Detailed Use Case Scenario Descriptions

WP4 – Deliverable 4.1

Deliverable	4.1 Detailed Use Case Scenario Description
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Status (D: draft; F: final)	F
Document's privacy **(Public: PU; Private: PR)**	PU
Reviewed by	Wolfgang Backhaus, Rupprecht Consult

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 636012.

SUMMARY SHEET

Programme	Horizon 2020
Contract N.	636012
Project Title	Electrification of public transport in cities
Acronym	ELIPTIC
Coordinator	Free Hanseatic City Of Bremen
Web-site	http://www.eliptic-project.eu/
Starting date	1 June 2015
Number of months	36 months
Deliverable N.	4.1
Deliverable Title	Detailed use case scenario descriptions
Milestones	
Version	1.0
Date of issue	
Distribution [Internal/External]	Internal
Dissemination level [Public/ Confidential]	Public
Abstract	The document contains the detailed use case scenario description for each use case, based on the outcomes of the WP4 workshops and the respective set up reports. This includes descriptions of the investigations that are carried out and the applied methodologies. It also gives an overview on the actions that will be carried out by WP4-leader RWTH Aachen (from now declared as “RWTH” within this document) to assist the individual partners. A short introduction to the RWTH software is given in the beginning.
Keywords	Use case overview, business cases, development schemes, simulation
Critical risks	

DOCUMENT CHANGE LOG

Version	Date	Main area of changes	Organnisation	Comments
0.9	31.03.2016	Initial Version	RWTH	Not complete
0.91	18.05.2016	Descriptions	RWTH	Update
0.92	02.06.2016	Descriptions	RWTH	Update
0.92	06.06.2016	Descriptions	RWTH	Update
0.93	15.06.2016	Chapt. 2 & 3	RWTH	Update
0.94	16.06.2016	All	RWTH	Update
1.0	30.06.2016	All	RUPPRECHT	Final REVIEW

PARTNER CONTRIBUTION

Company	Sections	Description of the partner contribution
RWTH	all	
RC, Bremen SUBV	all	Review of document
STOAG	3.1	Review of scenario description
BSAG	3.2	Review of scenario description
LVB	3.3	Review of scenario description
BBG	3.4	Review of scenario description
TMB, CENIT, BSM	3.5	Review of scenario description
TfL	3.6	Review of scenario description
STIB	3.7	Review of scenario description
SZKT	3.8	Review of scenario description
PKT, UG	3.9	Review of scenario description
MZA, PIMOT	3.10	Review of scenario description
FAS, ASSTRA	3.11	Review of scenario description

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1. Executive Summary

The first workshop series, a major part of work-package four (WP4), has finished. The overall aim was to establish a better understanding of the respective use case scenarios, aims and approaches for the individual public transport electrification. This is an important input for the WP4 aim, which is assisting the transformation of the respective use case scenarios into business cases, resulting in implementations with convincing positive financial, technical and functional feasibility and usefulness.

The document contains the detailed use case scenario description for each use case, based on the outcomes of the workshops and the respective set up reports. This includes descriptions of the investigations that are carried out and the applied methodologies. It also gives an overview on the actions that will be carried out by WP4-leader RWTH Aachen (from now declared as “RWTH” within this document) to assist the individual partners. A short introduction to the RWTH software is given in the beginning.

2. WP4: Workshops & Simulation

2.1 General Information & Conduction

The first workshop series, a main part of work-package four (WP4), started on 23rd of September with the first event at STOAG depot in Oberhausen. Within eight months, from September ’15 to April ’16, RWTH, accompanied by the project leadership (Rupprecht Consult and Bremen SUBV), have conducted meetings/conferences with the partners of each Eliptic-city, including the transport operators and local research/evaluation support.

The overall aim was to establish a better understanding of the respective use case scenarios, aims and approaches. Thereby, barriers and difficulties in implementing the individual plans have been pointed out by the partners. This is an important input for the WP4 aim, which is assisting the transformation of the respective use case scenarios into business cases, resulting in implementations with convincing positive financial, technical and functional feasibility and usefulness.

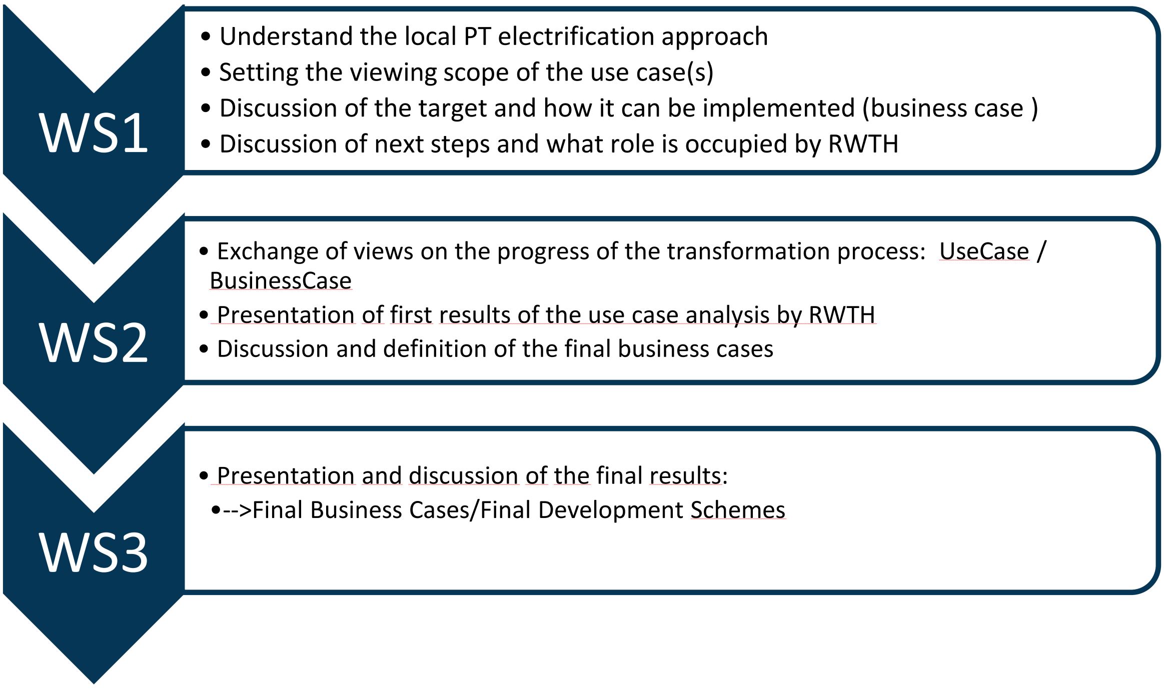
The general workshop procedure included a short introduction round, mostly followed up by a detailed presentation of the use case partners in charge. The approach and the obstacles were pointed out to give a clear understanding to the WP4 partners and the project management. Evaluation (WP3) was another point on the agenda, where discussions on the possibilities of data collection and processing took place. This is also important for the development of business cases and derivation of development schemes, which are common process patterns for the long-term electrification of public transport. Their derivation is another main part of WP4.

Project management issues, including e.g. risk assessment or reporting, were as well treated within the workshops. They were concluded with a presentation of RWTH on their specialty and the software-based planning approach. A subsequent discussion on the further proceeding closes the meeting and clarifies the tasks on both sides until the next workshop, where first results of the subsequent scenario analysis can be presented. The analysis will be founded on RWTH’s simulation of electric bus routes and result in giving advices for an extension of the electric service, which will be presented to policymakers and other relevant decision-makers in a third workshop.

The table below lists the conducted workshops with their respective date.

Date	Use Case	Pillar	Partner
23.09.2015	Oberhausen	A7,C5	STOAG, RWTH
06.11.2015	Bremen	A1,C1	BSAG
09.11.2015	Leipzig	A6,C4	LVB, Fraunhofer
12.11.2015	Eberswalde	A10	BBG, Fraunhofer
03.12.2015	Barcelona	A4,C3	TMB, CENIT-UPC
12.01.2016	London	A2,C2	TfL
28.01.2016	Brussels	A3,B2	STIB, VUB
04.03.2016	Szeged	A11,C6	SZKT, USZ
16.03.2016	Gdynia	A8,A9	PKT, UG
17.03.2016	Warsaw	A5	MZA, PIMOT, Warsaw Trams
11.04.2016	Lanciano	B3	Sangritana, Asstra

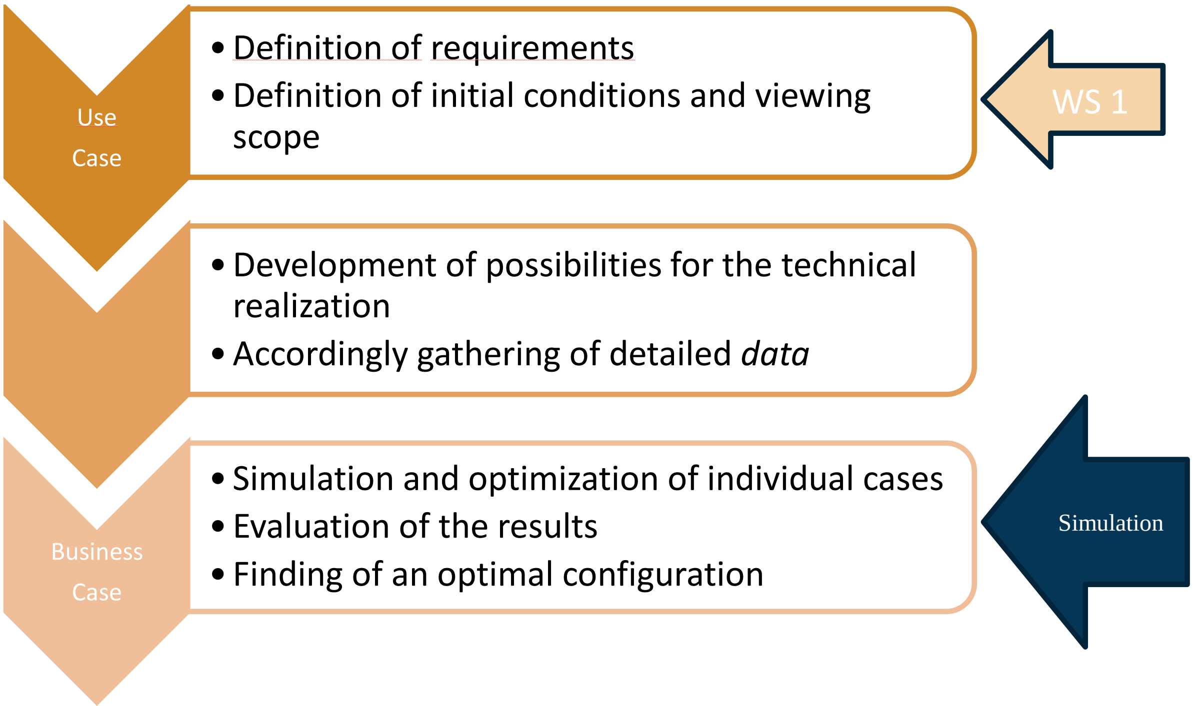
The workshop series (see picture below) forms a crucial part of WP4. Within the whole ELIPTIC runtime, three workshops will be conducted together with each Use Case city and its respective partners. Based on the results of the first workshop series, a further cooperation to reach the project goals (business cases and development schemes) will be carried out.



2.2 Electrification of Public Transport: Process from WP4 view

The process of transforming use cases into business cases is scientifically assisted by WP4-leader RWTH. It starts with the definition of the use case scenario, the initial requirements, conditions and viewing scope. This has been done in the first workshop.

Based on this understanding, possibilities/evaluation for/of the technical realization will be outlined within the further project runtime. This requires comprehensive data (e.g. regarding costs for all relevant components and technical information). Detailed simulations will be carried out in order to evaluate/find the most promising business case.


Use Case
• Definition of requirements
• Definition of initial conditions and viewing scope
WS 1
• Development of possibilities for the technical realization
• Accordingly gathering of detailed *data*
Business Case
• Simulation and optimization of individual cases
• Evaluation of the results
• Finding of an optimal configuration
Simulation

2.3 RWTH Software-based Approach

In order to evaluate technical solutions and identify promising Business Cases within Pillar A, RWTH will apply its software based e-bus planning approach. This chapter will explain the approach in general and present the data that is needed.

The picture below shows the general process. At first, comprehensive data has to be collected. A detailed overview is given in chapter 2.3.1. Based on this input, the load profiles and energy consumptions of the respective vehicles are calculated. This serves as input for the scenario calculation, where the total cost of operation (TCO) is calculated.

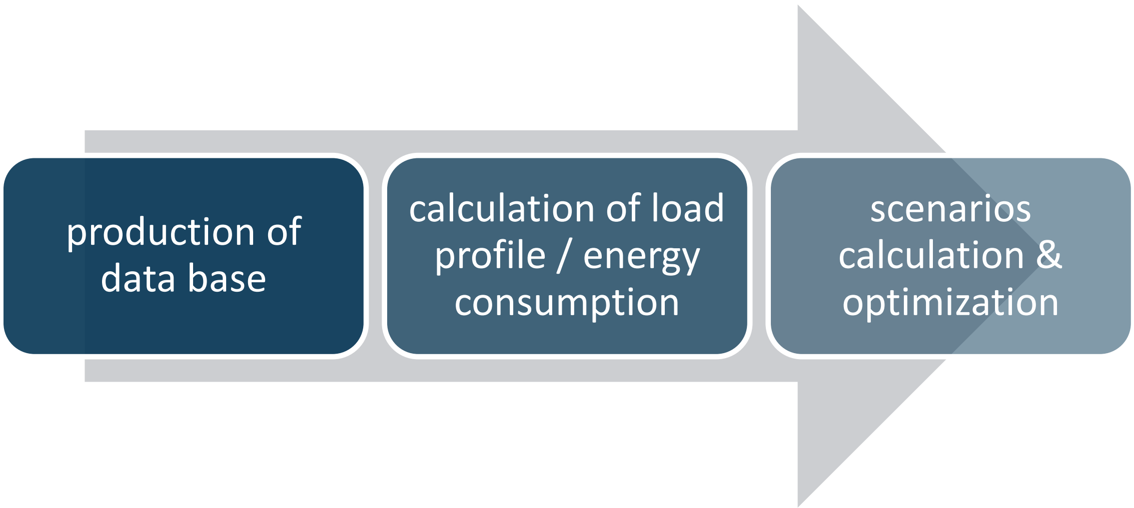


Figure 1 – General simulation process

The bus lines under investigation have to be mapped first. The mapping includes traffic lights, speed zones, curves and the height profile.

