches and crossings, which are associated with not inconsiderable cost and maintenance expenditure are necessary. The trolley:2.0 project therefore investigated battery-electric trolley buses and how they can open up further advantages through in-motion charging concepts. The potential of this technology includes efficient and reliable operation, as the proven technology of the trolley bus is combined with modern energy storage technology. Owing to the onboard energy storage system, branches, crossings or

other sections of track where electrification is costly or undesirable for aesthetic reasons can be designed without a catenary. Moreover, additional operational freedoms can be used: relocation of circuits, extension of existing lines and expansion through new lines. The TROLLEY 2.0 project demonstrated successfully how to reduce cost-intensive infrastructure elements of trolleybus networks without decreasing reliability and performance. The project partners demonstrated several technology items which – taken together – could be considered as a future smart trolley network, and as a backbone for zero-emission mobility systems in urban areas.

^ 1 Project Trolley Systems 4 Smart Cities (Trolley 2.0)

^ 1.1 Objective

The main objectives of Trolley 2.0 demonstrations in the partner cities Eberswalde (DE), Arnhem (NL), Gdynia (PL) and Szeged (HU) are

- to prove that trolley-battery-hybrid buses are the proper technology for extensions of trolley bus networks and replacement of Dieselbus lines in remote sections,
- to demonstrate that in motion charging is a proper strategy to recharge the batteries of battery supported electric-/trolley-buses,
- to account for the ability of battery supported trolley buses to pass catenary gaps (including automated wiring of the trolley poles),
- to develop catenary sections for both tram and trolley bus,
- to develop scalable battery packs for trolley buses and other applications and demonstrate the use of 2nd-life batteries as stationary energy storage systems,
- to investigate insulation aspects of alternative trolleybus frames,
- to investigate and demonstrate the potential of trolley grids to become urban DC backbones for the charging of electric vehicles (e-midi-buses as feeder system, e-cars and e-bikes) as well as the integration of PVs,
- to develop methodologies and models for the evaluation and design of battery supported trolley buses and
- to develop best practice examples, guidelines and policy recommendations how to make trolley grids “smart”.

In trolley 2.0, the functionality of off-wire operation will be integrated into trolley buses and in motion charging will be demonstrated with equipped trolley-battery-hybrid-buses in all partner cities. This will include evaluation of battery performance (based on different scalable battery packs) and different charging methods, e.g. trolleybus catenary, i.e. charge in motion, tramway catenary at a terminus, mid-power intermodal charging station at a terminus in absence of infrastructure on the basis of standard e-car DC charger, leading to optimised ratio between in motion charging and off-wire operation in different contexts and operational scenarios in partner cities. This will include the ability to pass catenary gaps and tests for an automated and highly reliable automatic wiring system for the trolley poles in Eberswalde. Furthermore, shared platforms and catenary sections for trams and trolley buses provide a smart connection of both systems and will be demonstrated in the partner city Szeged incl. tests with a new composite frame midi e-bus/trolleybus prototype (which will be tested also in other partner cities). Finally Trolley 2.0 will develop and demonstrate concepts for the integration of multipurpose charging stations based on a smart trolley grid in Arnhem. The results of demonstrations in all partner cities will be compiled to tools and guidelines to support the introduction of in motion charging systems and smart trolley grid concepts in other cities.

Planned start date	2018-01-01
Actual start date	2018-04-01
Planned end date	2020-12-31
Actual end date	2020-12-31

^ 1.2 Result

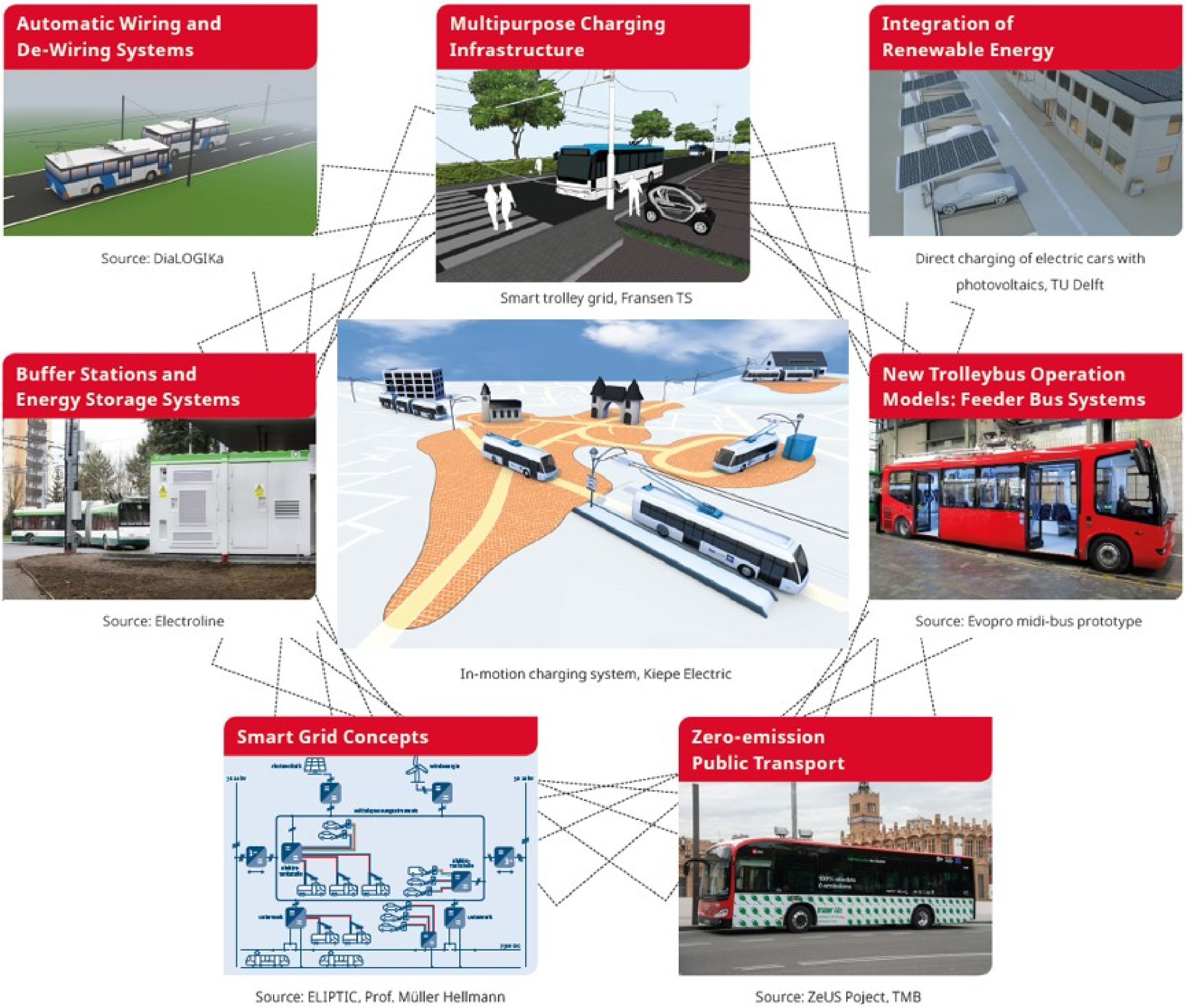
In the four project cities Eberswalde (DE), Szeged (HU), Gdynia (PL) and Arnhem (NL), TROLLEY 2.0 partners have collected new findings on the possibilities of battery electric trolley buses and smart trolley networks.

In **Arnhem,** the trolleybuses can operate autonomously for at least ten kilometres, thus ensuring local zero-emission public transport also outside of the city. In the future, it is planned that only battery-electric trolleybuses will be used throughout Arnhem's city transport system. The sections without overhead contact line will be battery electric. The TROLLEY 2.0 partner Power Research Electronics has demonstrated a 350 kw DC charger prototype, which will subsequently be tested integrated into the trolley networks in Arnhem. This enables hybrid trolleybuses to charge the battery for a few minutes at terminus stations and ensure safe circulation. The first charger was installed successfully in 12/20. In addition, project partner TU Delft completed analysis about the potential for the integration of renewable energy from PV and wind power into trolleybus networks, to create a true zero-emission public transport system.

Completely local emission-free travel is already possible in the Eberswalde's city area, after project partner BBG **Eberswalde,** has converted its buses with lithium-ion batteries. BBG has converted a diesel-powered regional bus line into a battery electric trolleybus line. All 12 trolleybuses are now equipped with batteries for this purpose. Since September 2020, the first battery-powered trolleybuses are operated on this new IMC line 910.

Just as Arnhem and Eberswalde, the **Polish city of Gdynia** has worked – i.e. through University of Gdansk as project partner - on expanding trolleybus lines throughout the metropolitan region. The studies and analyses focused on the one hand on existing routes on which diesel buses are to be replaced by trolley and electric buses. And on the other hand, on new trolleybus lines, which are to run on parts of the route without overhead lines. Based on extended CBA tool analysis routes have been identified and recommended to the associated partner City of Gdynia. In addition, a study was conducted on the possibilities of Stationary Energy Storage (SES) systems including the use of 2nd life batteries.

In **Szeged,** the economic efficiency of the systems shall be increased by the development and preparation for the use of new midi trolleybus types (8m) based on batteries. The first midi-battery trolleybus tested in Szeged and shall eventually operate on the 77A line in Szeged, where it will run for 30 km with up to 20 km without overhead line. The bus will benefit from a weight reduction of 20 percent owed to the composite frame, which also acts as an insulating material.



^ 1.3 Conclusion

Electric mobility has become an increasingly important topic for public transport in cities. In this context, trolley bus systems have established themselves as a modern and emission-free alternative to diesel buses. The infrastructure investments have so far required a corresponding traffic volume for the environmentally friendly systems to be viable from an economic point of view. In addition to track guidance on the overhead line, infrastructure elements such as switches and crossings, which are associated with not inconsiderable cost and maintenance expenditure are necessary. The trolley:2.0 project therefore investigated battery-electric trolley buses and how they can open up further advantages through in-motion charging concepts. The potential of this technology includes efficient and reliable operation, as the proven technology of the trolley bus is combined with modern energy storage technology. Owing to the onboard energy storage system, branches, crossings or other sections of track where electrification is costly or undesirable for aesthetic reasons can be designed without a catenary. Moreover, additional operational freedoms can be used: relocation of circuits, extension of existing lines and expansion through new lines. The TROLLEY 2.0 project demonstrated successfully how to reduce cost-intensive infrastructure elements of trolleybus networks without decreasing reliability and performance. The project partners demonstrated several technology items which – taken together – could be considered as a future smart trolley network, and as a backbone for zero-emission mobility systems in urban areas.

^ 1.4 Recommendation

Further research is needed in terms of **technical developments** regarding the battery capacity and use, the electronic control of power systems on IMC buses, storage systems and reducing costs. Furthermore, building new trolley / IMC systems from scratch is still a challenge for which knowledge about **strategies** that can be used and would help to make sound decisions on the right electric bus system are needed. For example, strategies on public participation or on dealing with legal planning procedures, for which also a Europe-wide harmonisation on regulations should be reached. Also, the mentioned integration of mobility and energy sector has revealed some legal challenges. These legal challenges are the key restricting factors for a holistic approach to electromobility with trolleybuses and to realise busienss cases like the multipurpose use of existing trolleybus infratsructure, e.g for electric vehicle charging with eneryg from the trolley grid. Therefore, a joint effort in clarifying the legal barriers for law makers is needed and should be a focus topic. Additionally, interesting is the request to discuss street **design** and BRT Design for the future of trollleybus systems as backbone of zero-emission public transport systems.

^ 1.5 Evaluation

As demonstrated through trolley 2.0 partner cities, the introduction of hybrid trolley buses is best done in cities which already possess a trolley bus network. Due to large investment costs, caused by vehicles and infrastructure, funding is needed for these vehicles.

To reduce these costs, the trolley buses in Eberswalde were retrofitted with batteries at a lower cost than purchasing buses. This strategy was valid, as the buses were not at their end of life and could not be replaced by new buses. This however came with difficulties and transport operators should be aware that the retrofitting process may cause different problems on every retrofitted bus. It however also benefitted the workshop staff, which gained additional competencies throughout the process.

Regarding Economic Performance of hybrid trolley buses, it is best to use them on lines with high vehicle frequency, passenger numbers and vehicle kilometers per year. This is because the system benefits to a large degree from the lower energy demand, operational costs and life time than diesel buses.

In cities with well-developed networks, investment costs for new infrastructure may be reduced significantly, speeding up the process of hybrid trolley bus adoption. Adjustment of the operation can help with decreasing operational and energy costs. This can be done by adjusting time tables to increase the frequency along bus lines, using the buses more on other lines normally served by diesel buses and using the buses on high intensity lines. Once a network is developed, other buses may also use the infrastructure and drive on lines without constructing extra infrastructure.

However, currently, the opportunity charging technology has economic advantages, due to low infrastructure investment costs, but is required to charge during standing times. If standing times are shortened due to operational circumstances such as high amounts of traffic, the strategy may gain a disadvantage.

As can be seen, the costs of electric buses are subject to several parameters, therefore, case studies for transport companies remain important. Due to the high investment costs associated with electric transport systems and the different operational strategies of electric bus systems, case studies for individual systems remain important to assess costs and develop strategies for the roll-out of these systems into a cost and energy efficient network.

^ 1.6 Impact

The trolley:2.0 project has helped to create a better basis for the evaluation of hybrid trolleybuses or IMC system respectively. In addition, formats like the User Forum Meetings, which took place in Solingen in November 2018 and in Linz one year later, as well as teh very successful final online conference have improved the image and acceptance of trolleybuses in Europe, which are intended to make transport in cities locally emission-free. A total of around 300 participants took part in the two trolley:2.0 User Fora and the final conference and used the opportunity to exchange views on trolley:2.0 innovations, on the latest developments in hybrid trolleybuses, and on smart trolley networks. Numerous feasibility studies for the installation of hybrid trolleybus lines could be prepared and carried out with the help of the trolley:2.0 final deliverables on use case implementations, business case developments or lessons learned.
The project showcased a deep integration of both mobility and energy sector offering great opportunities to increase system stability as well as economic feasibility of trolley/IMC systems. The insight into technical possibilities as the battery usage, increasing energy efficiency, automatic wiring, the synergy and compatibility of trolleybuses and electric buses as well as the sharing charging infrastructure for e-cars are some of the other relevant information the project provided as main outcomes of trolley:2.0.
To design the trolleygrid of the future, it was essential that trolley 2.0 brought together trolley cities and partners from academia and research. Trolley2.0 facilitated this network-making and knowledge-sharing between academic institutions and trolley grid stakeholders, allowing proejct partners to orchestrate feasible, new directions for trolley grids, e.g. for the integartion of RES into trolley grids.
The trolley 2.0 project has created a platform of collaboration between public transport operators, cities and scientists, which inspired partners to develop and realise developments towards new IMC trolleybus deployment concepts in their cities. The trolley 2.0 project participation gave partners important insights in hybrid trolleybus technology, regarding scaling of the batteries, charging powers as well as composite bus technology. This will be useful for future extension of the trolleybus network without infrastructure development using battery trolleybuses.

^ 1.7 Dissemination Activities

Dissemination_website_TROLLEY_2_0.pptx

2 Progress per Milestone

^ 2.1 Consortium Agreement formally agreed based on DESCA model

Planned finish date	2018-01-31
Actual finish date	2018-04-01

Status
The consortium agreement was signed on 01.04.2018 by all contracting parties. The reason for the

three-month delay were the national contracts of the partners and a change of partners in the Netherlands. Milestone 1 was thus reached with three months delay. For this reason, some of the deadlines are due three months later.

Deliverables

No.	Name	Description	Planned	Actual	Status
1.1	*Trolley 2.0 Risk register*	*Register with identified risks and mitigation plans due to risk managment task. The register will be updated several times within the internal progress reporting process.*	*2018-01-31*	*2018-09-30*	*The trolley:2.0 project consortium is aware of the fact that cooperation projects with different partners from different countries with local specifics and with a long duration carry a considerable degree of risk. Several factors such as the complexity of the implementation process of integrated measures continued political acceptance, external dependencies of demonstrations and others may put the whole project or parts of it at risk. In order to be prepared for any deviations which may arise during the lifetime of the trolley2.0 project, a trolley2.0 risk register has been developed. This tool is an evolving document reacting to upcoming developments and changes throughout the project lifetime. Therefore, all partners will continuously update the register. The latest version will be made available on the trolley:2.0 Dropbox (internal website).*

^ 2.2 SharePoint up?and?running

Planned finish date 2018-01-31
Actual finish date 2018-04-30
Status
trolley:motion has introduced an internal quality control mechanism, in which various templates were created, which are used by the partners for the creation of deliverables. To provide and share documents, a trolley: 2.0 Dropbox was introduced and used as the Internal Project Management website. The Dropbox is accessible for all partners since 31.04.2018 and is used as an internal project management website. The Dropbox serves as an efficient overall administration and reporting tool in which all partners store, update and supplement documents. Milestone 2 was successfully achieved.

Deliverables

No.	Name	Description	Planned	Actual	Status

^ 2.3 Successful mid-term review accomplished

Planned finish date 2019-04-30

Actual finish date 2019-04-30

Status

The project status was presented during the mid-term conference in Warsaw. Mid-term report has been approved.

Deliverables

No.	Name	Description	Planned	Actual	Status
1.2	*Mid-term report*	*Official EMEurope mid-term report*	*2019-05-31*	*2019-04-30*	*Mid-term report sent via CMT on 30th April 2019.*

^ 2.4 Successful final review accomplished

Planned finish date 2020-06-30

Actual finish date 2021-01-31

Status

The preliminary final project results have been presented on 2020-09-16 at the EMEurope R&I Project Final (online) Event. Final project results are submitted for review with this final report.

Deliverables

No.	Name	Description	Planned	Actual	Status
1.3	*Final report*	*Official EMEurope final report*	*2020-06-30*	*2021-01-29*	*Final report sent via CMT on 31st of January 2021.*

^ 2.5 Charging prototype finished and installation (Arnhem)

Planned finish date 2018-12-31

Actual finish date 2019-04-30

Status

PRE with the support from VenemaTech has realized a prototype DC to DC charger in the city of Oosterbeek. The first phase was to be able to charge CCS EV's. In the second phase, the ability to charge CHAdeMO EV's was implemented. Today this charger can charge CCS and CHAdeMO EV's. The max system power is 60kW, using 15kW DC//DC prototype modules that PRE developed. The weight of the complete 60kW charger is approx 140 kg. It is located at the top of the mast (see photo). The kiosk with a simple user interface is located at the ground (user) level. It is used for charging EV's from Connexxion (test evaluation phase). Lesson learned: Connexxion can only use this charging infrastructure for its own fleet of vehicles. They are not allowed to sell the energy to 3rd parties. This is a huge barrier for commercialization of the DC/DC charger and thus a huge barrier to better utilize the existing trolley infrastructure. The future that PRE power developers and TUD envision is to make Trolley systems economically more viable by using them as an advanced DC grid that offers: DC fast charging (= premium charging) in urban areas, without major investments in the electricity infrastructure (which is much more expensive in urban areas than the charger itself). Also, these urban DC fast chargers could be deployed in a reasonable amount of time since there are fewer approvals to be taken care of. Urban dc chargers are needed as key for several kinds of users: electrical taxi's, parking plaza's / garages that need to be upgraded with chargers, but do not have the electrical infrastructure to offer charging services, international tourists, business visitors. Since urban DC charging is a premium service, it could be the most profitable business since 2 things can be charged: parking place (EUR 8 per hour), energy consumption (EUR 1 per kWh, makes another 10 to 20 EUR per hour @ 10-20kW charging power). Another aspect is the assumption that the trolley power grid: has sufficient over capacity for such services, can easily be upgraded with a more powerful substation, can be upgraded using local battery storage, can be used to inject solar storage, could act as a blueprint for DC smart-grids in urban areas. Ideas for more prototypes during the project are a 150kW DC fast charger in Arnhem and a 50kW DC fast charger for Eberswalde

Deliverables

No.	Name	Description	Planned	Actual	Status
2.1	*Arnhem Use Case– set?up report*	*This report will include information about the Arnhem use case background/ set?up covering aspects such as objectives, operational environment, use case operational/ work plan, details about the selection and installation of the charging infrastructure and tt be charged electrified vehicles. The report will also specify the planned use case implementation.*	*2018-12-31*	*2019-04-29*	*This report summarizes the use cases of Arnhem. The objective of the use-case is to make the Arnhem trolleygrid more sustainable through the use of solar PV power, installing electric vehicle (EV) charging stations, recovering braking energy by using energy storage and by using bidirectional substations. This report provides a brief introduction to the state-of-the-art trolleybus system in Arnhem, context conditions, objectives, risks, description of the use cases, work plan and expected results. It also gives an idea of the flow of the tasks to be done to fulfill the objective of increasing the sustainability of the Arnhem trolleygrid. Finally, the timeline of the project is presented to achieve the objectives and the expected outcomes.*

^ 2.6 Review of state-of-the-art in trolley grids

Planned finish date 2018-12-31
Actual finish date 2019-04-30
Status
Transportation consists of thirty percent of global energy. Trolleybuses have clinched significant importance in recent times as an environmentally friendly transport system. Interestingly, the possibilities of harvesting huge potential of braking energy and its application on trolleybus functions like syncing vehicle timings, installing storage, bilateral connection between sections, reversible substations, EV charger connection on DC side of grid etc. are being well explored. Various projects like Eliptic, ACTUATE, Trolley, Trolley 2.0 etc in past decades paved a solid path towards increasing awareness and establishment of trolleybus network in urban areas. This article provides a comprehensive analysis of establishment, installation and working of several trolleybus projects along with discussion and recommendations to make system further energy efficient by exploiting braking energy potential.