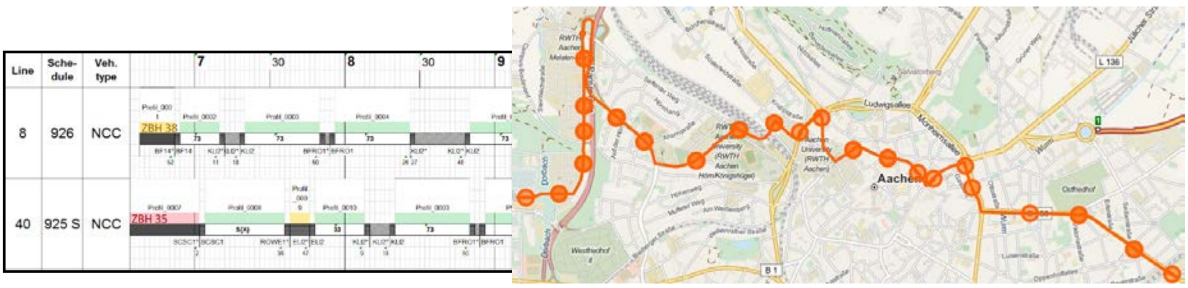


Figure 2 – Route mapping

For each of the mapped routes and based on the vehicles technical parameters, the load profile and energy consumption are calculated with help of a vehicle- and driver-model.

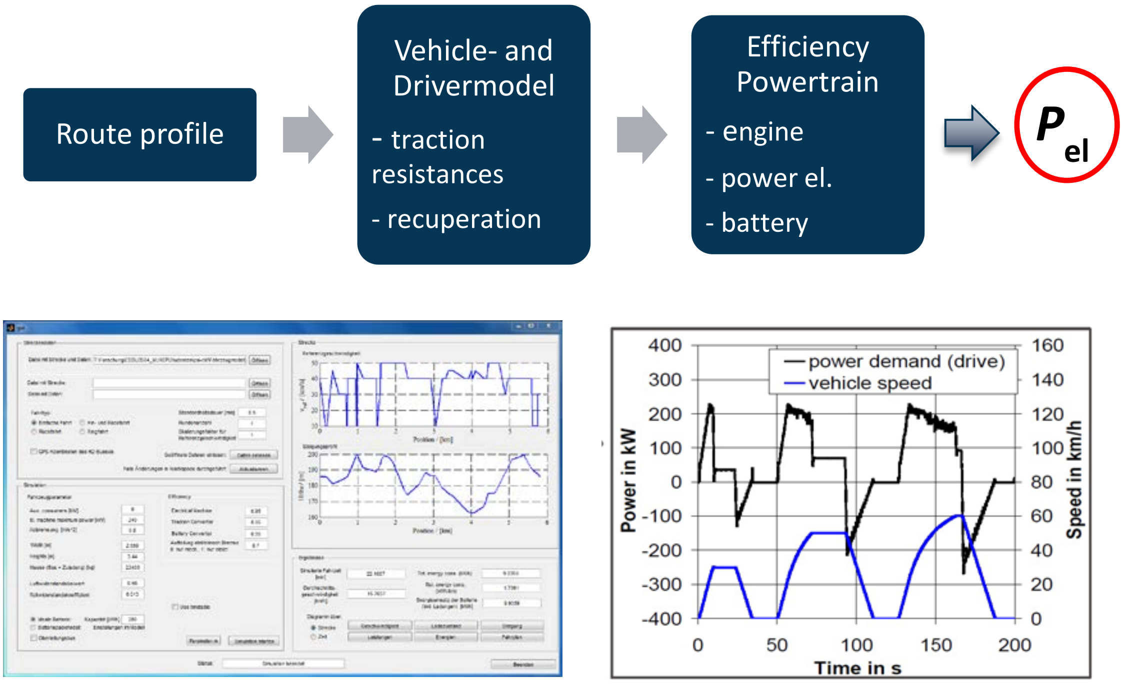


Figure 3 – Transforming route profile into load profile

Having the load profile for each route, the costs of all relevant components can be calculated for the different scenarios (the picture below shows the considered technical components). The calculation also takes into account:

- ageing of components, maintenance costs
- price/cost developments
- residual values
- penalty costs if i.e. the schedule can't be fulfilled or the SOC of the battery goes beneath a certain threshold
- staff costs

The expected TCO is given as final result.

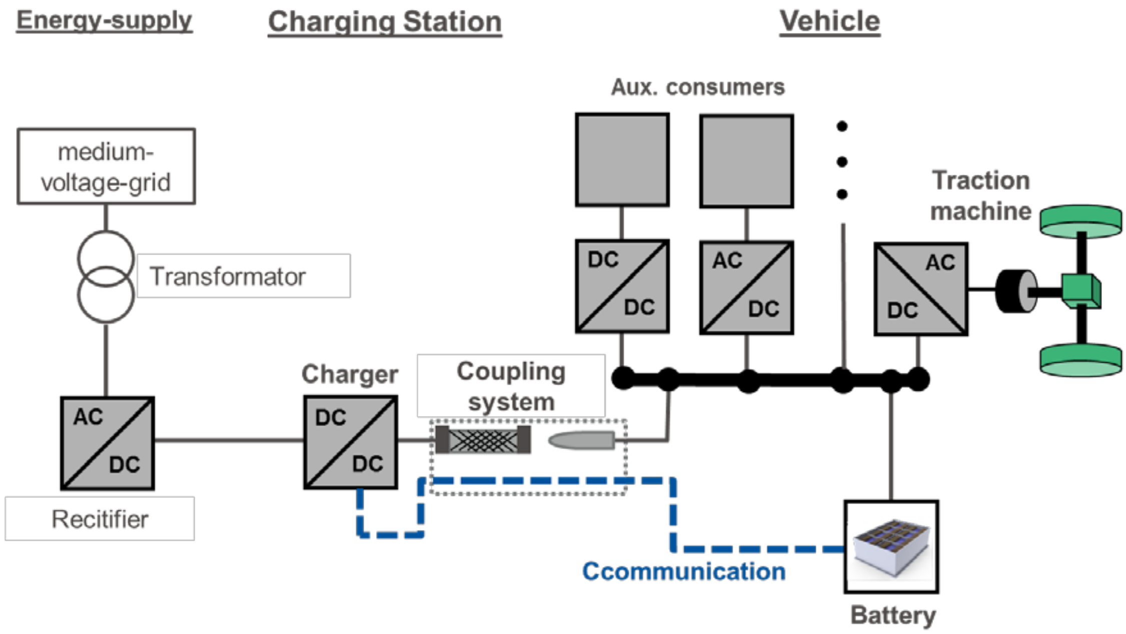


Figure 4 – Technical System under consideration

In a subsequent optimization (see picture below), the input parameters (energy-capacity of the battery and position and rated power of charging stations) can be adjusted by an evolutionary algorithm in order to find the configuration having the lowest TCO.

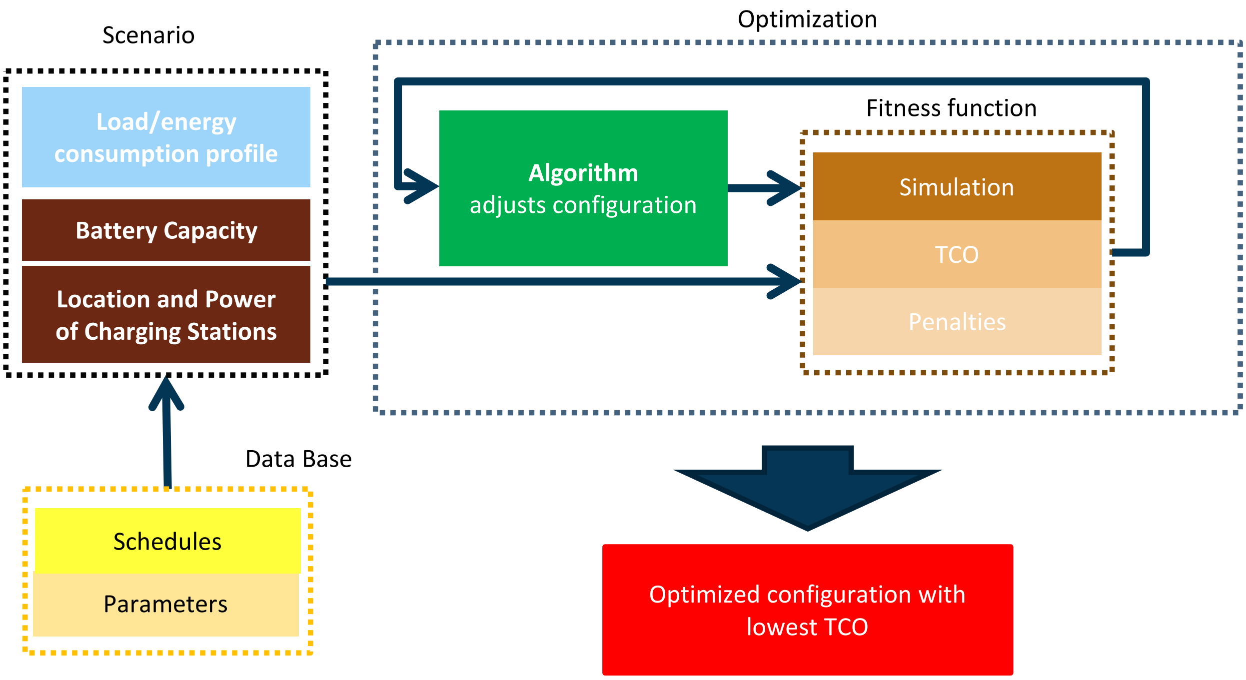


Figure 5 – Scenario calculation & optimization loop

2.3.1 Required Data Input

This chapter shows the most important input data.

2.3.1.1 Bus Network

- lines, routes and circulation plans of the electric busses
- position, power and costs of charging station(s)
- route segments under catenary (for trolley-hybrids)

2.3.1.2 Vehicles

For each vehicle in use:

Manufacturer / Type	-
Empty load	kg
Maximal weight	kg
Max. battery volume	l
Length, Height, Width	m
Number of seats	n
Number of standing rooms	n
Max. power traction machine	kW
Max. power auxiliary consumers	kW
Avrg. power aux. consumer during drive	kW
Avrg. power aux. consumer at depot	kW
Avrg. power aux. consumer at pause	kW
Avrg. power aux. consumer at charging station	kW
Avrg. power aux. consumer worst case	kW
Drag coefficient	-
Distribution electrical/mechanical brake (recuperation rate)	%
Coupling type	-
Price	€
Lifetime Hours (expected / certified)	h
Maintenance Costs	€

Table 1 – Software input data: Vehicles

2.3.1.3 Battery System

For each battery system in use:

Manufacturer / Type	-
Cell chemistry	-
Gravimetric energy density per cell	kWh/kg
Gravimetric energy density packing	kWh/kg
Fixed weight packaging	kg
Volumetric energy density per cell	kWh/l
Volumetric energy density packaging	kWh/l
Fixed volume of packaging	kWh/l
Efficiency charging	%
Efficiency discharging	%
Minimal SOC	%
Maximal SOC	%
Initial SOC (moving out of depot)	%
Standstill SOC	%
Nominal Cell Voltage	V
Standstill Cell Voltage	V
SOC/OCV curve	-
C-rate charging	C
C-rate discharging	C
System costs / price	€
Maintenance costs	€
Lifetime (certified)	y/cycles

Table 2 – Software input data: Battery system

2.3.1.4 Electric Connection & Charging System

Relevant technical components for charging the busses.

Electricity Costs	
Price electrical production	€
Price electrical production trend	€/%
System usage charge per kW (+ growth)	€
System usage charge per kWh (+ growth)	€
Price EEG (+ growth/trend) (for Germany)	€ or %
Energy Tax (+ growth)	€ or %
Value Added Tax	%
Terminal Costs (fixed part)	€
Terminal costs per m	€
building costs surcharge (fixed)	€
building costs surcharge per kW	€
Emissions by electricity generation	g/kWh
Power electronics and recharger	
Lifetime hours	h
Lifetime cycles	n
efficiency	%
Price	€
Price per kW	€/kW
Maintenance costs per kW	€/kW
Maintenance costs per cycle	€/n
Transformers	
efficiency	%
Lifetime hours	h
Lifetime cycles	n
Price total	€
Price per kW	€/kW

Table 3 - Software input data: Electric connection & charging system

3. Detailed Use Case Scenario Descriptions

Pillar A: Safe integration of ebuses using existing electric public transport infrastructure

Oberhausen	A7: Use of tram infrastructure (catenary and sub-station) for (re)charging e-buses
	Methodology / Investigation: - test-operation (STOAG) - simulation of lines 966/962 (RWTH)
Bremen	A1: Use of tram infrastructure (catenary and sub-station) for (re)charging e-buses
	Methodology / Investigation: - test-operation (BSAG), evaluation (Prof. Pütz) - simulation of lines 29/52 (RWTH)
Leipzig	A6: (Re)charging of ebuses using tram infrastructure
	Methodology / Investigation: - test-operation (LVB) - simulation/survey (Fraunhofer IVI)
Eberswalde	A10: Replacing diesel bus lines by extending trolleybus network with trolley-hybrids
	Methodology / Investigation: - feasibility study (BBG, Fraunhofer IVI) - SWOT (Siemens)
Barcelona	A4: Opportunity (re)charging of electric buses based on metro infrastructure
	Methodology / Investigation: - Test-operation (TMB), evaluation (CENIT) - simulation of line H16 (RWTH)
London	A2: Opportunity (re)charging of ebuses and/or plug-in hybrid buses (using metro infrastructure)
	Methodology / Investigation: - study/analysis (TfL)

Brussels	A3: Progressive electrification of hybrid bus network, using existing tram and underground electric Infrastructure	
	Methodology / Investigation: - feasibility studies (STIB) - SWOT (Siemens) - simulations (VUB & RWTH)	
Szeged	A11: Replacing diesel bus lines by extending trolleybus network with trolley-hybrids	
	Methodology / Investigation: - feasibility studies (SZKT) - demonstration test (SZKT) - simulation (RWTH)	
Gdynia	A8: Opportunity of (re)charging of e-buses connecting Tri-city agglomeration based on trolleybus infrastructure	
	Methodology / Investigation: - feasibility studies (PKT) - cost-benefit-analysis (UG, PKT) - SWOT (Siemens)	
	A9: Replacing diesel bus lines by extending trolleybus network with trolley-hybrids	
	Methodology / Investigation: - feasibility studies (PKT) - cost-benefit-analysis (UG, PKT) - simulation (RWTH)	
Warsaw	A5: Use of tram infrastructure for recharging e-buses	
	- feasibility Study / possibly Demonstration (MZA, PIMOT) - SWOT anaylsis - simulation (RWTH)	

Pillar B: Innovative energy storage systems to increase operational efficiency

Bremen	B1: Recuperation of braking energy from trams: refurbishment of a flywheel storage system	*Methodology / Investigation:* - study to restart the system (BSAG) - if successful: study on performance (BSAG)
Brussels	B2: Optimised braking energy recovery in light rail network	*Methodology / Investigation:* - system modelling (STIB) - SWOT analysis (Siemens)
Lanciano	B3: Light rail (tram) operation for rural rail track	*Methodology / Investigation:* - Feasibility study (Sangritana, Asstra) - SWOT analysis (Siemens)

RWTH will perform a general comparison on the potential of the different energy storage systems that are used to save braking energy and thereby increase operational efficiency:

- 1) identification of the general energy saving potential
- 2) comparison of technologies regarding costs, lifetime, availability, saving potential
- 3) implementation of a tool to compare the technologies based on given input profiles

Pillar C: Multi-purpose use of electric public transport infrastructure

Bremen	C1: From uniqueness to system: Extension of existing multimodal mobility hub station
	Methodology / Investigation: - User survey/user behaviour (BSAG / moveabout) - SWOT (Siemens)
London	C2: Use of metro sub-station for (re)charging TfL support fleet vehicles (e-cars & e-vans) and zero-emission capable taxis (rapid charging hubs).
	Methodology / Investigation: - feasibility studies / analysis (TfL) - SWOT analysis (Siemens)
Barcelona	C3: Use of metro/tram infrastructure for recharging e-cars (municipal fleet and private e-cars)
	Methodology / Investigation: - feasibility studies (B.SM) - SWOT analysis (Siemens)
Leipzig	C4: Use tram network sub-stations for (re) charging e-vehicles
	Methodology / Investigation: - feasibility Study (LVB) - SWOT analysis (Siemens)
Oberhausen	C5: Fast-charging stations for e-cars powered from the tram network
	Methodology / Investigation: - test-operation (STOAG) - user-survey (?)
Szeged	C6: Multipurpose use of infrastructure for (re)charging trolley-hybrid-buses, e-bikes and e-cars
	- feasibility study (SZKT) - SWOT analysis (Siemens)

3.1 Oberhausen

Partner	Stadtwerke Oberhausen AG (STOAG), Prof. Müller-Hellmann, Berends Consult
Date, location and participants of 1st Workshop	23.09.2015, STOAG depot - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - STOAG: Julia Gesing, Stefan Thurm, Ute Koppers-Messing, Katja Deppenkemper, Uwe Achterfeld, Olaf Walenciak - Berends Consult: Helmut Berends - Oberhausener Netzgesellschaft mbH: Lukas Spitalny
Data Collection	Operational data available from approx. July ‘16
Planned methodologies	- Demonstration test - Feasibility study / analysis - simulation
Reviewed by, date	STOAG, 30.03.2016

3.1.1 Use Case Description

Oberhausen A7: Use of tram infrastructure (catenary and sub-station) for (re)charging e-buses:

On 4th of October 2015, the transport association Rhine-Ruhr (VRR - Verkehrsverbund Rhein-Ruhr) and STOAG have started a project, in which by means of the existing DC tram infrastructure electric buses will be loaded during operation. The charging energy is either taken transformed from the tram catenary at the train station Sterkrade (bus line 962 – route see figure 4) or from the sub-station at the station Neumarkt (bus line 966 – route see figure 5). Part of the concept is that during regular operation charging of the electric buses at the bus depot is not required.

The power transmission takes place by means of a swing-conductively pantograph which is placed on the roof of the bus. Through regular recharging during the turning time at both terminus stations (Sterkrade and Neumarkt) the traction batteries can be relatively small and thus saves weight and costs of the deployed buses. All auxiliary equipment such as air conditioning and heating are powered electrically. Nevertheless the battery capacity is dimensioned that in case of unforeseen events up to three charging cycles may be omitted.

The electric buses will run every hour with a turning time of 17 respectively 14 minutes. The effective turning time is set with 10 minutes and the charging capacity with 220 kW. In winter, 25 kW of charging power for heating of a heat accumulator are used during the charging time. As a result the attainable driving distance is accordingly with the charging capacity of 220 kW from 19.3 km to 28.9 km and during winter operation with 195 kW charging capacity from 17.1 km to 25.7 km.

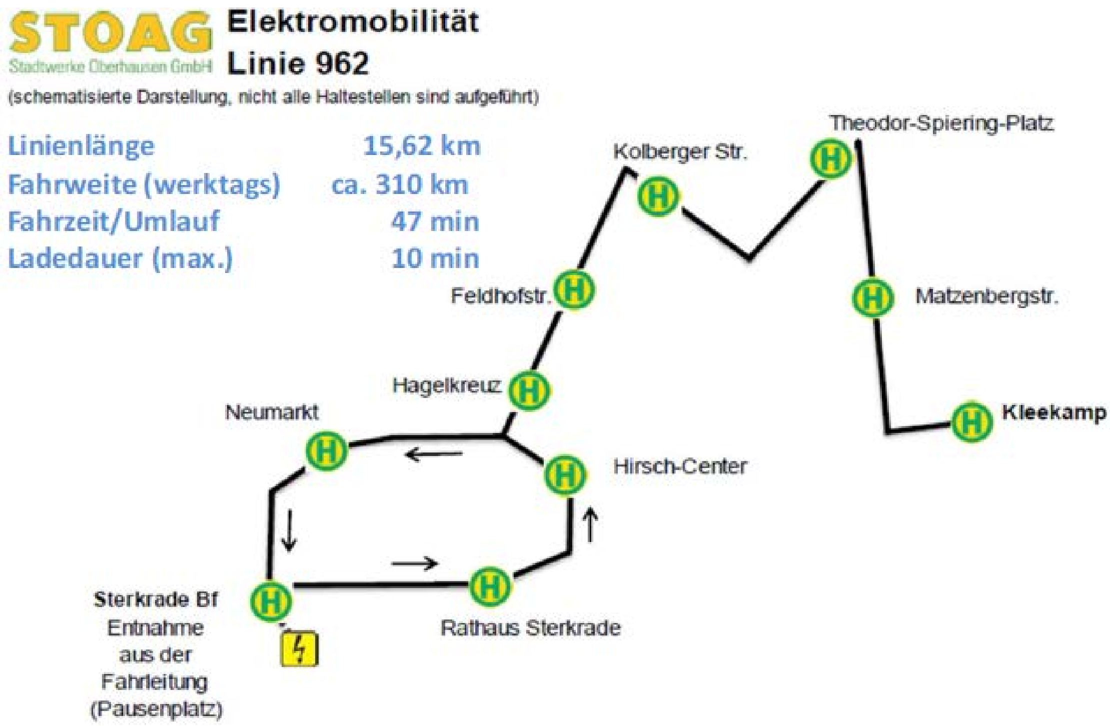


Figure 6 – Use Case Bus Line 962 (source: STOAG)

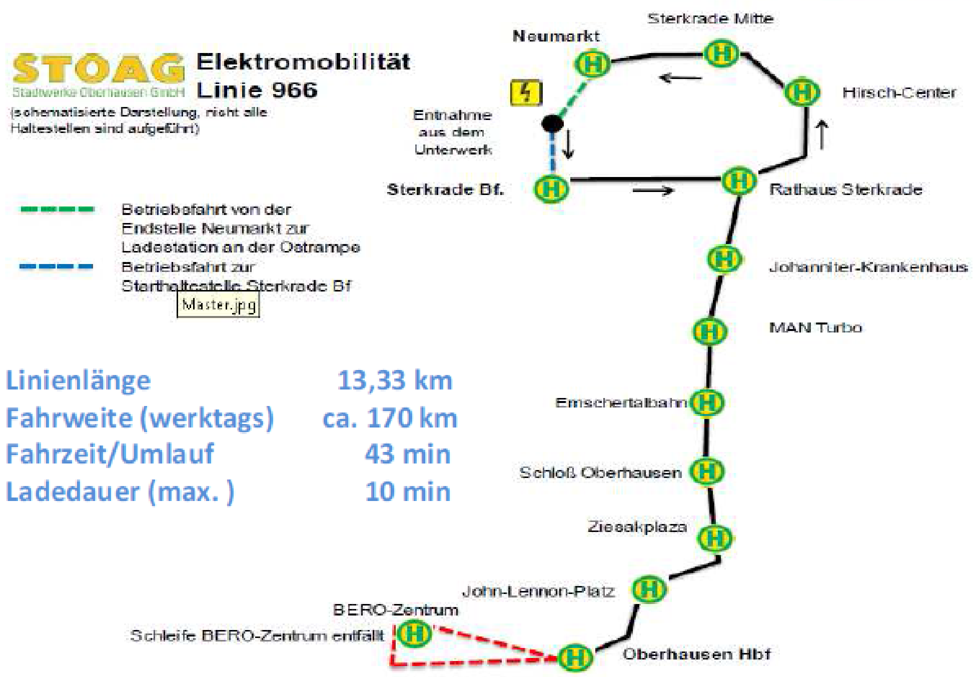


Figure 7 – Use Case Bus Line 966 (source: STOAG)

The deployed electric vehicles – one standard 12m bus for each bus line – are SOLARIS Urbino 12 with low-floor technology and air conditioning systems to maintain the usual standard for urban buses operated by STOAG. The drive takes place by the electric wheel hub motor ZF axle AVE 130 with two asynchronous motors.

The battery cells are provided by the manufacturer A123 and have storage capacity of 200 kWh. The charger is supplied by the company Ekoenergetyka and the pantograph by the company Schunk. The charging infrastructure has been implemented by the company Siemens.

The following table shows the assigned tasks for the involved partners in both Use cases (Pillar A and C):

Involved Parties	Assigned Task	Pillar A (Vehicle)	Pillar C (Infra-structure)
STOAG	Public transport operator, Use Case coordinatior	X	X
SOLARIS	Bus vehicle manufacturer	X	X
Ekoenergetyka	Charger	X	X
Siemens	Charging infratructure	X	
Wiegand & Partner Spiekermann	Planning consultancy	X	
VRR (transport association Rhine-Ruhr)	Funding body	X	X
City of Oberhausen	Monitoring construction work	X	X
EVO (local energy supply provider)	Power supply		X
RWE (energy group)	Billing portal		X

Table 4 - Assigned Tasks for Involved Parties

For the line 966, the charging energy is taken from the sub-station at the station Neumarkt (see figure 6 and 7). This solution not only has the advantage of sharing the existing medium-voltage switchgear, the converter transformer and the rectifier of the sub-station, but also allows the weather-proof placement of the charger in the sub-station. Hence there is no additional space (probably subject to approval) required, except for the mast and integrated charging device.

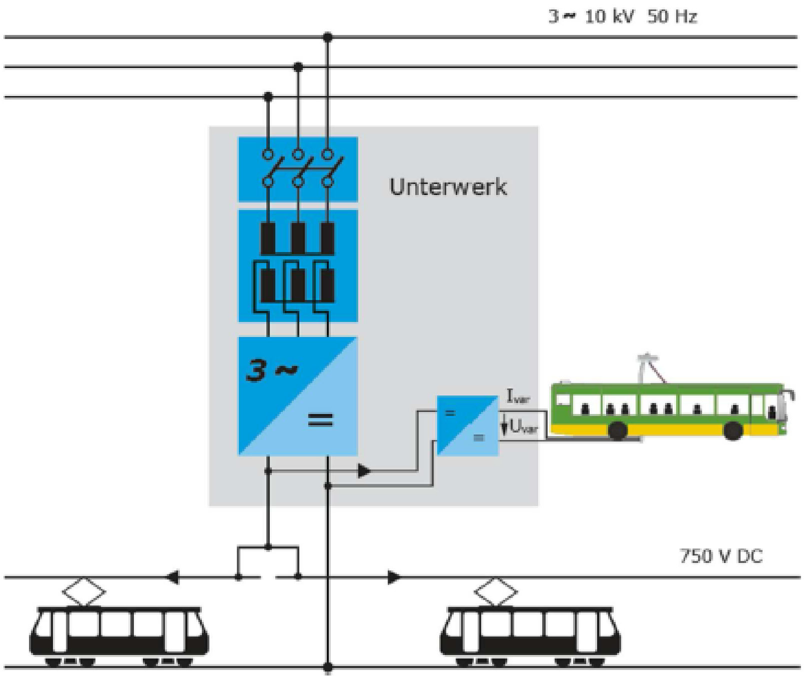


Figure 8 – Schematic Sketch of the Bus Charging from the Tram Sub-station at the Station Neumarkt (source: Müller-Hellmann)

Figure 9 - Pantograph on top of the SOLARIS Bus Roof and Charging Infrastructure at the Station Neumarkt (source: STOAG)

The charging energy for the line 962 is taken from the tram catenary at the train station Sterkrade (see figure 8 and 9). This solution is especially used in the immediate vicinity of the tram catenary where several waiting positions for electric buses are available and sufficient space for the implementation of charging devices for electric vehicles of other means of transport is available.

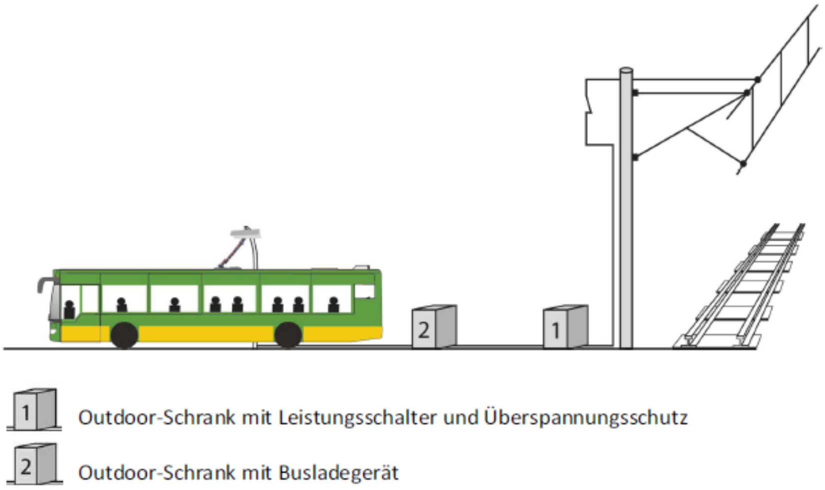


Figure 10 – Schematic Sketch of Bus Charging from the Tram Catenary at the Train Station Sterkrade (source: Müller-Hellmann)

Figure 11 – Images from the Train Station Sterkrade (source: STOAG)

The demonstrated solutions will be of particular importance, as the monitoring and evaluation of these “real data” demonstrations will be an important input for use case implementation as well as technology, business case and development schemes assessment in ELIPTIC. In ELIPTIC, STOAG will furthermore analyze an extension and upgrade of this e-bus introduction concept based on existing tram infrastructure for the wider city area of Oberhausen. This study will be supported by the application of the simulation tools of ELIPTIC’s research partner RWTH Aachen University.