Deliverables

No.	Name	Description	Planned	Actual	Status
2.2	*Report on smart trolleybus grids*	*State-of-the-art technologies and research done in the domain of DC micro-grids and trolley grids for integration of distributed solar generation storage and charging of electric vehicles.*	*2018-12-31*	*2019-04-29*	*Transportation consists of thirty percent of global energy. Trolleybuses have clinched significant importance in recent times as an environment-friendly transport system. Interestingly, the possibilities of harvesting huge potential of braking energy and its application on trolleybus functions like syncing vehicle timings, installing storage, a bilateral connection between sections, reversible substations, EV charger connection on DC side of grid etc. are being well explored. Various projects like Eliptic, ACTUATE, Trolley, Trolley 2.0 etc in past decades paved a solid path towards increasing awareness and establishment of trolleybus network in urban areas. This report provides a comprehensive analysis of establishment, installation and working of several trolleybus projects along with discussion and recommendations to make system further energy efficient by exploiting braking energy potential.*

^ 2.7 Model and System design for DC trolley grid of Arnhem

Planned finish date 2019-12-31
Actual finish date 2020-04-23

Status

A generic Trolley grid model split into sections and substations has been developed that can be used for any trolleygrid. The model has the possibility to simulate multiple busses on the network. The model gives values of currents, voltages, and power loss in the trolleybus grid. Bus schedules (weekly and seasonal) can be implemented into the model. The model is now being adapted for the Arnhem grid based on parameters received from Connexxion and HAN. Further parameters about the trolley grid in Arnhem will be received in the next months. New information received from Arnhem has exposed that the grid has a bilateral connection, so that also needs to be taken into account now and the model needs to be upgraded. Currently, the model is being used for ongoing study for PV placement and placement of EV charging.

Deliverables

No.	Name	Description	Planned	Actual	Status
2.3	*Laboratory proof of principle and design report*	*Laboratory proof of principle and design report for the power converter for charging of EV, integration of PV array and storage to the trolley DC grid. The control algorithms for the DC micro-grid will be implemented on these converters.*	*2019-12-31*	*2020-12-03*	*The deliverable is finished. It was postponed from 31/12/2019 to 30/6/2020 under the 3+3 months extension. An extra 6 months was asked due to staff change and extra corona-delays as traveling between Delft and Breda was not as possible and the collaboration needed more time.*

^ 2.8 Smart trolley grid developed

Planned finish date 2020-06-30
Actual finish date 2020-10-30

Status

PV and Wind have been explored at multiple locations in the grid (decentralized or centralized) and with different sizes. Storage was studied in synergy with the PV and Wind scenarios to show how far the grid can be renewable while not relying on the AC grid for power exchange. A suggestion to connect the EV charger using a 3 Point Connection rather than a 2 point connection was conducted. A 25 kW DC/DC fast charger for EV was designed and prototyped.

Deliverables

No.	Name	Description	Planned	Actual	Status

2.4	*Final Arnhem Use Case Report*	*The Final Arnhem Use Case Report will document the implementation of the use case as well as specify results of the use case/ data collection and lessons learnt.*	*2020-06-30*	*2020-12-31*	*Final deliverable 2.4 is delivered on time. The six months delay from the original proposal deadline of 30/6/2020 are: the 3 months covid-19 extension, and the 3 months postponed start date of the project. Under this new deadline, the deliverable is then precisely delivered on time on 3/12/2020.*
2.4	*Final Arnhem Use Case Report*	*This report will include information about the Szeged use case background/ set?up covering aspects such as objectives, operational environment, use case operational/ work plan, details about the selection and installation of the charging infrastructure and the electrified vehicle, i.e. the midi trolleybus trials.*	*2020-06-30*	*2020-12-31*	*Final deliverable 2.4 is delivered on time. The six months delay from the original proposal deadline of 30/6/2020 are: the 3 months covid-19 extension, and the 3 months postponed start date of the project. Under this new deadline, the deliverable is then precisely delivered on time on 3/12/2020.*

^ 2.9 Vehicle in service / start of trials

Planned finish date	2018-12-31
Actual finish date	2020-08-31
Status	

The frame of the prototype vehicle was delivered to Szeged with an approx. delay of 4 months as it was planned initially. The reason for the delay is that SZKT's partner Ikarus Egyedi Kft. bankrupted then it took a long legal process to take the vehicle to Szeged. After the delivery of prototype to Szeged, SZKT had to analyze the status and this process took longer than it was planned, as the vehicle came in a lower state of assembly. SZKT started to dismantle and preparation of the semi-finished e-bus for its new examination in October 2018. This task supposed to be evopro’s task, but after the failure of Ikarus-Egyedi, SZKT has taken the lead regarding the installation phase. Regarding the vehicle’s examination, we have received a positive resolution from the Vehicle examination authority. The coronavirus outbreak will cause delays, the current end date is end of Summer 2020 (best estimate).

Deliverables

No.	Name	Description	Planned	Actual	Status

3.2	*Composite framed midi Trolleybus*	*Compsite framed midi trolleybus with optimized battery mode suitable for in-motion charging, authorized for trials in various cities (starting in Szeged). The trolleybus is suited with an automated wiring system.*	*2018-12-31*		*In addition to the 4 months delay of the beginning of the project, the frame of the prototype vehicle was delivered to Szeged with an approx. delay of 4 months as it was planned initially. The reason for the delay is that SZKT's partner Ikarus Egyedi Kft. bankrupted then it took a long legal process to take the vehicle to Szeged. After the delivery of prototype to Szeged, SZKT had to analyze the status and this process took longer than it was planned, as the vehicle came in a lower state of assembly. SZKT started to dismantle and preparation of the semi-finished e-bus for its new examination in October 2018. This task supposed to be evopro’s task, but after the failure of Ikarus-Egyedi, SZKT has taken the lead regarding the installation phase. Regarding the vehicle’s examination, we have received a positive resolution from the Vehicle examination authority. The coronavirus outbreak will cause delays, the current end date is the end of Summer 2020 (best estimate).*

^ 2.10 New optimized battery pack

Planned finish date 2019-12-31

Actual finish date 2020-03-25

Status

M10 (New optimized battery pack) has a modified goal due to the changes by University Szeged. Instead of designing and assembling the battery packs, the University of Szeged study explores the market for the availability of the right type and parameter battery with the BMS fitted. University Szeged has performed tests with the existing battery sets and started analyzing the data collected by evopro Bus Ltd. on the buses in Budapest to estimate the expected SOC values of the specified capacity battery pack on the proposed Szeged line.

Deliverables

No.	Name	Description	Planned	Actual	Status
3.3	*Optimized battery set*	*Optimized battery set with diagnostics tool for the in-motion or opportunity charging, as traction battery and a later 2nd life stationary energy storage battery for 600 V DC networks.*	*2019-12-31*	*2020-03-25*	*Optimized battery pack has a modified goal due to the changes by University Szeged. Instead of designing and assembling the battery packs, the University of Szeged study explores the market for the availability of the right type and parameter battery with the BMS fitted. University Szeged would perform tests with the existing battery sets and started analyzing the data collected by evopro Bus Ltd. on the buses in Budapest to estimate the expected SOC values of the specified capacity battery pack on the proposed Szeged line. The trolleybus battery pack optimization is complete. After reviewing the available modules and consulting with the manufacturers, we selected the most suitable module. Due to the relatively low power consumption of the composite bus, the determining factor was not the energy storage capacity but the maximum performance of the battery pack. Packages of different capacity can be assembled from the selected module according to the track. Examining the bus routes in Budapest, we determined the length of track on which the IMC system should be built in the case of battery packs of different sizes. Our analyzes and the battery pack versions with different capacity were published in the Toolkit (Toolkit_Trolley 2.0_Szeged, Chapter 4: Optimized battery set for in motion charging, Chapter 5: Simulations for existing routes, pp. 46-63). Tests were performed on a used battery pack. The package consisted of cells with $LiFePO_4$ technology, similar to the new modules we chose. Voltage differences were measurable between cells and some cells were defective. We performed the charge-discharge tests with the SZTE battery tester, with which the faulty cells can be selected from such used packages. I enclose a brief description of the measurements (DIGATRON charger and battery tester measurement.pdf) Cell level measurements were performed during the charging process. I attached the measurement results (Charge measurement.pdf)*

^ 2.11 Multi-pupose charger in service

Planned finish date 2019-02-28

Actual finish date 2020-10-31

Status

The EV charger could be connected to the trolleygrid ordinarily as a 2-port-converter (2PC) connected to one section, or as a 3-port-converter (3PC) by connecting it to two sections. The 3-port converter (3PC) is more efficient than 2-port converter (2PC) for relatively short section lengths. The efficiency of the 3PC based solution increases relative to 2PC as the substation distance from point of EV charging increases. An additional advantage is that the loading on the trolley grid conductors is relatively lower with 3PC based EV integration compared to 2PC based solution for the same charging power. As a trade-off, the 2PC solution has superior location flexibility, while the 3PC solution is restricted to end-of-section points. However, at this location, 3PC can concurrently serve the additional functionality of making bilateral connection between two isolated sections of the grid.

Deliverables

No.	Name	Description	Planned	Actual	Status

^ 2.12 Toolkit developed

Planned finish date 2020-02-29
Actual finish date 2020-11-30
Status
The toolkit comprises several use cases for IMC take-up in existing trolleybus networks (e.g. Prague, St. Petersburg) and describes technology aspects for further improving IMC systems like lightweight chassis costructions, existing tram infratsructure usage for charging or automated wiring technology for more flexibility.

Deliverables

No.	Name	Description	Planned	Actual	Status

^ 2.13 Completed trials with composite framed midi trolleybus in partner cities

Planned finish date 2020-06-30
Actual finish date 2020-12-31
Status
The midi bus trials started in August 2020 in Szeged and due to the corona-pandemic it was not possible to start the trials also in the partner cities. The bus was tested successfully in Szeged and testing will be continued beyond runtime of the TROLLEY 2.0 project (e.g. in Budapest).