Summarized Scenario description:

The use case scenario includes the investigation of the operation of two 12 meter pure electric busses on lines 966 and 962 in Oberhausen. Both lines are recharged within short time at the terminal, one by taking energy directly from the catenary and the other from the substation.

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with opportunity charging, taking energy from the catenary/substation of the tram-network, can be a business case in the near future. The outcomes of the test-operation and additional simulation, also fed by the results of this test, will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

WP4 Method of investigation:

To investigate this scenario, RWTH will at first simulate the operation of the already existing e-buses, based on their circulation plans. For a realistic reproduction, detailed technical/monetary data is required as specified in chapter 2.3.

Confidential data has to be compensated by plausible assumptions in the first step. Based on these inputs, calculations on the energy consumption and operation costs are performed. They result in a total value of the TCO (Total cost of ownership). These results will be used for a business-case evaluation afterwards.

Based on the first results, STOAG's electrification process can be assisted by identifying and simulating new potential charging points and lines to be electrified best. This process will be done in close cooperation with the partner, who identifies the general possibilities and potential lines. Based on these, RWTH simulations can serve as evaluation and input for potential discussions with political decision-makers.

Further steps:

Timeframe	Action
Feb ’16 – 2nd workshop	Simulation of the Use Case Scenario (2 electric busses on line 962 & 968)
Sep ’16 – May ’17	2nd workshop: - Discussion on results/assumptions of first simulation - Discussion on further development (new potential charging points/e-buses etc.)
After 2nd workshop	Further simulations to account for input of 2nd workshop
Sep ’17 – Apr ‘18	3rd workshop: - discussion on results - final business case

Oberhausen C5: Fast-charging stations for e-cars powered from the tram network:

The second use case of STOAG aims to show how the existing DC power infrastructure of the local tram/rail network can be used for fast charging of e-cars. STOAG examines the planning, construction and connection of a fast charging station for private e-cars which takes charging energy from an existing DC power line in Oberhausen. This will include the consideration of legal and payment frameworks. The local energy provider EVO will support these activities led by STOAG and examine the local construction aspects of such a fast charging station for private e-cars.

The following figure shows the basic concept for the fast-charging infrastructure for electric cars and light commercial vehicles as well as electric buses at the train station Sterkrade. Via an unlockable two disconnectable circuit-breaker (see cabinet no 1), an overvoltage protection and a catenary mast disconnecting switch the fast-charging devices for the electric bus and the three charging stations for the road vehicles are connected with the tram catenary.

The energy is taken from with 750 V DC tram catenary and transformed in the cabinet no 1 (see figure 10) for the three (3) fast-charging stations powered with 50 kW.

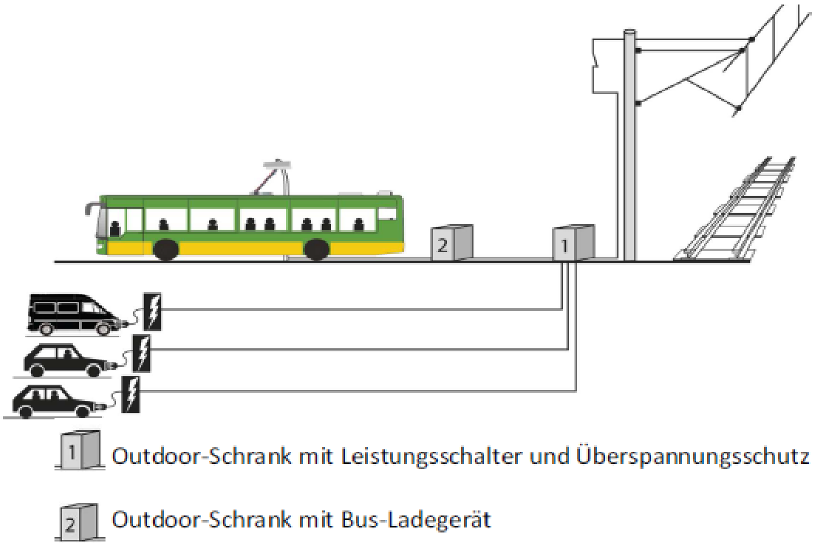


Figure 12 - Schematic Sketch of Fast-charging for e-Vehicles from the Tram Catenary at the Train Station Sterkrade (source: Müller-Hellmann)

Summarized Scenario description:

This scenario aims at investigating how the existing DC power infrastructure can be used to serve as charging station for electric cars. STOAG will build one car charging station next to the bus charging station at terminal “Sterkrade”. Several aspects are of interest. From a technical point of view, the realization possibilities have to be clarified. (charger has to be custom built). Another point under investigation is to clarify legal issues in operating such a public charging station and taking energy from the transportation grid. This is generally a crucial point for Work-package 4 work in Pillar C, since several other cities are dealing with the same interrogation. Furthermore, there has to be a clarification on the accounting system. Another crucial point is to see how the attraction of e-mobility can be increased by the availability of fast charging stations. This will be derived from the frequency of use over the project runtime.

Business case/purpose:

The use case aims to show under which preconditions (availability of charging stations, clarification of legal issues, public acceptance) this scenario can be a future business case.

The results will serve as input for a generic concept-description, comprising and comparing the different approaches that are under investigation within the ELIPTIC project.

WP4 Method of investigation:

The investigation will be based on the outcomes STOAG's test-operation. The focus will be an assessment of the technology and proving the general approach of building charging stations which are fed by the tram DC-grid.

Further steps:

Timeframe	**Action**
Apr '16 – 2nd workshop	review of concept, planning and realization data analysis/evaluation
Sep '16 – May '17	2nd workshop: - status update
After 2nd workshop	further evaluation
Sep '17 – Apr '18	3rd workshop: - discussion on results - final business case

3.2 Bremen

Partner	Bremer Straßenbahn AG (BSAG), SUBV Bremen
Date, location and participants of 1st Workshop	06.11.2015, BSAG depot - Bremen SUBV: Hendrik Koch, Michael Glotz-Richter, Jan Eiken - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - BSAG: Kai Teepe, Carsten Peters, Yusuf Demirkaya, Michael von Thun - Berends Consult: Helmut Berends
Data Collection	- Energy consumption / noise
Planned methodologies	- test operation - feasibility study / analysis - simulation - user-survey
Reviewed by	Yusuf Demirkaya (BSAG), 15.03.2016

Bremen A1: Operation-optimized system of opportunity charging at bus depots

The Bremer Straßenbahn AG (BSAG) will test in total three (3) electric low-floor buses in regular operation (two standard 12m and one articulated 18m) on the bus line 29 and 52. The reason why these two lines were chosen are:

They are closely linked in day-to-day operation. They pass the main bus and tram depot (located next to the airport).

Hence in case technical problems the electric buses can be replaced easily by diesel buses. On these combined bus route already other electric and hybrid buses were tested and thus the test results can be compared with one another simply and traceable.

Operation key features of the bus route are:

During day-to-day operation in total five (5) buses are running: two standard and three articulated buses. The circular route distance is 60km. The operation distance per day is minimum 200km for standard buses and minimum 300km for articulated buses.

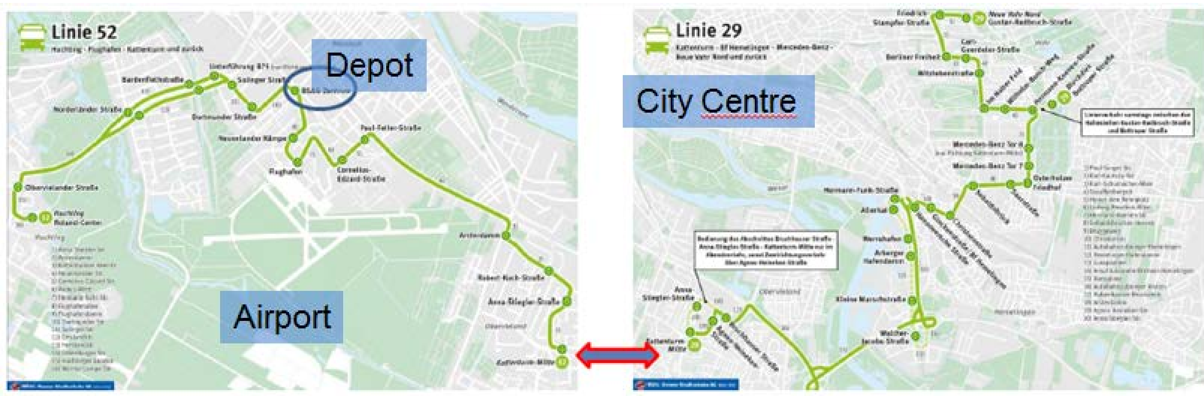


Figure 13 – Use Case Bus Line 29 and 52 (source: BSAG)

The deployed electric vehicles – two standard 12m buses (Ebusco, SILEO) and one articulated 18m bus (SILEO) - are equipped with low-floor technology, ticket vending machines and air conditioning systems to maintain the usual standard for urban buses operated by BSAG.

The charging infrastructure is made available (leased) by both vehicle manufacturer companies and can be used only for their own vehicle. The energy will be supplied with power from the medium-voltage network of the local energy supplier. Hence no energy from the existing DC tram infrastructure at the depot is used.

The following table shows the assigned tasks for the involved partners in the Use case Pillar A:

Involved Parties	Assigned Task
BSAG (Bremer Straßenbahn AG)	Public transport operator, Use Case coordinatior
Ebusco/ SILEO	Bus vehicle manufacturer
Swb	Local energy supplier
Berends-Consult	Technical coordination and planning support
University of Applied Science Landshut	Scientific monitoring of the operating electric buses

Table 5 - Assigned Tasks for Involved Parties (Pillar A)

Summarized Scenario description:

The Bremen Use Case primarily investigates overnight depot-charging of electric buses with a large traction battery. This approach is based on the approach to use electric buses similar to Diesel fueled, which ensures only minimal changes to the already existing and established operation at present. This scenario investigation will serve as a good comparison to other ELIPTIC Use Cases, having the opportunity charging approach as basis for operation.

Currently, there are three electric buses in or close to operation on lines 29/52. They have differences in their technical setup, like having the batteries at different spots within the vehicle. One circulation is approximately 60 km, and the whole distance covered during one day is 330 km. Serving these 3 busses, the charging infrastructure at the depot is at the moment at its limit, but additional 8 MW could be installed. A scientific data collection of the vehicles, including charged energy, energy consumption as well as operation noise is planned. The availability and publication of data has to be negotiated bilaterally with the bus manufacturers and will be decided on a case by case basis.

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with large battery capacity and using overnight depot-charging can be a business case in the near future. The outcomes of the test-operation and additional simulation, also fed by the results of this test, will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario. A comparison to the opportunity charging approach could be realized based on simulations.

Method of investigation:

To investigate this scenario, RWTH will at first simulate the operation of the already existing e-buses, based on their circulation plans. Afterwards RWTH will simulate a line operation based on the opportunity charging approach for the reason of comparison. Therefore, the following technical and monetary data is required as specified in chapter 2.3. Confidential data has to be compensated by plausible assumptions in the first step. Based on these inputs, calculations on the energy consumption and operation costs are performed. They result in a total value of the TCO (Total cost of ownership). These results will be used for a business-case evaluation afterwards.

The investigation of noise reduction compared to Diesel-fueled buses is another crucial point and will be carried out with scientific assistance of Prof. Pütz.

Further Steps:

Timeframe	Action
Apr '16 – 2nd Workshop	Simulation of the Use Case Scenario (electric busses on line 29 & 52)
Sep '16 – May '17	2nd workshop: - Discussion on results/assumptions of first simulation - Discussion on further development - Discussion on first results of test operation (reliability etc.)
	Possibly further simulations

Bremen B1: Recuperation of braking energy from trams: Re-operation and refurbishment of a flywheel energy storage

Public transport providers are interested in reducing the power demand of their tram systems. One possibility to save electric power is to reuse the braking power of the tramcars. Nowadays, the braking power which is recuperated to the catenary is only used to 30 %. To re-use the kinetic energy more efficiently and to reduce expensive compensations of reactive power, stationary flywheel energy storage systems can be a solution. Flywheel storage systems are able to store braking energy which cannot be used for an accelerating tram in the same section of the line, as rotational energy. The energy is stored until another tram in the same section of the line needs acceleration power. The power for this tram will then be partly provided from the flywheel.

Such a flywheel energy storage system was installed in Bremen in a tram sub-station in 2012. As the provider of the technology went bankrupt, a regular operation could never be ensured. In order to support BSAG's future proofing and sustainability strategy of reducing fossil fuel consumption and to meet the target of efficient use of innovative vehicle technology, the re-operation of the flywheel energy storage system is targeted. This requires a detailed analysis of the existing system as a first step and as a second step the refurbishment, update and operation – based on the current technical installation. The investments of the second step depend and will only be undertaken if the outcome of the feasibility study in the first step is positive.

The flywheel is located along the tram line 1 next to the tram stop ‘Weserpark’ (see figure below, marked with a red ring). It was installed in the year 2011 - but not in operation at present due to a few technical problems.

Figure 14 – Flywheel location along tram line 1

It is foreseen to tender the modelling & simulation in order to get solid, traceable, reproducible and authentic data for carrying out a planned reactivation study. Main part of the tendered work will be a tool which takes into account all electrical components and operational conditions and:

- calculates the energy usage,
- displays voltage flow in the catenary system,
- analyses the benefits of investments,
- shows energy usage of traction vehicles.

The tool having in mind is the so-called Energy Flow Simulation (EFS) tool developed by the Austrian engineering company KRUCH[1].

Technical data of the flywheel system are as follows:
- Effective energy: 2 kWh
- Maximum power: 250 kW
- speed range: 15000…25000/minute
- Maximum discharging current : 1,500A
- Efficiency rate: 80%
- Weight : 10 tons
- Noise : <45dB(A) (distance 45 m)

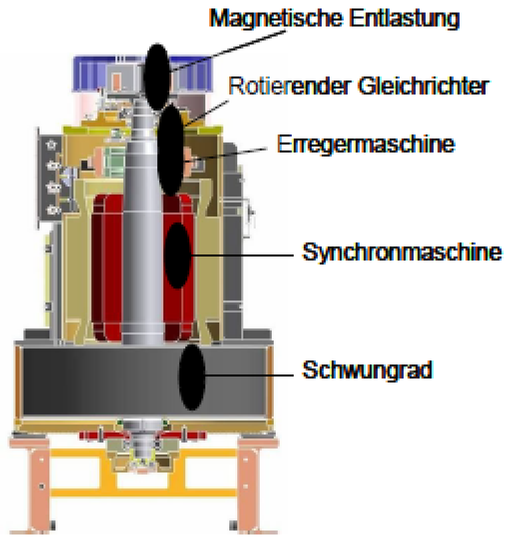


Figure 15 – Flywheel layout examples (cross-section and 3D view)

Summarized Scenario description:

Analysis of the tram line operation based on a potentially refurbished flywheel energy storage system.