Deliverables

No.	Name	Description	Planned	Actual	Status
3.5	*Final Szeged Use Case Report*	*Summarizing the experiments and trial operations in a toolkit for third parties to optimize an opportunity/in-motion charging infrastructure and vehicle/battery set capabilities given the existing trolleybus or tram infrastructure.*	*2020-06-30*	*2020-12-31*	***SZKT analysed how*** *the economic efficiency of IMC systems could be increased and analysed several best practices to compiel this toolkit, incl. lessons learned with the development and preparation for the use of new midi trolleybus types (8m) based on batteries (Szeged use case).*

3.5	*Final Szeged Use Case Report*	*The Final Szeged Use Case Report will summarise the trials in Szeged and the evaluation results based on data collection as well as lessons learnt.*	*2020-06-30*	*2020-12-31*	*SZKT finalised the development of the composite framed midibus with IMC. Authorisation and testing of the vehicle could not be finalised due to Covid-19 pandemic situation. Test were only realsied in Szeged. The testing of the automated (re)wiring system has been carried out successfully in Szeged.*

^ 2.14 Status analysis for in-motion charging in Gdynia finished

Planned finish date 2018-12-31
Actual finish date 2019-04-17
Status
Milestone 14 "Evaluation of the initial state of trolleybus transport in Gdynia" is connected to Deliverable "The report identifying Gdynia Use Case". It was prepared in a broader version, providing a comparison of trolleybus transport in Gdynia to other trolleybus systems in Poland (Lublin and Tychy). The report includes economic and technical data. Apart from that, a deep analysis of strategic documents related to public transport passed by the City Councils was conducted. They were also helpful for the development of the next reports, i.e. focused on indicators and assumptions to Cost-Benefit Analysis. Indicator analysis prepared for all three trolleybus systems in Poland has shown that technological development in batteries is an important factor stimulating the development of the in-motion charging business model.

To summarise, the quantitative and qualitative analysis confirmed the development of trolleybus transport in Gdynia (together with Sopot), Lublin, and Tychy. Measures focused on trolleybus development and are complemented with activities related to the acquisition of battery electric buses (Gdynia and Lublin), studies on using photovoltaic farms to increase non-emission potential of trolleybus systems (Gdynia and Tychy) and to maintain and develop CNG buses (Gdynia and Tychy).

Also, a deep analysis of particular trolleybus lines operating IMC vehicles was done. By the end of 2019, there were six trolleybus lines operating partly without catenary in Gdynia and one in Sopot. Moreover, since 2019 trolleybuses have partly replaced diesel buses on one 'conventional' bus line nr 181. On that line, trolleybuses from Gdynia to Sopot partly operate without catenary. The number of lines on which trolleybuses operate partly without catenary is steadily increasing since 2015. The total vehicle km without catenary covered by trolleybus transport increased significantly in 2019 and accounted for 8.17% of the total trolleybus supply in the cities of Sopot and Gdynia. In 2020 another diesel bus line was replaced by the in-motion charging trolleybuses (6 12-meter vehicles).

Deliverables

No.	Name	Description	Planned	Actual	Status
4.1	Gdynia Use Case - set-up report	*This report will include information about the Gdynia use case background/ set?up covering aspects such as objectives, operational environment, use case operational/ work plan, details about the selection of in-motion charging trials and functions for the SES control system in Gdynia's trolley network.*	*2018-12-31*	*2019-04-17*	*Acquisition of new trolleybusses (with support of the EU funding) increases the number of vehicles with modern traction batteries with the range of operation without catenary up to 30 kms. Therefore next stage of the spatial development of low-emission trolleybus transport could be made in Gdynia and neighbouring cities. Based on previous experience and analysis made in CIVITAS DYN@MO and ELIPTIC project, a study of new trolleybus service in Gdynia and Sopot will be prepared. The study would include: 1. Current status of battery and e-charging infrastructure development process (to analyse the future need for catenary development). 2. Evaluation of social support for trolleybus development process based on the results of marketing research conducted among Gdynia's citizens (to evaluate the perceived quality and ecological advantages of electric transport in Gdynia). 3. Based on the results of ELIPTIC project, a CBA of hybrid trolleybuses compared to classic trolleybuses to support decision making-process in the city.*

^ 2.15 System design for SES control functions finalised

Planned finish date	2019-02-28
Actual finish date	2020-10-31

Status

Utility analysis and rating of energy storage in trolleybus power supply system was prepared by prof. M. Bart?omiejczyk. Standard traction substation and Storage Energy systems with low power charging from the AC network were compared. It was found that the use of an SES makes it possible to reduce the peak power consumption of the substation to the level of maximum load on a one-hour scale. It could result in a significant reduction in the fee for contracted power, and in the case of building a new substation, it would reduce the costs of building a power line. The energy storage should have a capacity between 5 and 15 kWh. Such a level of capacity determines the type of energy storage as electrochemical batteries. Due to the high peak power consumption and high frequency of charge and discharge cycles, lithium-titanate (LTO) batteries are the preferred solution. Besides capacity, the battery needs to provide high peak power of a value 400–800 kW. LTO batteries can be discharged at 10-15 C, which requires batteries with a capacity of 40-80 kWh.

Moreover, the scheme of the trolleybus supply system with a PV plant was developed in line with the analysis of strategic documents described in M14. As a supplement, the analysis intitled "OVERVIEW OF THE CURRENT STATE OF DEVELOPMENT OF TRACTION BATTERIES IN URBAN TRANSPORT" was prepared (author dr. inz. M. Koniak). It was followed than by the detailed analysis of LTO batteries being used in e-buses operated by MZA Warsaw sp. z o.o.

Deliverables

No.	Name	Description	Planned	Actual	Status
4.2	*Report on advanced trolleybus supply system with Stationary Energy Storage (SES) systems*	*Report on system design for optimised energy usage in Gdynia's trolleybus network based on SES. Furthermore, the potential for integration of PVs into Gdynia's trolley grid will be assessed.*	*2019-06-30*	*2020-04-24*	*The main reason for delay in delivering D4.2 was a delay in the employment of prof. dr hab. Miko?aj Bart?omiejczyk at the University of Gdansk within the Trolley 2.0 project. As Prof. Bart?omiejczyk is employed at the Technical University of Gdansk, PKT Gdynia sp. z o.o., the University of Gdansk had to be very strict with the volume of monthly hours assigned to prof. Miko?aj Bart?omiejczyk within Trolley 2.0. The employee of the UG cannot exceed 278 hours of total professional activity per month.* *As only Mr. Bart?omiejczyk was approved he immediately started to work on Deliverable 4.2.*

^ 2.16 Completed trials in Gdynia

Planned finish date 2020-06-30
Actual finish date 2020-12-31

Status

It was agreed that the midibus could arrive for trials in Gdynia after trials have been completed in Hungary. Due to the Coronavirus, this Milestone could not be reached, as the testing of teh Evopro vehcile could not be carried out in Gdynia.

Deliverables

No.	Name	Description	Planned	Actual	Status

4.3	*Final Gdynia Use Case Report*	*The Gdynia Use Case Report will summarise the trials in Gdynia regarding in-motion charging and SES contol functions and the evaluation results based on data collection as well as lessons learnt. Furthermore, recommendations for spatial and operational modifications of trolleybus routes based on in-motion charging concepts (incl. performance parameters for traction batteries) will be developed.*	*2020-06-30*	*2020-12-22*	*Deliverable completed. It was finished with the delay (impact of COVID-19 that slowed down the process of data collection and made cooperation with the trolleybus operator in Gdynia more difficult. For that reason a request for the project extension was formulated and submitted to NCBiR).*

^ 2.17 Extended CBA model published

Planned finish date 2020-06-30
Actual finish date 2020-12-23
Status
In order for the modelling results to be as close to reality as possible, many explanatory variables were included in the developed economic model. The model makes it possible to determine the minimum annual bus mileage, at which electromobility solutions will be characterized by a lower financial net present value of costs compared to conventional buses meeting the Euro VI emission standard. The model enables modelling and analysis to be carried out for a variety of urban transport systems from any country. The model has been updated for this analysis to include additional variants for a public transport line, respectively diesel bus service; 'classic' trolleybus service with network construction costs along an entire route and without batteries; BEVs with mixed and overnight charging — the most promising BEV solution in most cases as shown by the ELIPTIC project findings because of the optimal trade-off between battery costs and operational capabilities resulting from the battery capacity; BEVs charged from overhead trolleybus networks – IMC trolleybuses or so-called 'trolleybus without catenary' – a solution that can be used only in cities with existing trolleybus infrastructure that run buses along the trolleybus network to connect to stations with no overhead network. In these cases, although BEVs may be introduced without investment in infrastructure, vehicle costs increase due to the battery component. As well, overhead network wear increases slightly, resulting in some additional costs. The model was prepared as easy-to-operate scheme published on the websiteand is available under the link:
http://trolley.mamutec.pl/en/Home/Index

Deliverables

No.	Name	Description	Planned	Actual	Status

4.4	*CBA model for in-motion charging concepts in Polish trolleybus systems*	*The extended CBA model will describe costs and benefits for conventional trolleybuses and -in comparison - in-motion charging concepts providing guidance for planning trolleybus systems or extensions of existing systems based on the results of Trolley 2.0 trials and experiences made in Polish trolleybus cities. The deliverable will also include guidelines how to use the model and recommendations how to realise in the future in-motion charging concepts in the involved Polish trolleybus cities.*	*2020-06-30*	*2020-12-23*	*Deliverable completed. It was finished with the delay (impact of COVID-19 that slowed down the process of data collection and made cooperation with the trolleybus operators more difficult).*

^ 2.18 Evaluation Framework completed

Planned finish date	2018-06-30
Actual finish date	2018-09-30

Status

The evaluation has been completed with three months delay because also the project started three months later.