Business case/purpose:

The energy and monetary savings of such a flywheel storage are under investigation. A comparison of the energy saving potential between Bremen and Brussels within

[1] http://www.kruch.com/en/productsandservices/efssimulationsoftware/

WP4 is thinkable, if the Bremen system is able to be set back into operation mode. The Business case will show, under which preconditions the operation of such a system could be useful.

WP4 Method of investigation:

In case of a positive result of the pre-study to restart the flywheel energy storage system, BSAG will provide a study on the performance of the restarted system. This will become part of a general comparison with the different energy storage technologies for recuperation to increase energy efficiency of existing electric public transport systems within Pillar B use cases. The results will be used as basis for decision-making for selecting the “right” recuperation energy storage system in different contexts.

Bremen C1: From uniqueness to system: Extension of existing multimodal mobility hub station

Within an integrated mobility approach, car ownership will not play the same role as in the past. Increasing costs, dependence on oil, climate change and the fact that owning a car for young people continues to lose its attractiveness, make new solutions for sustainable mobility necessary. For the City of Bremen the combination of Carsharing with electric mobility looked to have the potential to be the right way forward. Based on this approach a first multimodal mobility hub station was inaugurated with the title “VAHR vernünftig” in July 2014. One special aspect of this project is that different actors/stakeholders e.g. City council, public transport operator (BSAG), mobility service provider (Move About) and social housing company (GEWOBA) have joined forces to give an impulse to this very far-sighted concept.

The aim of this project is to extend the public transport services by a readily available and at the same time environmentally friendly mobility services. The existing mobility chain is to be extended by the use of electric mobility.

At central locations within the social housing area “Vahr” the existing public transport services (tram, bus) was complemented for the tenants GEWOBA by electro mobile car sharing and bike rental services. Since this operational success, the stakeholders that took the initiative to set up the original hub station have discussed further opportunities to widen the services and develop further features (diversification strategy). An important factor for consideration is that, depending on its location, the specifications of a certain mobility hub station will differ.

Implementation of the diversification strategy will therefore require a detailed analysis of where to place such stations. A further aim of the strategy is to use the existing tram energy infrastructure to put it to dual use. In order to overcome technical and operational challenges associated with implementation of the strategy, inter-institutional cooperation between public transport operator (BSAG), public and social housing company (GEWOBA) and mobility service provider (Move About) will need to be intensified. Therefore project coordination processes are necessary to ensure that the appropriate communication and partnership working structures are in place.

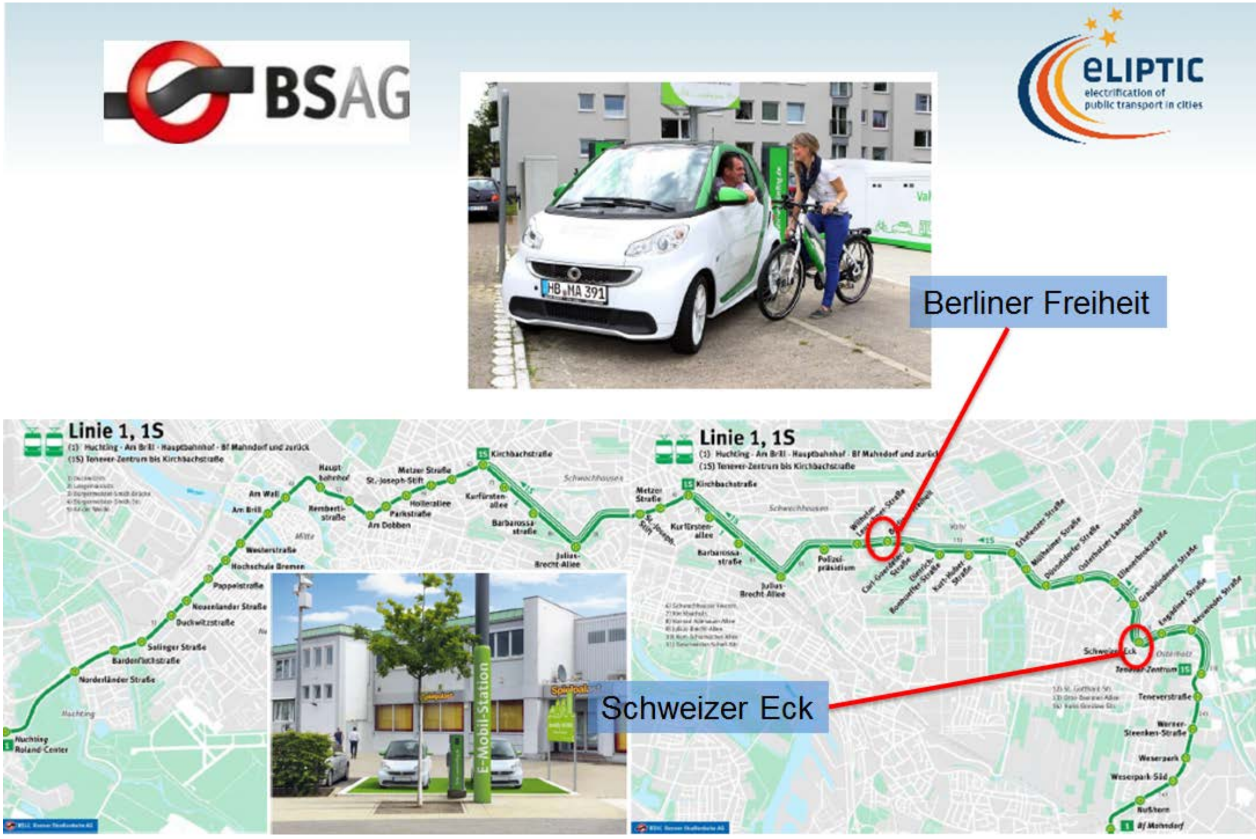


Figure 16 – Mulitmodal mobility hub locations along tram line 1 (source: BSAG)

Summarized Scenario description:

Analysis of the planning process of a multi-mobility hub incl. electric means of transport.

Business case/purpose:

The aim of this use case is to show how the public transport services can be extended by readily available and at the same time environmentally friendly mobility services. The existing public transport system is to be extended by the use of electric mobility means. BSAG will focus on the cooperative planning process and the business model for such an extended multimodal mobility hub station by electric mobility means (incl. aspects of attractiveness of such services).

WP4 Method of investigation:

The investigation will be based on data regarding the user behavior and additional user surveys on the general acceptance/satisfaction, which will likely be conducted by BSAG in cooperation with moveabout. Furthermore, qualitative results from ELIPTIC's process evaluation related to drivers and barriers for setting-up such a cooperative multimodal (electric) mobility hub station will be used for the development of a "generic" business case for Pillar C.

3.3 Leipzig

Partner	Leipziger Verkehrsbetriebe (LVB), Fraunhofer IVI
Date and participants of 1st Workshop	09.11.2015, Lindner-Hotel Leipzig-Leutzsch - Bremen SUBV: Hendrik Koch, Michael Glotz-Richter, Jan Eiken, Niklas Rahn - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - LVB: Eberhard Nickel, Martina Trültzsch, Wagner, Andreas Böttcher, Christoph Wassermann - Fraunhofer IVI: Thoralf Knote
Data Collection	- Energy consumption
Planned Methodologies	- Feasibility (scenario) study - Cost-Benefit Analysis - SWOT Analysis - Simulation (Fraunhofer IVI)
Reviewed by	E. Nickel, 09.06.2016

3.3.1 Use Case Description

Leipzig A6: (Re)charging of ebuses using tram infrastructure

LVB will analyse possibilities to operate electric buses (12 m buses) in the city of Leipzig under special consideration of the already existing tram infrastructure. The work in Leipzig will be based on the experience of two running national projects:

1) operating an electric battery bus on an inner city bus line in the city of Leipzig using tram infrastructure (project Batterfly) and

2) investigating the potentials of bus lines with articulated buses for the operation of trolley-hybrid-buses (Skorpion).

The overall objective of the use case is the technical and economic analysis of all bus lines regarding the possibilities of operating battery buses on these lines. In total, 42 bus lines that are predominantly served with standard buses will be analyzed.

The basis for this analysis is the operation of two battery buses on bus line 89 between Kreuz Connewitz and Leipzig Main Station / Goethestraße. The operation started in early 2016. The 5.4 km long bus line is subdivided into three sections. The first section is situated in the very city center of Leipzig where the buses partly drive through a pedestrian area and where their average commercial speed is very low. The second section leads through an area with speed limits of 30 kmph. After that, the buses run on major roads with a speed limit of 50 kmph.

The buses are recharged at the bus depot and at the terminal stop Kreuz Connewitz. The charging power at the terminal stop will be 250 kW. The charging station will be connected to the DC grid of the local tram system.

One of the battery buses, which both belong to Fraunhofer IVI, is equipped with measuring devices that allow the measurement of energy consumption on different sections.

The operation of the battery buses is part of a R&D project called “eBus Batterfly”, which is co-funded by the German government. However, results of the operation will be used for Pillar A of the Leipzig Use Case. The operation of battery buses on bus line 89 provides important information on energy consumption that will be used for the analysis of all other bus lines mentioned above.

The analysis will be carried out using the so-called energy balance calculation method implemented in the Fraunhofer software tool IVIsion. The method has been used for the evaluation of many bus lines and entire bus networks in the past. It uses the existing or planned bus operation schedules and duty rosters as the operation of battery buses shall not lead to any changes in the bus schedules or especially the labor requirements.

The so-called energy balance calculation method compares the available energy in the vehicle energy storage with the consumed energy and the necessary energy reserve at any time throughout a day of operation. The operation of battery buses on a certain line is deemed to be possible if:

$$E_{bat} + \Sigma E_{ch} > \Sigma E_{con} + E_{res} \quad (3\text{-}1)$$

with

E_{bat} energy content of the battery after leaving the bus depot [kWh]

E_{ch} energy charged during operation [kWh]

E_{con} consumed energy [kWh]

E_{res} energy reserve [kWh]

is given at any time throughout a day of operation.

Summarized Scenario description:

Within this use case, the operation of electric buses with recharging from tram-substations at two different points is under investigation. The real energy consumption of the vehicles is of special interest. The examination is scientifically accompanied by Fraunhofer IVI. Its results are especially interesting for the WP4 development schemes, since the scenario is comparable to and/or valuable as input for other use case examples like Warsaw or Oberhausen.

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with opportunity charging, taking energy from the catenary/substation of the tram-network, can be a business case in the near future. The outcomes of the test-operation and additional simulation, also fed by the results of this test, will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

WP4 Method of investigation:

The survey will be carried out by Fraunhofer IVI through simulation and evaluation of the actual tests. A extensive explanation of the development logic can be found in the final Use Case Set up report.

The (public) results of this survey will be used for the WP4 Business Cases and Development Schemes.

Further steps:

Timeframe	Action
Sep '16 – Apr '17	2nd workshop: - Update on use-case progress
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

Leipzig C4: Use tram network sub-stations for (re) charging e-vehicles

LVB will analyse additional loading effects for charging e-cars and e-bikes at a modified tram sub-station and will determine the impact such additional loading may have on the overall tram operation in Leipzig. Since tram/(light) rail energy networks are dimensioned for full energy availability and short-term capacity overloads, capacity reserves could (theoretically) be used for charging other e-vehicles. Therefore, simulations will be carried out to calculate load capacities (minimum and maximum level) and load management for the existing tram network based on different use case scenarios.

A second, very important aspect of LVB's use case will be a study on legal barriers, juridical background (e.g. ownership unbundling for PT networks) in relation to multi-purpose use of the existing tram infrastructure, i.e. selling energy from the tram network to third parties. In particular for Germany, with its Renewable Energy Sources Act, this study will produce important legal findings on the potential drawbacks such a use case may have. The study will consider German and European energy (market) regulations, the impact on relevant tax issues (tax benefits) and the future of current subsidy agreements for public transport services. The study will produce policy recommendations to be taken up by the (national/ European) political decision making process.

Summarized Scenario description:

The scenario focusses on a study on legal barriers and juridical background in relation to multi-purpose use of infrastructure of the existing tram infrastructure, i.e. selling energy from the tram network to third parties. A comparison to other partners with the same problem (like Oberhausen, Warsaw, Barcelona) within WP4 is imaginable and potentially useful.

Business case/purpose:

The use case aims to show under which preconditions (availability of charging stations, clarification of legal issues, public acceptance) this scenario can be a future business case.

The results will serve as input for a generic concept-description, comprising and comparing the different approaches that are under investigation within the ELIPTIC-project.

WP4 Method of investigation:

The investigation will be based on the outcomes of Fraunhofer IVI and LVB's survey/simulations and the Cost-Benefit- and SWOT analysis by partners UG and Siemens.

Further steps:

Timeframe	Action
Sep '16 – Apr '17	2nd workshop: - Update on use-case progress
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

3.4 Eberswalde

Partner	Barnimer Bus Gesellschaft (BBG), Fraunhofer IVI, TU Dresden
Date and participants of 1st Workshop	12.11.2015, BBG depot - Bremen SUBV: Hendrik Koch, Michael Glotz-Richter, Niklas Rahn - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner - BBG: Frank Wruck, Stephan Rutscher - Fraunhofer IVI: Thoralf Knote - TU Dresden: Jan Bockhoff, Steffen Dutsch - Cegelec Prag: Zdenek Vytous - Prague Public Transit Co.: Jan Barchanek
Data Collection	Data available from simulation by Fraunhofer IVI
Planned methodologies	- Transport planning study (subcontractor TU Dresden) - Simulation (Fraunhofer IVI) - Cost-Benefit analysis (UG) - SWOT analysis (Siemens)
Reviewed by	Frank Wruck, 4.4.2016

3.4.1 Use Case Description

Eberswalde A10 Replacing diesel bus lines by extending trolleybus network with trolley-hybrids

The Barnimer Bus Gesellschaft mbH (BBG) operates two trolleybus lines in Eberswalde with in total 12 articulated trolleybuses. Beginning in 2010 BBG has been substituting its older rolling stock for new trolleybuses from SOLARIS.