Deliverables

No.	Name	Description	Planned	Actual	Status
6.1	*Trolley 2.0 impact and process evaluation plan*	*This report describes the methodology to evaluate impacts as well as process-related aspects, including KPI definiiton and practical guidelines for the data collection process.*	*2018-06-30*	*2018-09-30*	*This document contains the Impact Evaluation Plan for the project Trolley 2.0 described in Work Package (WP) 6 as Deliverable 6.1. In the plan, the most important steps for the evaluation of the project on a quantitative basis are described, as well as the motivation and background that lead to the development of the steps. The objective of the plan is to develop a strategy for the project partners to evaluate their individual research in a coordinated manner. As a result of this, a comprehensive evaluation of the project will be made possible with the overall goal of delivering data for business case developments involving the technologies studied as described in WP 7.* *Section 2 gives a brief overview of the background and the context of the project, which will provide insight into the where Trolley 2.0 fits in within other recent EU projects. Section 3 shows the research aims and promised tasks of the project evaluation. This will provide a more detailed look into WP 6 as well as its role to fulfill the project objectives. Section 4 provides an overview of the different partner cities and the details of their working packages, showing how measures could impact the current system.* *Section 5 then describes the methodology chosen to approach the evaluation of the work done in Trolley 2.0. This is done by first summarizing the thematic impact areas that have been selected on the basis of literature. These impact areas will be split into a final list of key performance indicators (KPI) and strategic data that needs to be collected in order to inform or calculate the KPI.* *Section 6 will show the methodology of the process evaluation. This section involves the examination of the different tools necessary to carry out the process evaluation, which can also be described as research methods. The next step is to categorize the different phases the project will undergo and how the research methodologies can be used to evaluate these phases appropriately.* *Section 7 will show the standard quality criteria that serve as a guide for good evaluation. These include for example the guarantee of anonymity for stakeholders and privacy of data but also the appropriateness of data collection methods.* *Section 8 will show the aspired time plan as well as the responsibilities of the individual stakeholders.* *Lastly section 9 will show the aspired results of the project evaluation such as transferability potential as well as input for WP7.*

^ 2.19 Evaluation of impact assessment results finalised

Planned finish date	2020-06-30
Actual finish date	2021-01-27

Status

Several measures introduced by the Trolley 2.0 partners were evaluated for their impact. The impact was measured through Key Performance indicators, which were drafted in the project evaluation plan. Due to the delays and hindrances in the project, several work packages were not completed and could therefore not be evaluated in their entirety, Therefore several of these had to be evaluated with different indicators. For the use case of Arnhem, it was concluded that the Network could be powered 100% by local renewable energy sources, however would also require upwards of 1200

MWh of storage. To achieve roughly 80% of direct renewable uptake from local energy sources, about 100 MWh are required. For the use case in Szeged, the tested automatic wiring system achieved reliabilities of approximately 77-90% during trials in the depot and on route. This reflects an improvement over previous trials and a step towards further implementation of this technology. In Gdynia, calculations were made on the use of stationary energy storage to reduce the peak power demand from the network. Through the installation of the storage, peak power demand was reduced by 90% for a substation in Gdynia. In Eberswalde, 12 buses were retrofitted with batteries and are now operating on the trolley bus routes 861 and 862. This retrofit process enabled a reduction in overall costs, compared to diesel buses and reduces CO_2 emissions from operation by at least 44% and approximately 90% when only renewable energy sources are used.

Deliverables

No.	Name	Description	Planned	Actual	Status
6.2	*Full impact and process evaluation report*	*This report describes the results from the “before?during” comparison of the Trolley 2.0 demonstrators both at local and cross?site, including results from the extended CBA model.*	*2020-06-30*	*2020-12-31*	*The document was delivered in time - calculating the 3+3 months delay of the whole project.*

^ 2.20 Extended CBA model validated

Planned finish date 2020-02-29
Actual finish date 2020-12-23
Status
The extended CBA tool was developed and tested for trolleybus systems in the Polish trolleybus cities Gdynia, Lublin and Tychy.

Deliverables

No.	Name	Description	Planned	Actual	Status

6.3	*Extended methodology for CBA of in-motion charging concepts*	*This extended CBA methodology will include an advanced economic model for comparison of trolley-battery-buses operated in in-motion charging concepts with other clean bus types (incl. fully catenary dependant vehicles) and diesel buses. The methodology/model will be validated by associated partners and Trolley 2.0 user forum members by discussing criteria and parameters, e.g. cost items, operators remuneration into fixed and variable cost components, external cost factors etc.*	*2020-02-29*	*2020-09-30*	*Deliverable completed. It was finished with the delay (impact of COVID-19 that slowed down the process of data collection and made cooperation with the trolleybus operator in Gdynia more difficult. For that reason a request for the project extension was formulated and submitted to NCBiR).*

^ 2.21 Transferability potential for Trolley 2.0 results validated

Planned finish date 2020-06-30
Actual finish date 2020-12-23
Status
IThe transferability report was completed for fo some project key aspects / measures, incl. general data gathering processes, research processes and the introduction of renewable energy sources, and recommendations for public transport operators and decision makers. Recommendations include the continued necessity of research projects as a means for data gathering and the building up of a data basis for transport companies, if this does not exist already. Another key message about the introduction of renewables was the consideration of stationary storage and the requirements of large storage sizes that should be considered when more local energy sources are to be introduced. Other messages included the role of Hybrid-Trolley bus lines and the automatic wiring technology and its future role in helping to reduce costs in the future for hybrid trolley bus lines.

Deliverables

No.	Name	Description	Planned	Actual	Status
6.4	*Evaluation findings and transferability potential at European level*	*This report will synthesize the key findings from all the Trolley 2.0 case studies and provides references for transferability of the Trolley 2.0 use cases at European level.*	*2020-06-30*	*2020-12-31*	*The document has been delivered in time - calculating the 3+3 months delay of the whole project due to project delay and the coronavirus.*

^ 2.22 Trolley 2.0 Business Cases validated

Planned finish date 2020-04-30
Actual finish date 2020-11-30
Status
For all TROLEY 2.0 use cases, a bussines case - based on an adopted CANVAS model were developed (D7.1).

Deliverables

No.	Name	Description	Planned	Actual	Status
7.1	*Report on final business cases*	*Report on the final business cases developed on basis of the Trolley 2.0 use case demonstrations in each partner country incl. further take-up/ implementation plans.*	*2020-06-30*	*2020-08-31*	*The Business Cases have been elaborated during more single and group sessions and also during the 5th Partner Meeting in May 2020. Afterwards the Business Cases have been finished and have been delivered in August 2020.*

^ 2.23 Trolley 2.0 development schemes validated

Planned finish date 2020-04-30
Actual finish date 2020-12-23
Status
The main project results from TROLLEY 2.0 - plus lessons learned form User Forum cities - have been compiled to a guide for setting up IMC systems (D.7.2).

Deliverables

No.	Name	Description	Planned	Actual	Status

7.2	*Final Trolley 2.0 development schemes*	*Report on finally agreed development schemes for Trolley 2.0 use cases towards electric public transport based on in-motion charging concepts and smart trolley grid solutions.*	*2020-06-30*		*In this report the reader will find main lessons learnt from the TROLLEY 2.0 project and knowledge from the exchange with TROLLEY 2.0 User Forum members which are outlined in the following as elements of a development scheme for the deployment of in-motion charging (IMC) systems.*

^ 2.24 Trolley 2.0 Lessons Learnt and Policy Recommendations published

Planned finish date 2020-06-30
Actual finish date 2021-01-29
Status
A final project results' brochure incl. all relevant lessons learned gathered from the project activities has been created and was published (D7.3).

Deliverables

No.	Name	Description	Planned	Actual	Status
7.3	*Joint Trolley 2.0 lessons learned & policy recommendations*	*Key deliverable of the Trolley 2.0 project: results on lessons learned and policy recommendations in all 4 project languages plus EN and optional 3 further languages in EMEurpe programme area with high replication potential due to exisisting trolleybus networks (Belarus) or several implementation plans for trolley networks (e.g. Turkey).*	*2020-06-30*	*2020-12-23*	*Main results from TROLLEY 2.0 use cases' preparation and realisation/implementation as well as from business cases' development and from User Forum knowledge exchange have been collected and a project lessons learned brochure has been created.*

^ 2.25 Trolley 2.0 Communication Plan finalised

Planned finish date 2018-06-30
Actual finish date 2018-09-30
Status
The corporate identity (logo and claim) was created within May 2018. The trolley: 2.0 project is listed on the index-tab of the trolley:motion homepage as a microsite. Project-related articles are published on the trolley:motion homepage and on the trolley: 2.0 News. Furthermore, news regarding the global development of trolleybus systems as well as project-related news are published in the social media channels of trolley:motion. In addition, a trolley:city news site will be modernized. The social media channels include:n

- Facebook: approx. 700 readers, trolley: motion, trolley promoting public transport - from 2013: approx. 800 readers
- LinkedIn Special Interest groups: Public Transport (about 42,000 readers), Bus Industry (about 8000 readers), Civitas Horizon (about 1900 readers)
- Xing Group: Public Transport: approx. 2000 readers)
- trolley: motion Newsletter, published about 5 times a year: about 3800 readers

In total, three press releases are planned; one at the beginning of the project, one in the middle and one at the end of the project. The trolley: 2.0 project was thematically included in the press release for the 6th International e-Bus Conference. An interim report as a press release was published in the middle of April 2019.

A four-page project flyer was realized in English and provides information about the trolley: 2.0 project in general, the work packages of the use cases of the four cities, the partners, the user forum, the associated cities as well as contact information and funding information. This was completed in October 2018.

In addition, a 40-page conference and program brochure was produced for the 6th International e-Bus Conference in Solingen in November 2018 and printed 250 times. The conference and program brochure include the opening of the president of trolley: motion, greetings from the mayor of Solingen, the conference program, information about the venue, a map of the city of Solingen with information about the venue and a brief overview of the speakers' presentation. The program on November 22, 2018, was organized and designed exclusively by and for trolley: 2.0.nnIn order to ensure the corporate identity of the project in the external presentation, a uniform template was created, which was made available to all partners on the Dropbox.

trolley:motion was the organizer of the 6th international eBus conference in November 2018 in Solingen with about 200 participants from different kind of institutions. Another conference is planned for 2020.

trolley:motion and the project partners participated in different related events (i.e. Elekbu, European ZEB Conference, 4th international trolleybus conference in Parma etc.). Further participation in conferences, workshops, and related events is planned for 2019 and 2020.

Deliverables

No.	Name	Description	Planned	Actual	Status
8.1	*Trolley 2.0 Communication and Dissemination strategy*	*Trolley 2.0 partners (led by trolley:motion) will develop a dedicated Communication and Dissemination strategy, which will guide the project’s communication activities throughout the project and beyond. The communication and dissemination strategy will be updated in month 15 to ensure that project findings are disseminated effectively in the last year of the project.*	*2018-06-30*	*2018-09-30*	*This Communication Plan has been developed at the outset of the project and identifies opportunities and actions for each of the partners for their own countries as well as European wide dissemination of the findings and recommendations from the project. The plan itself will remain a ‘live’ document and will be updated if the working progress of the project requires it.*

^ 2.26 Final Conference

Planned finish date 2020-06-30
Actual finish date 2020-11-13
Status
The final project conference took place online on **12 and 13 November 2020**. Due to the corona travel restrictions, it was not possible to organize a conference and on-site visit in Eberswalde. Participants of the conference learned about the main accomplishments of the project in the development of smart trolley grids and innovative in-motion charging concepts. This comprised lessons learned from the trolley 2.0 demonstrations that took place in various European trolleybus cities as well as new knowledge products. Speakers included representatives of leading trolleybus operators including SZKT Szeged, PKT Gdynia, BBG Eberswalde as well as leading academic (University of Gdansk, University Dresden, TU Delft) and industry representatives (evopro, PRE Power, Kummler+Matter AG, Libroduct). The conference was organized and moderated by the leading European trolleybus interest group, trolley:motion. we had **260 registered persons and 170 participants per day from all over the world**.

Deliverables

No.	Name	Description	Planned	Actual	Status
8.2	*Trolley 2.0 Final Conference*	*At the end of the project, a Trolley 2.0 conference will be organised to showcase the project's accomplishments and present the results of the use cases and lessons learned of the project. To enhance take-up of the Trolley 2.0 results, the conference will be linked to trolley:motion's international trolleybus conference in 2020.*	*2020-06-30*	*2020-11-13*	*The final conference was planned, held and organized in time.*

^ 2.27 Trolley 2.0 Twinning replication plans

Planned finish date 2020-06-30
Actual finish date 2020-12-31
Status
The twinning replication activities refer to the different cities and how far they have come with their objectives during the project life-time. Unfortunately, due to the coronavirus travel restrictions also the project has some delays with its original plans.
The city of Solingen wants to test the automatic wiring and de-wiring system from Libroduct.
The city Budapest will definitely test the trolleybus as soon as the authorization has been received.
Berliner Verkehrsbetriebe (BVG) are developing upon the trolley:2.0 project their pilot line, the IMC kit and toolkit.
The city of Arnhem will use the studies from TU Delft for the opportunity chargers and Pre Power will build further opportunity chargers.

Deliverables

No.	Name	Description	Planned	Actual	Status

8.3	*Report on Trolley 2.0 Twinning activities*	*Documentation of the twinning activities with associated partners (site visits/workshops). The report will also conatin a section on a replication plan per twinning partner to document concrete next steps / actions towards the implementation of Trolley 2.0 solutions, e.g. implementation/investment, tendering and procurement processes.*	*2020-06-30*	*2020-12-31*	*The twinning activities have been organized and elaborated during the whole project time. Some twinning activities will also go on after the official trolley:2.0 project finish.*

^ 2.28 Trolley 2.0 User Forum established

Planned finish date 2018-06-30
Actual finish date 2018-10-31
Status
For milestone 28: Establishing a User Forum, trolley: motion created an open call in September 2018, to which interested cities and public transport associations could apply. trolley:motion accepted, selected and evaluated the applications so that a good quality of participants could be guaranteed. The User Forum consists of Hordaland AG, Bergen (NO), Municipality of Maribor (SLO), Berliner Verkehrsbetriebe (BVG) (DE), OSY S.A. Athens (GR), Pilsen City Transport Company (CZ), TPER SpA, Bologna (IT), Public Transport Klagenfurt (AT), Public Transport Zurich (CH), Marburger Verkehrsgesellschaft (DE). In addition, all associated trolley: 2.0 partners participate in the User Forum.
The milestone was successfully accomplished within the 31.10.2018.

The User Forum Cities benefit from an exchange of experience on the following trolley: 2.0 topics:

- In-motion charging concept for battery-operated trolleybuses
- Midi-hybrid trolleybus as a system to extend the existing trolleybus network to remote areas
- Testing automated wire-and-wire technologies
- Multi-purpose trolleybus networks enabling the charging of other electric vehicles and the integration of solar energy
- Stationary energy storage systems and intelligent energy management of trolleybus networks (eg optimized use of recuperation energy,
- Integration of 2nd-life batteries, bilateral energy supply, etc.

The first User Forum Event took place during the 6th International e-Bus Conference in Solingen in November 2018. Another event is planned for September 2019 in Arnhem and a third 2020 (time and place not yet defined).

Deliverables

No.	Name	Description	Planned	Actual	Status

8.4	*Report on Trolley 2.0 User Forum activities*	*Documentation of three User Forum events with about 20 participants each. The user forum activities include discussion forums, site visits, online pre-surveys and assessment / validation excercises for Trolley 2.0 project results.*	*2020-06-30*	*2020-12-31*	*The deliverable was finished in time with a 3 months + 3 months delay because of the corona-virus.*

^ 2.29 Completed tendering and procurement process

Planned finish date 2018-12-31
Actual finish date 2019-04-15
Status
This milestone describes the procurement process of different technologies to be tested in the use case Eberswalde. For the procurement of all planned topics, this deliverable should give an overview about the actual status of the procurement. The Barnimer Busgesellschaft mbH has three different types of technologies which it will procure, install and test during the project. The first one is the installation of traction batteries to the existing trolley busses and the conversion of the diesel bus line 910 to a full trolley bus line. The second topic is the procurement and testing of an automatic wiring system. The third topic is the procurement of the multipurpose charger from the project partner PRE. For the batteries, we can deliver a small text about the chosen form of tendering and a report about the procurement process of the batteries. The procurement process of the wiring system and the charging system is still open due to different problems of suppliers. A quote for the charging station from the project partner has been submitted but currently exceeds the funding allocated for this project. In total, the project goals depend on the work of all suppliers.

Deliverables

No.	Name	Description	Planned	Actual	Status

5.1	*Report on tendering and procurement process*	*The report will document the process of tendering specification and the actual procurement process. TU Dresden will support BBG in specifying the tender documents and conditions.*	*2018-12-31*	*2019-04-15*	*This deliverable describes the procurement process of different technologies to be tested in the use case Eberswalde. For the procurement of all planned topics, this deliverable should give an overview about the actual status of the procurement. The Barnimer Busgesellschaft mbH has three different types of technologies which it will procure, install and test during the project. The first one is the installation of traction batteries to the existing trolley busses and the conversion of the diesel bus line 910 to a full trolley bus line. The second topic is the procurement and testing of an automatic wiring system. The third topic is the procurement of the multipurpose charger from the project partner PRE.* *For the batteries, we can deliver a small text about the chosen form of tendering and a report about the procurement process of the batteries. The procurement process of the wiring system and the charging system is still open due to different problems of suppliers. A quote for the charging station from the project partner has been submitted but currently exceeds the funding allocated for this project.* *In total, the project goals depend on the work of all suppliers.*

^ 2.30 Successful introduction of regional trolleybus line with in-motion charging

Planned finish date 2019-06-30

Actual finish date 2020-11-30

Status

The use case for Eberswalde (BBG) was succesfully implemented by the smooth introduction and operation of a new IMC line as well as the generation of operational data which were used to evaluate this new line concept. For this, batteries replaced the diesel APUs in 12 trolleybuses in Eberswalde.

Deliverables

No.	Name	Description	Planned	Actual	Status

5.2	*Eberswalde use case set-up report*	*This report will include information about the introduction process (including collecting required permissions) of the regional trolleybus line in Eberswalde as well as use case background/ set?up covering aspects for the multi-purpose charger demonstration scenarios, such as objectives, operational environment, charging infrastructure location or the to be charged vehicles.*	*2019-02-28*	*2019-04-29*	*This report describes the set up for the use case Eberswalde in the project Trolley 2.0.* *Objectives in this use case include the smooth introduction and operation of this new line as well as the generation of operational data which will help evaluate this concept. For this, the first batteries have been procured and replaced the diesel APU in the bus. Other objectives include the installation of a new multipurpose charger and test its operation, the testing of an automatic wiring pantograph system as well as a new type of midi bus.* *Potential impacts include the generation of experience for battery-trolley busses and the provision of information about the energy storage system. This will require a thorough analysis on the basis of technological and economic parameters, but also the public opinion. In addition to this, the investigation of the multipurpose charger will make it possible to gain information about how to make DC infrastructure more economically efficient by adding another source of income, while being in line with the German legislature. Other impacts can be expected from the automatic wiring system, which would add more flexibility to the battery-trolley bus. Lastly, the midi bus should reveal technical aspects related to the insulation of the bus as well as an understanding of this technology within the German legislature.* *Risks for these endeavors include that the automatic wiring system cannot be installed since it is still in prototype status and that the multipurpose charger can only be used restrictively due to the German legislature.* *Expected results include the successful implementation and safe operation of an In-Motion-Charging bus line and data generation, analysis and evaluation of the concept in Eberswalde. Other expected results are the procurement and operation of a multipurpose charger and an automatic wiring system for the bus. Lastly, an analysis of the German legislature for the Midi bus supplied by project partners will be made to understand whether or not this bus can be introduced in Germany. Secondly, this bus will be tested in Eberswalde.*

^ 2.31 Completed trials and demonstrations in Eberswalde

Planned finish date	2020-06-30
Actual finish date	2020-12-31

Status

This milestone was impossible to complete as testing vehicle of Evopro was never delivered to Eberswalde due to the coronavirus situation and other technical delays.

Deliverables

No.	Name	Description	Planned	Actual	Status

5.3	*Final Eberswalde Use Case Report*	*The Eberswalde Use Case Report will summarise the operation of the newly introduced regional trolleybus as well as the trials regarding multi-purpose charging in Eberswalde. TU Dresden will support BBG in compiling the final use case / evaluation report for Eberswalde.*	*2020-06-30*	*2020-12-31*	*The deliverable, as well as the whole project itself, was delayed through the consequences of the coronavirus/ COVID-19 pandemic. With the travel restrictions that determined it was impossible for our foreign project partner to travel to Eberswalde and complete their parts of the project in time. The final project aspects were also finished just in time. After the last test in the last weeks of December 2020 we were finally able to complete the deliverable.*

3 Deliverable per Workpackage

^ 3.1 Project Coordination and Management

No.	Name	File	Dissemination level	Explanation	Impact
1.1	*Trolley 2.0 Risk register*	*Trolley_2.0_risk_register_final.pdf*	*Confidential*	*internal tool to which partners should openly contribute to in order to mitigate risks and successfully run the project*	*Constant awareness of changes and constraints to lower the risk that project activities cannot be implemented and mitigation of risks so that necessary actions can be taken*
1.2	*Mid-term report*	*D1.2 Mid-term report.docx*	*Public*		*n.a.*
1.3	*Final report*	*D1.3 FInal report .docx*	*Public*		*n.a.*

^ 3.2 Arnhem Use Case

No.	Name	File	Dissemination level	Explanation	Impact
2.1	*Arnhem Use Case– set?up report*	*Use case set up report template_updated1.pdf*	*Public*		*Recommendations about extent of usage of PV, storage, their location, quantifying the reduction in emissions*
2.2	*Report on smart trolleybus grids*	*Deliverable report template_Arnhem_updated1.pdf*	*Confidential*	*Confidential because we are writing a paper which is almost similar to this deliverable and would like to request to make it public after we have published the paper*	*Knowledge of the state-of-the-art of trolleygrids and hence, defining the tasks for the project.*

2.3	*Laboratory proof of principle and design report*	[*D2.3 Laboratory proof of principle and design report.docx*]	*Public*		*The deliverable shows, with a prototype, the feasibility of charging an EV vehicle directly from the trolleygrid. The trolleygrid has then an extra functionality, allowing it, as the project envisions, to become an active grid and a flexible backbone to the main grid.*
2.4	*Final Arnhem Use Case Report*	[*D2.4 Final Arnhem Use Case report.docx*]	*Public*		*The deliverable shows the potential of the integration of renewable energy sources, storage, and EV charging in the grid. The trolleygrid has the potential to be a sustainable, active grid.*
2.4	*Final Arnhem Use Case Report*	[*EME-Trolley2.0_D.3.1_Szeged_Set-up_report.docx*]	*Public*		*The deliverable shows the potential of the integration of renewable energy sources, storage, and EV charging in the grid. The trolleygrid has the potential to be a sustainable, active grid.*