Each vehicle is equipped with ultra-capacitors. Necessary provisions to substitute the autonomous power unit (APU) for a battery have been made in all buses. Within the ELIPTIC project the possibilities for using the existing catenary network for the fully electric operation of regional transport buses are to be evaluated. For that purpose bus line 910 between Finowfurt and Eberswalde has been selected. Approx. 70% of the route of this line is already equipped with a catenary. Within a feasibility study the following aspects are to be evaluated:

- efficient and passenger friendly operational concept in which line 910 is to be merged with the two trolleybus lines in order to minimize the number of additional trolleybuses
- elaboration of a concept which describes the electrical implications such as necessary energy content of the onboard storage unit, recharging possibilities within the existing catenary network and necessary retrofitting of the existing catenary network to cover the additional charging power
- test of a system for automated wiring of the pantographs

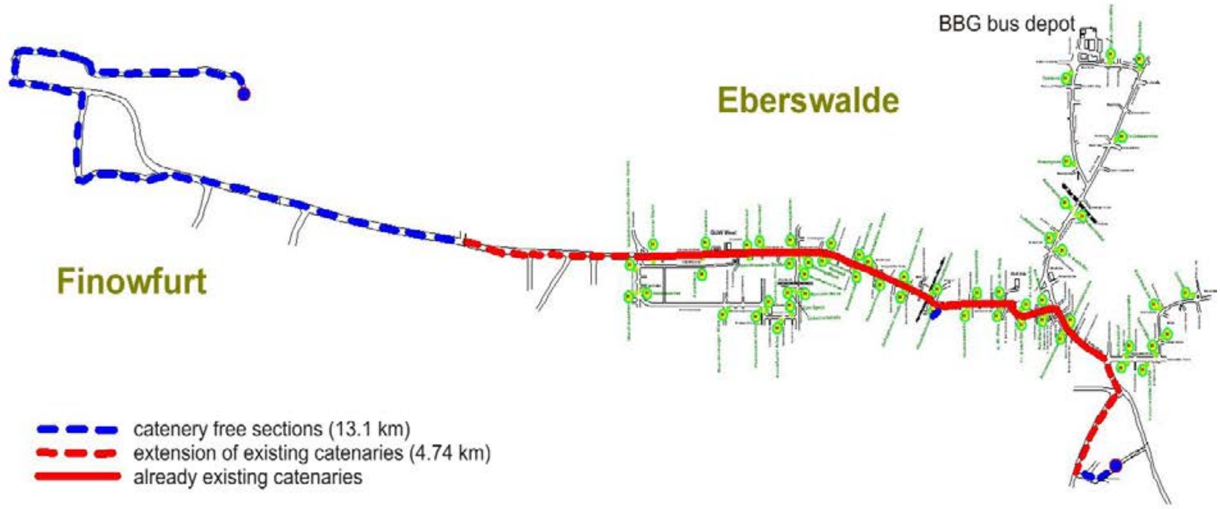


Figure 17 – Bus line 910 - existing configuration

In the future this line is to be served with trolleybuses equipped with batteries instead of auxiliary power units.

Trolleybuses already procured in 2010 and 2012 will form the basis for the new operational concept. (Figure 3) Currently, 11 out of the 12 trolleybuses are equipped with auxiliary power units which are not suitable for regular bus services. It is planned to retrofit some of the buses with suitable electric energy storages in order to replace conventional diesel buses on bus line 910, subject to the results of the feasibility study.

Figure 18 – trolleybus currently operated in Eberswalde

Within a feasibility study the following aspects are to be evaluated:

- an efficient and passenger friendly operational concept in which line 910 is to be merged with the two trolleybus lines in order to minimize the number of additional trolleybuses
- elaboration of a concept which describes the electrical implications such as necessary energy content of the onboard storage unit, recharging possibilities within the existing catenary network and necessary retrofitting of the existing catenary network to cover the additional charging power
- test of a system for automated wiring of the pantographs

The results of the feasibility study will be the basis for strategic decisions on the future bus network in and around the city of Eberswalde.

The feasibility study consists of two major iterative steps. Step 1 is the elaboration of an adapted operational concept which considers the future passenger demand. The major results will be a new alignment of the line, especially in the neighboring town Finowfurt, public schedules, and the according bus operation schedules. The technical feasibility of this new concept will be evaluated within the second step. The questions to be answered are

1. Can the new operational concept be served with trolleybuses that are equipped with batteries that do not cause any losses in passenger capacity and do not exceed the gross axle weight ratings?
2. Can the batteries be recharged while driving beneath the catenaries?
3. Are catenary extensions necessary or useful?
4. Are additional charging stations at the terminal stops necessary or useful?
5. What nominal and usable energy contents must the batteries have?

The analysis will be carried out using the so-called energy balance calculation method implemented in the Fraunhofer software tool IVIsion. The method has been used for the evaluation of many bus lines and whole bus networks in the past. It uses the existing or planned bus operation schedules and duty rosters as the operation of trolleybuses without catenaries shall not lead to any changes in the bus schedules or especially the labor requirements.

The so-called energy balance calculation method compares the available energy in the vehicle energy storage with the consumed energy and the necessary energy reserve at any time throughout a day of operation. The use of trolleybuses with partial catenary-free operation on a certain line is deemed to be possible if

$$E_{bat} + \sum E_{ch} > \sum E_{con} + E_{res} \quad (3\text{-}1)$$

with

E_{bat} energy content of the battery after leaving the bus depot [kWh]

E_{ch} energy charged during operation [kWh]

E_{con} consumed energy [kWh]

E_{res} energy reserve [kWh]

is given at any time throughout a day of operation.

First tests with a trolleybus which is already equipped with a battery will be used to evaluate the simulation results. Systems for automated wiring of pantographs are necessary if trolleybuses are to be operated on bus lines that partially have no catenaries. They provide a higher flexibility and lower the threshold for partially catenary-free operation, as neither manual wiring nor the use of so-called wiring funnels are necessary. The outcome of the tests is still open. The feasibility study as such assumes that there is a system that is quick and flexible enough. However, it also assumes that wiring is possible at bus stops only.

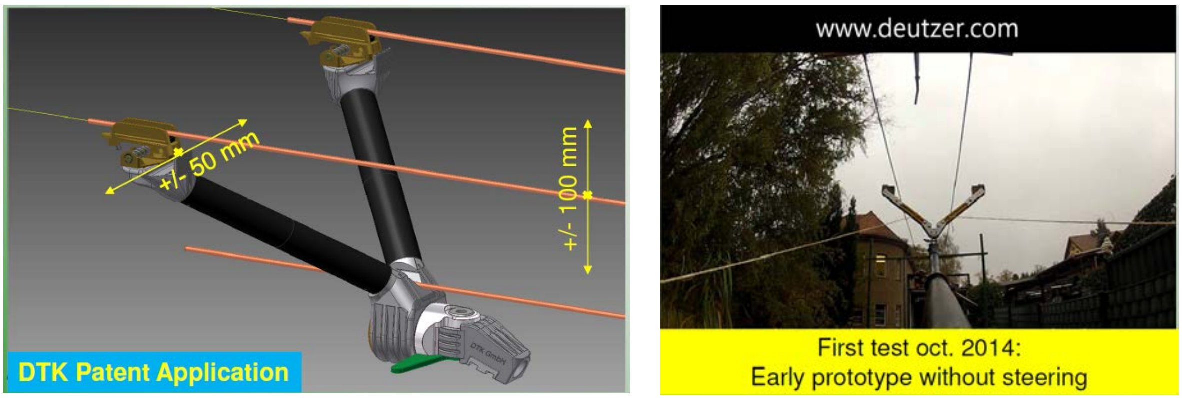


Figure 19 – Automatic wiring system from Deutzer

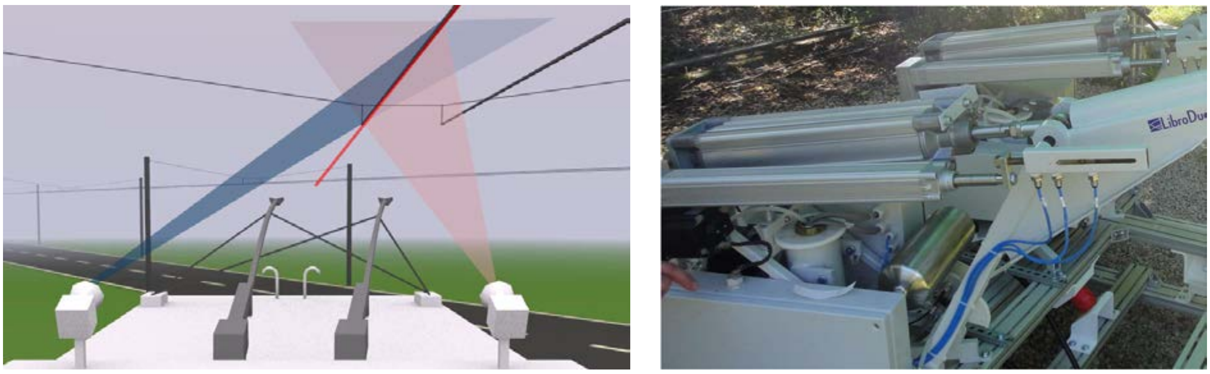


Figure 20 – Automatic wiring system from Kummler + Matter / Dialogica

Until now the companies Kummler + Matter and Deutzer have expressed their willingness to carry out tests of their automatic wiring systems in Eberswalde.

Summarized Scenario description:

The central questions of this Use Case, described in the chapter before, are if the infrastructure can provide the required electrical energy and how the battery should be designed to meet the requirements of the Trolley-hybrid operation.

BBG is scientifically accompanied by TU Dresden and Fraunhofer IVI. TU Dresden is in charge of the case study regarding route, schedule and circulation plan of potential new Trolley-hybrids, while Fraunhofer IVI is engaged with the technical part regarding the electrical grid capacity and dimensioning of the battery.

Business case/purpose:

The use case scenario targets to show how the concept of converting an existing diesel-bus line into an electric, operated with Trolley-Hybrids, can be a Business Case. The energy for recharging the battery will be taken from the catenary, which is available at about 60 % of the route. The outcomes of the survey and additional simulation will outline the preconditions (costs, technical reliability, availability of technical solutions for automatic wiring etc.) that have to be met to create a promising business case for this scenario.

WP4 Method of investigation:

The (public) results of the transport planning study for the envisaged line as well as the simulation of this line, carried out by Fraunhofer IVI and BBG, will serve as input for a business case consideration within WP4 and as comparison to other cities with similar approaches (Gdynia and Szeged), which will be useful regarding the creation of development schemes. Furthermore, a cost-benefit analysis (supported by UG) and a SWOT analysis (with a focus on the tested system for automated wiring of the pantographs supported by Siemens)will assist the investigation.

Further Steps:

Timeframe	**Action**
Sep ’16 – May ’17	2nd workshop: - Update on use-case progress
Sep ’17 – Apr ‘18	3rd workshop: - discussion on results of Use Case investigation - final business case

3.5 Barcelona

Partner	TMB:Bus, B:SM, CENIT
Date and participants of 1st Workshop	03.12.2015, TMB Triangle Ferroviari Depot - Bremen SUBV: Hendrik Koch - RWTH Aachen: Fabian Meishner, Thomas Nemeth - BSM: Maria Roman, Oscar Puigdollers Zanon, Victor Jodar Plaza - TMB: Josep Ariño, Josep Maria Armengol , Isabel Criado - CENIT: Miquel Estrada, Victor Cuevas Perez, Jaume Roca Guitart
Data Collection	Detailed field data available from ZeEUS demonstration
Planned methodologies	- Feasibility study - Demonstration - Simulation
Reviewed by	Pillar C:Jodar Plaza (BSM), PillarA: Cuevas (UPC), Ariño (TMB)

3.5.1 Use Case Description

Barcelona A4 Opportunity (re)charging of electric buses based on metro infrastructure

TMB will study and explore the feasibility of using energy from the metro system/public grid for charging e-buses as well as the effects of overnight charging / maintenance during night hours (while the metro system is not operated) and the potential cost reduction of using the energy system at off peak hours. If feasible, TMB plans to undertake a demonstration in the ELIPTIC project linked to Barcelona's demonstration within the ZeEUS project. The operational demonstration and the cost of charging infrastructure is funded by the ZeEUS project, but connecting the charger to the metro substation using the grid is the complementary part of the ELIPTIC project. The ELIPTIC demonstration will include using the existing metro infrastructure to charge electric buses in two ways: opportunistically and also at the depot in slow charging mode. For demonstration in ELIPTIC and ZeEUS, TMB has purchased two new Solaris 18m ebuses for testing opportunity (fast) charging station at terminals connected one to the metro infrastructure and the other to the public electric grid.

Depot recharging operations are already operative at TMB mainly thanks to ZeEUs project. This typology is based on a slow recharge during the night time. Electric buses from the IRIZAR manufacturer have a battery capacity of 352 kWh and a 12 m length. These buses use an 80 kW power supply. They will be tested during a time service of 16-17h on lines 20 and 34, with 9,4km and 10,9 km, respectively. In this case, the energy supplier is currently Endesa but depending on the evolution TMB-METRO could become the new supplier.

The second model is new at Barcelona. In this case, fast recharging operations will let the service run. Two SOLARIS electric buses are going to perform the service through this operative model. These vehicles have a battery capacity of 125 kWh and an 18 m length. Less capacity means less time and energy at each recharge but more recharging operations. The opportunity recharge points to ensure the service will be placed at each header of H16 line providing each 400 kW electrical power. Besides, it will be also required a slow recharge at depot from a supply of 50 kW in order to let batteries recover themselves from fast recharging operations. H16 line has a length of 12,2 km between headers. Compare to the previous model, in this case recharging time will be within minutes instead of hours. The electric supply is going to be provided by Endesa.

Currently, depot opportunity points are place at Triangle's depot of TMB. The other 2 opportunity recharging points are supposed to be placed at Cisell Street close to Zona Franca and the other is still uncertain. These two elements are deployed by a tender process. Cisell's recharging point is already awarded but the other is still on a planning stage.

The test-operation is planned to be started in July 2016, first only operating with the fast recharger taking energy from the public grid (Endesa). For slow charging at the depot based on using metro energy/infrastructure, TMB will demonstrate slow charging of the new ebuses (Irizar buses, which are used in the ZeEUS project, too; operating since August 2014; by this, data from the operation and the energy consumption for these ebuses will be available for analyses and further use case implementation in the ELIPTIC project.). This use case fits into the existing city council strategy to develop an electric vehicles network on the smart city criteria.

Summarized Scenario description:

The main investigation is on the use of opportunity charging using the metro electric infrastructure. At the moment, there are two electric 12m-buses from Irizar running on lines 20 and 34, having a battery-energy capacity of 356 kWh. They are recharged in the depot overnight (80 kW power installed at the moment). Additionally, two new Solaris 18m electric-buses are purchased to be tested on line H16 (125 kWh battery-energy). This line will include depot charging (50 kW) as well as opportunity charging from Metro grid + local supply company (400 kW).

One of the most crucial parts of the investigation is to determine the cycle life of the battery and see its behavior in real operation. Therefore, detailed data (including voltage, power, energy) is available. The use case is scientifically accompanied by CENIT.

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with opportunity charging (on and off-street), with the additional option of taking energy from the catenary/substation of the metro-network, can be a business case in the near future. The outcomes of the study, test-operation and additional simulation, also fed by the results of this test, will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

WP4 Method of investigation:

From WP4 point of view, a deeper investigation of line H16 by applying simulations tools will be applied and helpful to evaluate the Business Case development.

Therefore, technical and monetary data is required as specified in chapter 2.3. Confidential data has to be compensated by plausible assumptions in the first step

Based on these inputs, calculations on the energy consumption and operation costs are performed. They result in a total value of the TCO (Total cost of ownership). These results will be used for a business-case evaluation afterwards.

Further steps:

Timeframe	Action
Apr '16 – next workshop	Exchange on tools, possibilities of simulation, data exchange
Sep '16 – May '17	2nd workshop: - Discussion on results/assumptions of first simulation - Discussion on further development
After 2nd workshop	Refining of simulation(s)
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

Barcelona C3 Use of metro/tram infrastructure for recharging e-cars (municipal fleet and private e-cars)

Within ELIPTIC's Pillar C from Barcelona Use Case (C3) a feasibility study is carried out in order to prove the convenience of deploying vehicle charging network connected both to the general electric network of the city, and to the electric network from metro system, benefitting of its synergies and opportunities.

The study will analyze the whole city, by exploring the possibilities of deploying and opportunity recharging point nearby metro substations. By doing so, it will be required to analyze from an infrastructural, operational and strategic point of view the convenience of the intervention. If, as a result of the report, the measures results feasible, the planning and proposes have to be provided. Barcelona should follow in an eventual real deployment of the solution.

To do so, Use Case C3 is integrated by Barcelona de Serveis Municipals, the main public parking operator, TMB, the operator of the metro system, and CENIT, a research center in terms of transport and mobility associated to the Universitat Politècnica de Catalunya.

The study will reach its conclusions by approaching to the solution by through a three stages scheme: infrastructure, operation and strategy.

The first stage will study the case from an infrastructural point of view. It will analyze connection opportunities that the current metro electric network brings, and, considering the potential vehicle demand of at different areas of the city, identify the parking lots and slots where recharging points could be deployed. The infrastructural analysis should provide the economical scheme cost of the project in order to better approach next two objectives.

The operational point of view will explore better solutions to carry out the system exploitation, once it would be deployed. The study will focus on how could match parking operator needs with customer needs in terms of charging its vehicles. It is also interesting to explore how the two networks will be used and combined.

As a combination of the infrastructural and the operational conclusions, the study will define the strategy for the following years about an eventual deployment of the electric vehicle charging system connected to metro's network. This last stage will define the objectives to achieve for an appropriate network deployment. As an initial approach, these objectives should be:

1. Increasing the use of electric vehicles in Barcelona, private ones as well as public fleets, which will be the main target demand.
2. Improving the air quality of the city by cutting down emissions of conventional cars, considering a switching from conventional cars to electric vehicles.
3. Social cost-benefit and urban resilience, improving the city networks to face eventual high demands or supply cuts.

Summarized Scenario description:

The main aspects of this Use Case are to investigate how a municipal structure for the fast charge of EV can be established and how legal issues in selling/providing energy can be solved. This question is comparable to other Use Cases (Oberhausen, Bremen, Leipzig) and the results will serve as a good input for the derivation of development schemes in Pillar C.

Business case/purpose:

The use case aims to show under which preconditions (availability of charging stations, clarification of legal issues, public/poltical acceptance) this scenario can be a future business case.

The results will serve as input for a generic concept-description, comprising and comparing the different approaches that are under investigation within the ELIPTIC project.

WP4 Method of investigation:

The WP4 investigation will be based on the outcomes of B.SM's feasibility study and a SWOT analysis of the technological and urban mobility planning concept (supported by Siemens).

3.6 London

Partner	Transport for London, LU, LOS
Date and participants of 1st Workshop	12.01.2016, Palestra House - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - TfL: David Talbot, Mark Poulton
Data Collection	Depending on the decision whether a bus line with connection to the metro grid as charging infrastructure will be identified
Planned activities	- Feasibility study - Simulation - Cost Benefit Anaylsis - SWOT Analysis
Reviewed by	David Talbot, 22.04.16

3.6.1 Use Case Description

London A2 Opportunity (re)charging of ebuses and/or plug-in hybrid buses (using metro infrastructure)

This use case will undertake an overarching investigation of both the London Underground electricity supply system and the London bus network to understand where suitable bus garages and other charging locations (which could include bus stations and bus stands where suitable) are in reasonable proximity to a point where a connection to the LU power network can be made. What constitutes reasonable proximity will vary from site to site depending on local geographic and infrastructure factors.

This feasibility study will include developing a detailed understanding of LU's ability to supply power, for example more available during the nightly shutdown of the majority of the underground rail network, at points close to suitable bus garages. This will then be compared to the detailed demand profile based on the routes suitable for electric plug in vehicles operated from those garages. It will also investigate the potential legal, contractual, planning and policy barriers to implementing the demonstration project and more general LU power network supported bus charging facilities.

Overnight charging, while ensuring vehicles are well charged for their first journey of the day, will not deliver sufficient power for all day operations. To address this issue the use case will also investigate the possibility of implementing opportunity charging systems at bus termini to provide top up charges through the day and how this can be supported from the LU power network. Delivering this with no adverse impact on the safe and efficient operations of London Underground will be one of the major challenges to be addressed.

Once the feasibility study has identified bus garages and routes with a suitable demand profile close to a viable connection to the LU power system the use case will move into a demonstration phase (possibly linked to the ZeEUS project). This is intended to include connection of charging infrastructure to LU power network and real time monitoring of demand from the buses operating on the chosen routes. These could be the approximately 1500 hybrid buses currently operating in London2, a figure which is expected to rise to 1700, or 20% of the total fleet by the summer of 2016. Alternatively these could be drawn from the pure electric bus fleet. 17 such vehicles are currently operating on 4 routes across the city, a number which is growing all the time. For example 51 e-buses are planned to be operational on routes 507 (between Waterloo Station and Victoria Bus Station) and 521 between Waterloo and London Bridge stations by the summer of 2016.

[2] https://tfl.gov.uk/campaign/bus-investment

Summarized Scenario description:

The city of London has ambitious aims in reducing traffic emissions in the city center and has implemented an ultra-low emission zone. In the course of that, all new single-deck busses must be zero emission capable by September 2020. Since it is expensive to lay new electric cables and space is very limited the analysis aims at finding suitable connections to the underground grid, in order to recharge the new electric vehicles.

Business case/purpose:

The use case scenario targets to show how the concept of using energy from the underground rail grid to recharge electric busses in a densely populated area can be a business case in the near future. The outcomes of a first analysis will identify possible locations for a useful realization of such scenario. Based on the outcomes, the construction of a demonstrator is envisaged within the project.

Method of investigation:

A comprehensive analysis of the tube network is carried out by TfL, in order to find out capabilities, but always under the pre-condition that there is no negative impact on the operation of the tube network. If suitable locations are identified, the realization and integration into the electric bus operation can be analysed. The simulation of a potential line will support the development of a business case and WP4 development schemes.

Further Steps:

Timeframe	**Action**
Sep '16 – May '17	2nd workshop: - Discussion on Use-Case progress (results of analysis), possibilities of support - Discussion on further development
After 2nd workshop	Refining of simulation(s)
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

London C2 Use of metro sub-station for (re)charging TfL support fleet vehicles (e-cars & e-vans) and zero-emission capable taxis (rapid charging hubs).

The primary task will be to assess the potential for multi-purpose infrastructure which could support the recharging of other plug-in vehicles. A second feasibility study would investigate the potential for using the LU power network for charging electric cars & commercial vehicles, such as TfL support fleet vehicles which may be garaged at common (London Underground & Surface Transport) depots. This study could also complement the London Mayor's policy proposals requiring all newly-licensed taxis operating in London from 2018 to be zero-emissions-capable. In practice this means plug-in hybrid or pure electric taxis. TfL is investigating how a network of rapid charging hubs could support this initiative. The ELIPTIC project could help to identify possible network locations where capacity could exist to support such a rapid charging hub network. The study will also include a analysis of the legal, policy, contractual and planning situation and issues around delivery of such a system.

Summarized Scenario description:

This use Case deals with the same issue like A2, but focusing on the recharging of other electric vehicles than busses.

Business case/purpose:

The use case scenario targets to show how the concept of using energy from the metro grid to rapid recharge electric vehicles in a densely populated area can be a business case in the near future. The outcomes of a first analysis will identify possible locations for a useful realization of such a scenario.

WP 4 Method of investigation:

A comprehensive analysis of the tube network is carried out by TfL, in order to find out capabilities, but always under the pre-condition that there will be no negative impact on the operation of the tube network. The identification of suitable locations for fast-charging hubs is envisaged and the concept will be further investigated by a cost benefit analysis (supported by UG) and a SWOT analysis (supported by Siemens).

3.7 Brussels

Partner	STIB, VUB
Date and participants of 1st Workshop	28.01.2016, STIB Brussels - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - STIB: Benjamin Roelands, Francois Deveaux, Ricardo Barrero - VUB: Omar Hegazy - UITP: Yannick Bousse
Data Collection	Detailed field data can be made available during the project runtime.
Planned methodologies	- feasibility studies - Cost-Benefit Analysis - SWOT analysis - Simulations
Reviewed by	Benjamin Roelands (STIB), 31.03.2016

3.7.1 Use Case Description

Brussels A3 Progressive electrification of hybrid bus network, using existing tram and underground electric Infrastructure

In this Use Case, three bus lines will be studied to provide insights on the impact of an electrification of those bus lines.

These lines are representative of the diversity of STIB's bus network. These lines are contrasted in terms of topology, urban density, but will also be powered with different techniques:

1. **Neighborhood line**: small vehicles, battery bus, single charging station;
2. **Feeder line**: standard vehicle, battery or plug-in opportunity charging;
3. **Trunk line**: large vehicle, multiple strategies.

The first step of the ELIPTIC project at STIB has been to select the lines to consider. At this stage, we selected the lines described hereafter. However, we could add/modify our current line selection later.

- **Line 17** as a Neighborhood bus-line operated by standard buses (12 m);
- **Line 86** as Feeder bus-line operated by standard buses (12 m);
- **Line 48** as a Trunk bus-line operate by articulated buses (18 m).