^ 3.3 Szeged Use Case

No.	Name	File	Dissemination level	Explanation	Impact

					Evopro Bus Ltd. has vast experience with composite frame buses, as the developer of the Modulo e-bus series. Composite frame buses are a novelty in the industry and can bring advantages from the conventional steel buses in terms of durability. It has a more rigid frame than steel vehicles, without any long-term corrosion problems. It is especially useful for electric buses, as an insulating body means fewer insulation problems for the high voltage equipment, as well as the lighter body structure, which means considerably less energy consumption (around 30 % less), consequently a higher range of autonomous operation. Modulo vehicles are comprised of modules that can modify the size of the vehicle, thus gives a variable range of vehicles for different customers. The vehicles fulfill all required European standards, and their low-floor arrangement is also suitable for disabled persons.
3.2	*Composite framed midi Trolleybus*	*Deliverable report Szeged_D3.2.docx*	*Public*		*The Trolley 2.0 project took an aim to modify an existing overnight charging e-bus construction to an « in motion » charging vehicle from trolleybus catenary. The resulting « trolleybus » is smaller than the usual vehicle sizes, but promise larger autonomous distances, thus it is an ideal vehicle for a supporter route role on an existing trolleybus backbone network or charging corridors. The routes with a smaller vehicle can branch off from the mainline after short recharging, the smaller size and smaller empty weight of the vehicle mean flexible usage in terms of the existing trolleybus catenary infrastructure as well as the route.* *This report details this modification project's elements from the customer's (Szeged Transport Company) requirements, the European and Hungarian legal requirements, as well as the modified electric components (current collector, DC-link/battery charger, traction batteries).*

3.3	*Optimized battery set*	*[D3.3 Optimized Battery Set.docx]*	*Public*		*We made recommendations for the Budapest routes: different battery pack versions and corresponding IMC sections. Considering the advantages and disadvantages of the different versions (fewer batteries, installation costs of the IMC system), energy efficiency can be increased on these routes.* *We compared the results of our analyzes with the characteristics of the planned track in Szeged. Accordingly, we proposed the battery pack of the Szeged hybrid bus, with which the SOC calculated for the entire daily distance is in the appropriate range.* *Accordingly, we proposed the battery pack of the Szeged hybrid bus, according to the desired performance and the calculated SOC value for the whole day.*

3.5	*Final Szeged Use Case Report*	*D3.4 Toolkit_Trolley 2.0_Szeged - 2020.11.30.docx*	*Public*		*The report highlights the advantages of in-motion-charging:* *- no need for construction of complicated catenary complexes: the vehicle can simply pull down the current collector at large junctions;* *- no need for standing (dead time waiting) while charging: in case of delays (e.g. due to traffic jams, accidents) the vehicle can immediately return to service in contrast of the opportunity charging method;* *- existing, reliable technology;* *- upscaling for heavy duty operation is easier. There are barely articulated 18 m overnight charging e-buses on the market, on the other hand in the heavy-duty bus routes the feasibility of a partial overhead catenary is significant. There are examples of bus rapid transit (BRT) systems, where significant part is electrified (Rimini, Baoding, Jinan, Shanghai, Beijing, Mexico City, Marrakesh);* *- the used traction battery sets can have a second life as a stationary energy storage, which used batteries can be still capable. In stationary storages for IMC charging there is no need for high fluctuance of the SOC of the batteries – only max. 1-2 % fluctuation is reasonable –, instead high-power absorption and reemission is required. Thus, a used battery, that lost 20 % of its initial energy storage capacity, can still be well used in a buffer station. Further research is required in this field;* *- using battery trolleybuses/IMC e-buses can limit the power surges at existing power substations – at peak demand "smart charging" trolleybuses can reduce the battery recharging or use the traction batteries for acceleration.*

3.5	*Final Szeged Use Case Report*	[*D3.5 trolley 2.0 final use case report Szeged.docx*]	*Public*		*Legal barriers regarding the authorisation for the midi-trolleybus led to dealys and SZKT recommends the follwoing:* *With regard to regaultion UNECE 100 5.3.:* *Shoudl be modified:* *- an exception should be possible from banning the movement during charging for IMC e-buses/trolleybuses. UNECE 100 should also clarify the electric insulation safety requirements. Today it writes (5.1.2.3):* *„In the case of motor vehicles which are intended to be connected to the grounded external electric power supply through the conductive connection, a device to enable the galvanical connection of the electrical chassis to the earth ground shall be provided.(…)”* *This text shows, that galvanic chargers are either grounded or ground independent. In both cases single insulation is enough (with or without grounding).* *Trolleybus catenaries are neither grounded, nor ground independent. This is why double insulation is required. Proposed regulation:* *- IMC e-buses/trolleybuses must have double insulation, but this should be also achievable through galvanic separation device in the high voltage bus (i.e. usage of DC-DC link, which provides one insulation level all the on board high voltage electric circuit on its output side).*

^ 3.4 Gdynia Use Case

No.	Name	File	Dissemination level	Explanation	Impact
4.1	*Gdynia Use Case - set-up report*	*Use_Case_Setup_Rep_GDYNIA_17_04_2019.docx*	Public		*Use Case report set the background for planned activities within WP4. It evaluated the starting point with attention to strategic documents being passed from Gdynia City Council as well as Lublin and Tychy.* *It was confirmed that trolleybus transport holds a strong market position and its qualitative and quantitative development is continued. Among the most important trends identified are increased number and role of hybrid trolleybuses, increased out-of-catenary operations and willingness to steadily replace diesel buses with trolleybuses under certain conditions.*

4.2	*Report on advanced trolleybus supply system with Stationary Energy Storage (SES) systems*	*Deliverable report 4.2. SES.docx*	*Public*		*The article discusses two energy storage applications in power supply system of public electrified transport. The first application aims at reducing the peak power of the traction substation. The second application increases effectiveness of using solar power plant to cover partial power demand of traction supply system. These two applications were discussed and analyzed based on trolleybus supply system in Gdynia, where most measurements were recorded.*
4.3	*Final Gdynia Use Case Report*	*D4.3 trolley 2.0 final use case report Gdynia_22_12_2020.docx*	*Public*		*The evaluation of results based on real-life operations was conducted. It supported several decisions on the trolleybus network development.*
4.4	*CBA model for in-motion charging concepts in Polish trolleybus systems*	*D4.4 CBA model for IMC concepts in Polish trolleybus systems.docx*	*Public*		*It provides a cost and benefits analysis for conventional trolleybuses and -in comparison - in-motion charging concepts as well as for the diesel and electric buses. It could be used as a supportive tool for planning, developing, or extending trolleybus systems.*

^ 3.5 Eberswalde Use Case

No.	Name	File	Dissemination level	Explanation	Impact
5.1	*Report on tendering and procurement process*	*D5.1 Report on tendering and procurement process.pdf*	*Public*		*This deliverable describes the process of tendering and therefore shows the challenges connected to the battery tendering process. Through this deliverable, we now have a better overview of the battery procurement and installation of batteries when retro-fitting and can use this as a basis for the acquirement of the remaining batteries. The workup of the tendering and procurement processes shows some delays for the battery ordering process and some delays for the procurement of the loading station fed from the catenary. Other impacts for the whole project could not be detected.*

5.2	*Eberswalde use case set-up report*	*[D5.2 Eberswalde Use case set-up report.pdf]*	*Public*		*The use-case set up report from Eberswalde describes and defines what has been done in the last year. It serves as a key to reflection for the completed tasks and those that are still open. It will help setting impulses for the remaining tasks and give a general overview of the status of the project.The workup of the set up report shows the risk of having some troubles with the supplier of the wiring system and the charging station. It becomes clear that there is no possibility to buy a wiring system because of the status of each supplier. In that case, the money for the project funding could be changed to some important changes in the infrastructure for loading the In-Motion-Charging-Bus. The impact for the charging station is much higher than for the wiring system because of the price in total for such a system offered from the company Venema. It is in total about 50% more expensive than calculated for the project funding. This could lead to a cancellation of the procurement process for the charging station.*
5.3	*Final Eberswalde Use Case Report*	*[5.3 Eberswalde Final use case report.docx]*	*Public*		*The impact of the deliverable was as the project itself very important for us. In terms of general understanding of our trolleybus fleet we were able to gain a lot of knowledge then even expected. For all employees involved into the project it is safe to say that the information and knowledge gain will be very valuable and useful in the future.*

^ 3.6 Impact Assessment

No.	Name	File	Dissemination level	Explanation	Impact
6.1	*Trolley 2.0 impact and process evaluation plan*	*[Trolley2_Impact and Process Evaluation Plan_Final_formatted.docx]*	*Public*		*This report describes the data collection process required for the impact and process evaluation of Trolley 2.0. This report will aid in structuring the overall evaluation process of the project by connecting common work packages amongst partners, deliver an evaluation by combining the work done by all partners and as well as explanations of the context of each use case and an evaluation of the process of the project.*
6.2	*Full impact and process evaluation report*	*[D6_2_Full Project Evaluation Trolley 2_V02_Formatted.docx]*	*Public*		*The document outlines the evaluation works during the project. The main impacts in the process evaluation outline the importance of good cooperation between stakeholders, as many project activities were delayed as a result of different problems relating to this category.*

6.3	*Extended methodology for CBA of in-motion charging concepts*	[*D6.3 Extended methodology for CBA of IMC Concepts.docx*]	*Public*		*Extended methodology for CBA of IMC concepts enabled the development of the CBA model that was used for the analysis of Polish trolleybus operators in Gdynia-Sopot, Lublin, and Tychy.*
6.4	*Evaluation findings and transferability potential at European level*	[*D6_4_Transferibility Report Trolley 2_V02.docx*]	*Public*		*The document outlines the transferable results from the process evaluation, impact evaluation and the cost benefit analysis (Deliverable 6.3)*

^ 3.7 Business cases, development schemes, guidelines, and policy recommendations

No.	Name	File	Dissemination level	Explanation	Impact

7.1	*Report on final business cases*	[*D7.1 Trolley 2.0 business cases.pptx*]	*Public*		*The trolley:2.0 partners aimed to prove that battery-supported trolleybuses are a way forward towards electric public transport systems in European cities by demonstrating the new charging concept in-motion charging (IMC), that allows for the partial off-wire operation of hybrid-trolleybuses in remote sections of the networks. The trolley:2.0 use cases aimed to demonstrate efficient public transport, flexible operation and simplified extension of trolleybus networks as well as the combined use of the existing trolley grid infrastructure for further electrification of mobility in cities.* ***The development of trolley:2.0 business cases ensure the long-term sustainability of the achieved project results.*** *For each use case, the local stakeholders compiled a list of measures necessary for permanent implementation. Price indications were collected and corresponding investment options were evaluated. The durations of the different steps of implementation were assessed (time planning). Different funding options were evaluated. The assessment of the relevant data and cost information needed for the planning of the realisation of a use case were supported on the one hand by the industry partners (trolley:motion members) who reviewed use cases in terms of technology feasibility / validation of use cases and reviewed the business cases bringing in their experience, e.g. in market development, prices etc. and on the other hand through exchange with associated partners and user forum members. trolley:motion supported the local use case teams (public transport operator, public transport authority, local research and industry partner) to develop concrete business cases for the further take-up of the use case (based on local and overall evaluation / impact assessment activities). Furthermore, development schemes were derived from cross-use case analysis to exploit synergies and to exchange results and experiences (e.g. possible solutions to certain technical challenges that two or more sites have in common).*

7.2	Final Trolley 2.0 development schemes	D7.2 Trolley 2.0 development scheme.pdf	Public		An entire community of practice has formed around trolleybus systems with the TROLLEY 2.0 partners and User Forum members in cooperation with UITP's Trolleybus Committee. Over the last 3 years a wealth of good practices around the deployment of IMC systems has been shared within this community; numerous presentations, and know-how are available on both the TROLLEY 2.0 project and trolley:motion's website (www.trolleymotion.eu); with the TROLLEY 2.0 User Forum a platform of major stakeholders and projects has been set-up (incl. the Clean Bus Europe support project APOLLO); and highly successful TROLLEY 2.0 events have been have been held in Solingen, DE (2018), Linz, AT (2019) and the final online conference (2020). Finally, IMC based trolleybus systems are increasingly seen as a real option for forward-looking cities to realise zero-emission public transport systems, and thus, batter-trolleybuses are considered as zero-emission vehicles in EU's Clean Vehicle Directive. The IMC concept is clearly a success story, but still many political decision makers are not aware of this solution, even though more and more cities are considering IMC-based trolleybus systems as a real option on their path towards carbon neutrality in 2050 (Green Deal Missions' goal). The following development scheme is a compilation of best practices and gathered knowledge - based on consultation with practitioners, and an active TROLLEY 2.0 community of practice - to support cities with the planning and deployment of IMC systems in the future.

7.3	*Joint Trolley 2.0 lessons learned & policy recommendations*	[*trolley2.0 deliverable 7.3.docx*]	*Public*		*Partner quotes: lessons learnt through the trolley:2.0 project**Arnhem:*** *"To design the trolleygrid of the future, it was essential to meet and work with many partner cities, allowing us to understand the status-quo of trolley grids across countries, and their practical strengths and challenges. Trolley2.0 facilitated this network-making and knowledge-sharing between academic institutions and trolley grid stakeholders, allowing us to orchestrate feasible, new directions from the current trolley grids. The steps that we are suggesting are futuristic and beneficial, but also concrete and realistic thanks to this international feedback pool. The connections we have made are solid and still active now, even beyond the final project conference."* ***Eberswalde:*** *"The Trolley 2.0 project has shown us that the trolleybus can very well be a future-oriented solution for public transport."* ***Gdynia:*** *"TROLLEY 2.0 has created a platform of collaboration between public transport operators, cities and scientists. Such an environment, full of ideas and practical developments inspired us toward new IMC trolleybus deployment concepts."* ***Szeged:*** *"The trolley 2.0 project participation gave us important insights in hybrid trolleybus technology, regarding scaling of the batteries, charging powers as well as composite bus technology. This will be useful for future extension of the trolleybus network without infrastructure development using battery trolleybuses."* *"Through the cooperation, we were able to get involved in a new form of trolleybus transport. We have been able to build valuable industrial relationships in the fields of bus manufacturing, transportation and battery manufacturing. In addition to the experience of analyzing the data collected in traffic, the experience gained during our measurements on battery modules and cells should be highlighted." (University of Szeged)*

^ 3.8 Dissemination, take-up and exploitation

No.	Name	File	Dissemination level	Explanation	Impact
8.1	*Trolley 2.0 Communication and Dissemination strategy*	*D8.1 Communication and Dissemination Plan final.pdf*	*Public*		*Good outreach of project results and a high level of visibility and reaching the target groups.*
8.2	*Trolley 2.0 Final Conference*	*D8.2 Final Conference Report.docx*	*Public*		*Initially, the Final Conference was planned to take place in Eberswalde, Germany together with the 7th international eBus conference. Travel restrictions due to the corona pandemic made it impossible to organize a conference on site. Therefore, an online conference was organized on* ***12 and 13 November 2020*** *by trolley:motion and Rupprecht Consult.* *The interest of the e-bus and trolleybus community was very high, and the conference registered 260 persons and 170 participants per day from all over the world. The corona pandemic has also its positive aspects for that kind of event. People who would have needed a lot of time and money to travel and come personally to the conference were now able to participate in the event. Therefore, we had registrations also from persons from Africa, America, Russia, Brazile. We are amazed by the fact that so many people participated in the event and showed a tremendous interest in learning about the current developments around trolleybuses and smart trolley grids.* *We greatly appreciate that so many shared opinions and actively contributed to the conference, even though, due to the current pandemic, we could not meet in person. We take great interest in this conference as a sign that the international trolleybus community is indeed a very vital one and hope to continue the discussions, thus contributing our best to the current trolleybus renaissance we are witnessing!*
8.3	*Report on Trolley 2.0 Twinning activities*	*D8.3 Report on Twinning Activities.docx*	*Public*		*The twinning activities are very important to spread the information of the benefits of a trolleybus system and give the* ***needed support to the cities*** *who are interested in an IMC system. Setting up a network and discussions with other trolley cities and public transport companies* ***is a must*** *for cities that want to implement an IMC system from scratch. Other cities instead are interested in the innovations from this sector and want to be the first to be part of it.* *Thanks to the twinning activities the cities are able to exchange, get the newest information, year-long know-how and the needed support to plan and implement IMC systems.*

8.4	Report on Trolley 2.0 User Forum activities	[D8.4 Report on trolley2.0 User Forum.docx]	Public		*The participants of the User Forum generally appreciated getting in contact with trolley bus experts from all over Europe. Furthermore, the participants highly appreciated the share of up-to-date information about technical and project-related developments and the exchange of knowledge, experiences, and technical solutions in other cities.* *The trolley:2.0 User Forum led to multiple lessons learnt for its participants. Mainly participants noticed that the development of the battery-trolleybus context goes into a similar direction in Europe, however in detail, the projects differ in their complexity and solutions. The main lessons learnt could be retrieved from the exchange of knowledge and experiences concerning energy efficiency, automatic wiring, synergies, compatibilities and many more aspects. Participants agree, that IMC-trolleybus systems are reliable and efficient.* *Finally, the participants agreed, that the topics of this User Forum were well chosen and besides the offered topics, they want to keep on discussing the topics from this User Forum.*

4 Issue/Risk

^ 4.1 R1: Management Risk

Milestone

Successful mid-term review accomplished

Description

Partners submit reports, data etc. after agreed deadline and with low quality.

Issue type

Communications

Status

Non applicable

Solution

Good internal communication structures, regular telephone conferences, bilateral communication, meetings.

^ 4.2 R2: Management Risk

Milestone

Successful mid-term review accomplished

Description
Managerial changes, thus core project team members might leave the cosnortium, which would delay project implementation due to knowledge gaps and needed familiarisation with project contents by successors.

Issue type
People

Status
Solved

Solution
President changed within trolley:motion group. Daniel Steiner was replaced by Mr. Wolfgang Backhaus.

^ 4.3 R3: Management Risk

Milestone
Charging prototype finished and installation (Arnhem)

Description
Partners have conflicts due to unclear decision-making processes or incompatible commercial interests with regard to the development of Trolley 2.0 solutions.

Issue type
Communications

Status
Workaround

Solution
Trying to approach associated partner city Arnhem to get infrastructure data for smart grids research and to deploy multi-purpose charger. Conflicts of interest between the City of Arnhem and grid-operator Connexxion need to be solved. In case of not being able to solve the conflicts of interest smart grid research and multi-purpose charger will be done or demonstrated respectively in another partner city.

^ 4.4 R4: Use case / Demonstration-specific Risk (Arnhem)

Milestone
Charging prototype finished and installation (Arnhem)

Description
Development of a converter prototype that meets the standards and is ready for use outside a laboratory might go beyond the capability of TU Delft. However, TU Delft has large experience in making innovative proof of concept that works on a laboratory scale.

Issue type
Company structure & Operations

Status
Workaround

Solution

1. Re-design of the transformer - reduce primary to secondary capacitance
2. Optimize gate drive circuit - optimize and reduce the trace distances, between the driver circuits and the switching elements

^ 4.5 R5: Use case / Demonstration-specific Risk

Milestone
Consortium Agreement formally agreed based on DESCA model

Description
Authorization processes - as a pre-condition to realise demonstrations - will necessarily lead to third parties involvement which can overrule technical solutions. E.g. Evopro / Ikarus plan to authorize its new midi-trolleybus not only in Hungary, but also for testing in partner countries/cities. Since there is no common European basis for trolleybus regulations and authorisation. There is a risk of non-implementation of tests with the vehicle at envisaged TRL 7, thus with passengers in operational environment, in partner cities.

Issue type
Policy

Status
Workaround

Solution
SZKT has got a positive resolution regarding the vehicle's authorisation from the National (Hungarian) institution for road safety.

Yet the concrete authorisation paperwork is still to be achieved by SZKT.

^ 4.6 R6: Use Case / Demonstration-specific Risk

Milestone
Consortium Agreement formally agreed based on DESCA model

Description
The envisaged planned current collector solution for automated wiring is still in prototype stage (TRL 6) and partners cannot anticipate every possible reaction in tests under TRL 7 in operational environment demonstrations.

Issue type
Products & Markets

Status
Workaround

Solution
Automatic de-and rewiring system was tested successfully by SZKT and company Libroduct in 2019. However, the technology still revealed minor weaknesses during tests in the operational environment (TRL7). The analysis helps LibroDuct to adapt the prototype and to develop it further in a marketable way.

^ 4.7 R7: Take-up, Exploitation & Dissemination Risk

Milestone
Multi-pupose charger in service

Description
In case of use case implementations in the use case areas 2) multi-purpose charging infrastructure and 3) integration of REs into the trolley grid, Public Transport operators enter territory under energy law and use case implementation under TRLs 7-9 might not be realised, as the legal situation/regulation is still unclear, e.g. providing/selling energy from a trolley grid to third parties or the integration of REs into the trolley grid.

Issue type
Policy

Status
Workaround

Solution
In the case of unsolved legal barriers to offering multi-purpose charger services to private e-car users, the charger will only be demonstrated with municipal fleet vehicles.

^ 4.8 R8: Take-up, Exploitation & Dissemination Risk

Milestone
Trolley 2.0 User Forum established

Description
Trolley 2.0 solutions and dissemination and exploitation measures are not suited to associated partners and other potential end users.

Issue type
Communications

Status
Non applicable

Solution
n.a.