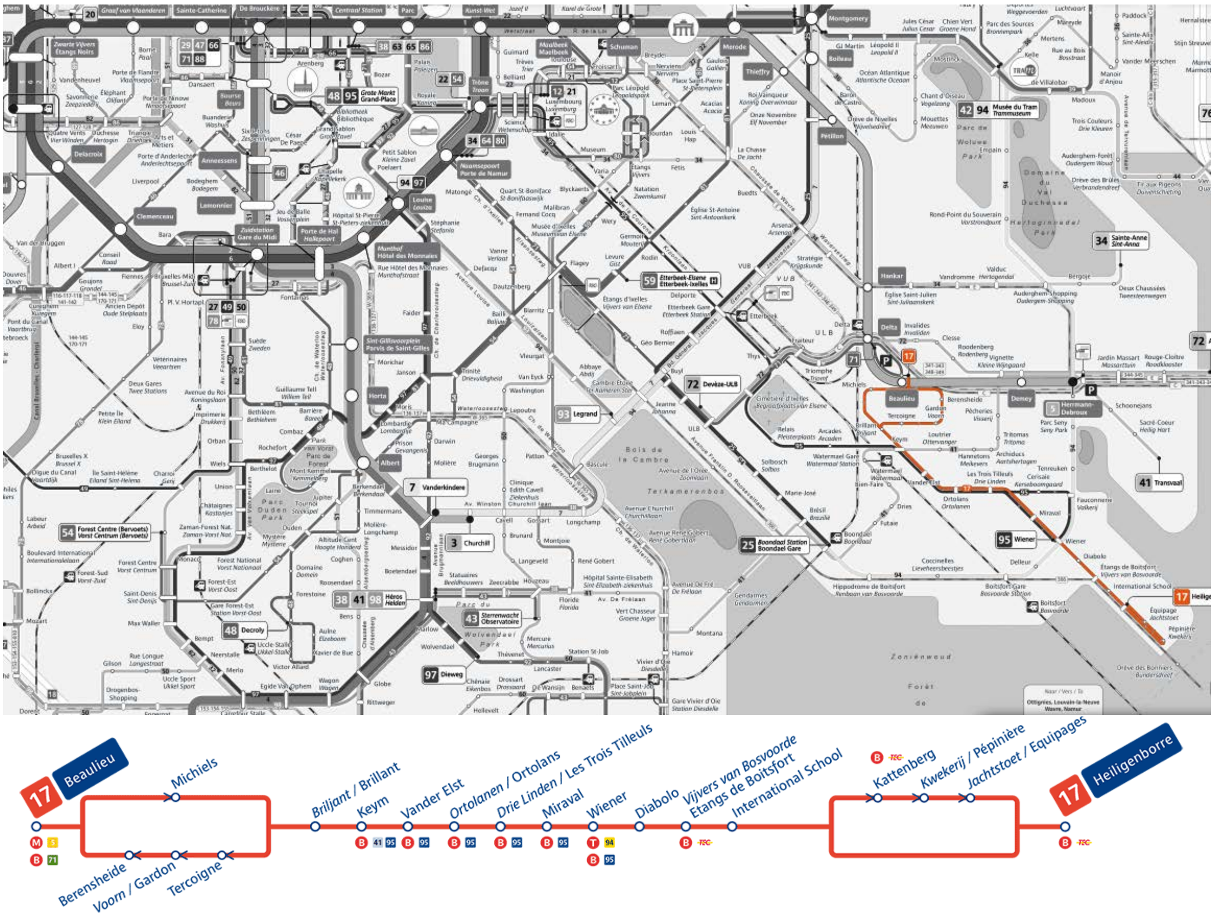


Figure 21 - Overview of line 17: Neighborhood line

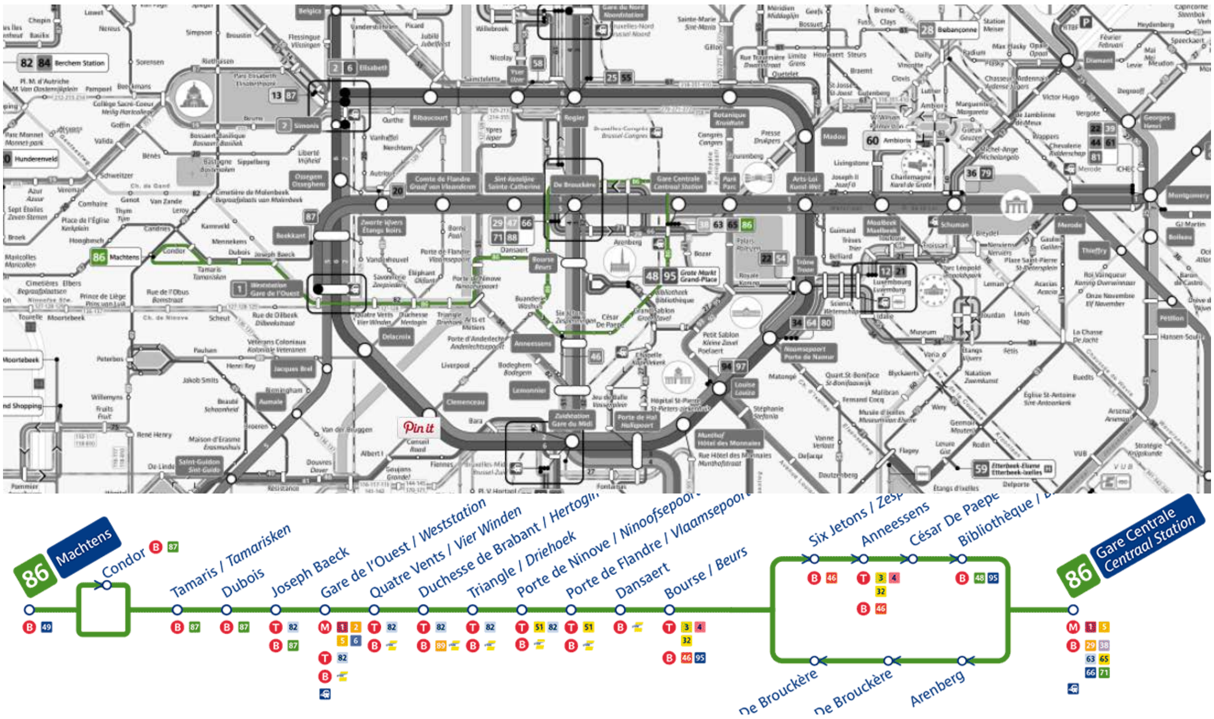


Figure 22 - Overview of Line 86: Feeder line

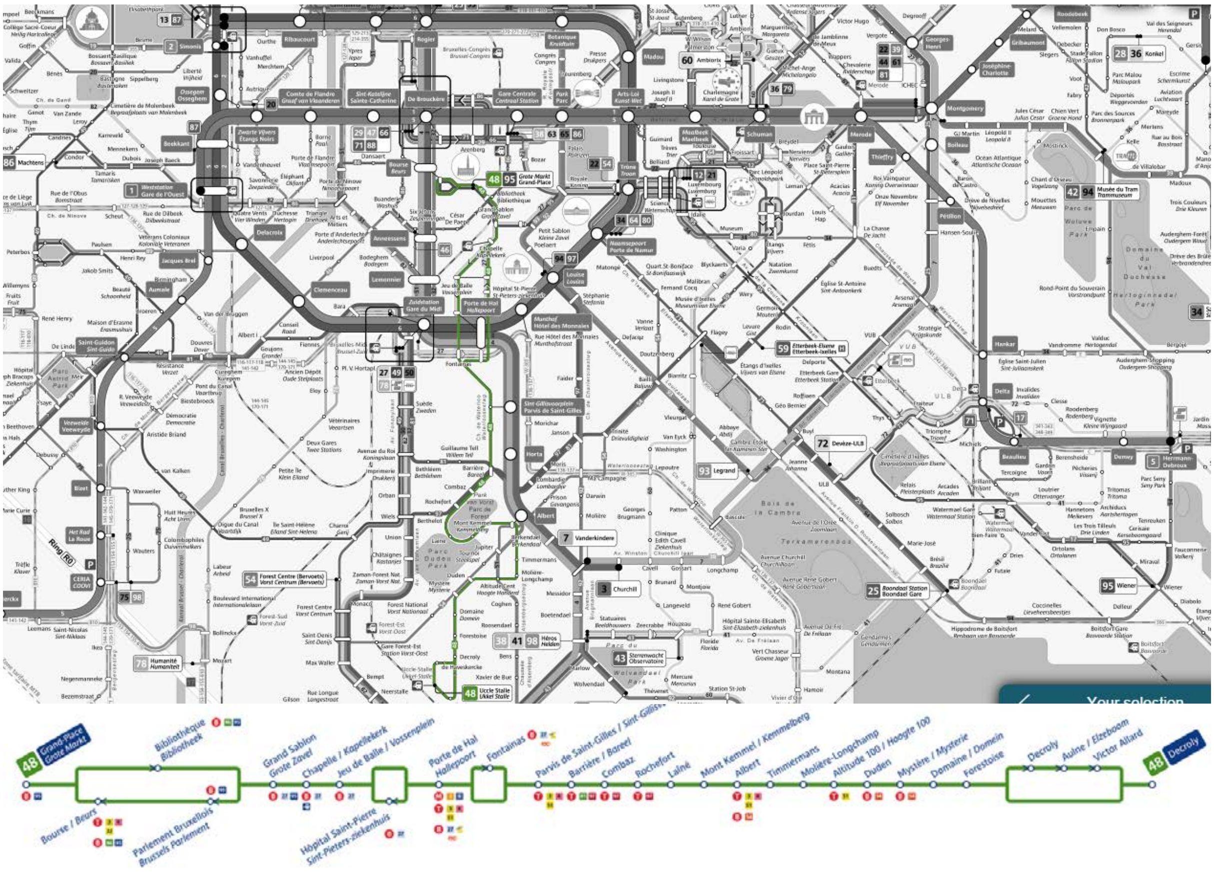


Figure 23 - Overview of Line 48: Trunk bus-line

Summarized Scenario description:

One aspect of this Use Case is to investigate how energy from the own grid can be used to recharge future electric busses. The general operation of a future electric bus fleet is also in consideration, if the political decision was made to purchase zero-emission vehicles.

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with opportunity/depot charging, with the additional option of taking energy from the tram-network, can be a business case in the near future. The outcomes of a feasibility study, supported by simulation, will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

Method of investigation:

A feasibility study will be carried out by STIB, being assisted by VUB, who will explore the technology and dimension three lines (simulative). Based on a process of discussion and consultation (mainly during the 2nd WP4 workshop), one line (of the three simulated lines by VUB) will be identified to be simulated also by partner RWTH Aachen to compare simulation results and to ensure a broader acknowledgement of the results. The results will be fed into the business case development in WP4. The integration into the power network is also regarded. Additionally, measurements are taken (diesel consumption) to determine the energy demand. In case no demonstration will be realised, a SWOT analysis of the technological concept of this use case approach will be conducted.

Further steps:

Timeframe	Action
Sep '16 – Apr '17	2nd workshop: - Discussion on Use-Case progress, possibilities of support - Discussion on further development / results of VUB simulations
After 2nd workshop	Simulation(s) by RWTH Aachen
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation and simulations results - final business case

Brussels B2 Optimised braking energy recovery in light rail network

STIB has modelled and evaluated strategies for optimal assimilation by the electric grid of braking energy recovered by underground trains. On this basis, 6 electric substations have been upgraded, resulting in energy savings that will pay back the investment in 5 years. Within ELIPTIC, STIB will transpose this successful approach to its light rail network, as to make optimal use of modern light rail vehicles' energy recovery ability. It will update the documentation of the light rail network and associated electric grid and identify the sections of the network with the greatest potential for braking energy recovery based on the amount of energy to be recovered (based on topography, vehicle speeds & loads) and network configuration.

Moreover it will also model the most promising sections of the network, in order to determine robust configurations of infrastructure and equipment. The models will be assessed with regards to:

- Energetic efficiency

- Technical, operational and architectural feasibility

- Cost-Benefit (as input for WP3 and WP4 “business case”)

In order to achieve the objectives of increased understating of the operational implications and financial impacts, the feasibility study will be fuelled by real measurements done on the three lines analysed.

The following data will be gathered:

Technical data (based on datasheets)

- Type of vehicles on the line (T3000, T4000 or T2000)
- Diagram of the vehicle kinematic chain (inverter, motor, gearbox, wheels, etc.)
- Specifications of the vehicle:
  - Mass; equivalent mass of the rotating components
  - Efficiency of drivetrain
    - motor, inverter, gearbox
  - Wheel diameter
  - the gearbox reduction factor
- Maximum acceleration according to speed.
- Front surface of the tram
- Traction and braking curves, i.e., max tractive effort. vs. speed, max braking effort. vs. speed.
- Max. traction power vs. overhead line voltage
- Dynamic braking behaviour: Power dissipated in braking resistors vs. catenary voltage. (or returned to the catenary power vs. voltage).
- Operation of the pneumatic brake and electrical vs. speed.
- Rolling resistance: equation and parameters
- Auxiliary consumption (measured or estimated) [kW]

Measurements on three lines

Required data (frequency ≈ 500 ms)

- Speed
- Entry Traction current
- Input voltage

Other useful data

- Annual consumption in kWh / km by type of train
- Annual Regeneration rate (if available) as a percentage. (Energy returned to the catenary / Energy consumed in traction)
- Power to the braking resistors (frequency ≈ 500 ms)
- Power to the engine (frequency ≈ 500 ms)
- Consumption of auxiliary
- Snakes load a route in rush hour, off-peak and weekend.

Measurements of vehicle time schedules:

- Stop Time intervals at intermediate stops;
- Max & min time at the end of the line.

The following figure illustrates the kind of data that will be collected

Ligne 7. Trajet : Vanderkindere -> Heizel. (Peak hour)						
Required data						
Time	t_0	t_1	t_2	t_3	…	t_n
Speed	v_0	v_1	v_2	v_3	…	v_n
Current	i_0	i_1	i_2	i_3	…	i_n
Voltage	V_0	V_1	V_2	V_3	…	V_n
Other useful data						
Snakes load	$Charge_1$			…	$Charge_k$	
Engine power	Pm_0	Pm_1	Pm_2	Pm_3	…	Pm_n
Braking resistors power	Pfr_0	Pfr_1	Pfr_2	Pfr_3	…	Pfr_n
Auxiliaries power	$Paux_0$	$Paux_1$	$Paux_2$	$Paux_3$	…	$Paux_n$

Figure 24 - Illustration of data collection for the tram measurements

Network Data (operational side)

- Average annual distance travelled by type of train and online
- Passenger load depending on the time of day
- Interval trains at various periods: peak hours, off-peak, night and weekend (winter and summer)
- Topographic profile selected tram lines
- Speed limits (if applicable)

Network data (infrastructure side)

Technical data

- Electric Map of the 700 VDC distribution network
    - o Location of substations
    - o Length and diameter of the cables connecting the substations with the catenary
    - o Interconnections between catenary different directions
- Section of the catenary, rails and any cable for transmitting energy along the line.
- Type substation (rectifiers 6 or 12 pulses)
- Topographic profile selected tramlines and rails bending radius depending on the location.
- Speed limits (if applicable)

Measures

- Open circuit voltage of traction substations feeding the selected lines, and internal impedance of substations

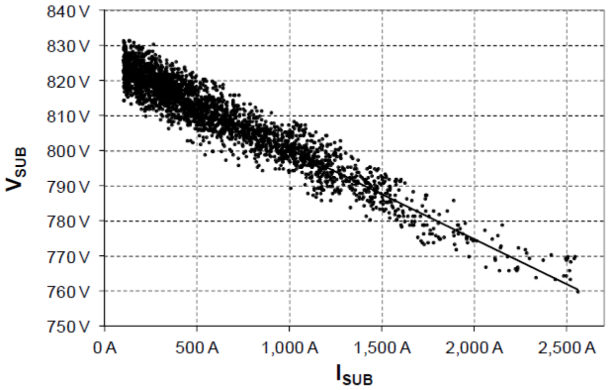


Figure 25 - Typical Open Circuit voltage of a traction substation

- Monthly consumption of traction substations supplying the line.
- For traction substations supplying several lines:
    - o Power profile given to other lines outside the scope of the study (frequency ≈ 500 ms - 1s)
    - o Energy consumed for monthly lined studied (This would involve taking measurements downstream consumption of the rectifier, only for the cables that feed the lined studied)

Development of a multi-train simulation tool adapted to the Brussels tram network topology

Based in the previous experience of a Brussels metro line model, a dedicated simulation tool for the Brussels tram network will be developed. Unlike the metro network, where each line is electrically isolated from the others and has dedicated sub-stations, the Brussels tram network is formed by a mesh with line junctions and substations that feed several lines at the same time. Thus, the system complexity is much higher than the one of the metro. To overcome this issue, a network model that accounts for the influence of several tram lines will be developed. This model will be able to realistically reproduce the behaviour of vehicles and substations of representative lines of the tram network that will be the subject of the study.

The objective of these models is to obtain realistic results in terms of power and energy flows. The vehicles' models can then be either quasi-static or dynamic, the latter being more precise but entailing higher simulation times. The input to the vehicle model will be the speed cycle reference, and the network voltage at the pantograph contact point.

Regarding the network model, a nodal approach can be utilised, although this research is opened to other methodologies (discovered during the state of the art research) showing advantages for highly complex networks. The network inputs will be the vehicles positions and their requested current; and the energy recovery systems positions and current. With these inputs, the network model will yield the voltages and currents in the line at the points of interest such as substations, vehicles pantographs, energy storage devices connection points, etc. Reversible substations will be modelled within this task and the control algorithm that manages the power flow will be defined. The systems will decide whether to withdraw energy from the tram network in function of the voltage.

Simulation of selected tram network zones, analysis and validation

This task consists in the simulation of the three selected lines of the tram network as they are in reality, without the influence of energy recovery technologies. The simulation will be carried out in different real traffic conditions (peak time, off-peak times and night & weekends periods) based on the measurements achieved on the network. The simulation will yield values such as the energy consumed by the traction substations, the energy exchange among vehicles, the energy dissipated in the braking resistors, as well as the vehicles power consumption and network current and voltages.

Modelling and simulation of braking energy recovery technologies

The influence of braking energy recovery technologies will be studied during this task. Simulations of the tram network including energy recovery technologies will be carried out considering the existing traffic conditions. The goal is to determine what would be the optimal solution for the tram network in terms of energy savings. Reversible substations, whose the technical characteristics will come from the current market will be compared in this regard.

Besides, the number of energy recovery systems (ERS) needed and their peak power capabilities can be assessed by developing a sensibility study, i.e., several simulations are run with an increasing (or decreasing) number of ERS so that we can see what is the added value of having an extra ERS in the network. Likewise, the same approach can be used for the peak power of the ERS.

The outcome of this task will be the potential energy savings achieved with a certain number of ERS with certain technical features such as peak power capabilities, etc.; and their ideal location on the selected tram lines.

This study will also evaluate the costs, benefits and operating efficiency of these use case scenarios.

Summarized Scenario description:

Analysis of the light rail operation using reversible substations to recover breaking energy.

Business case/purpose:

The energy/monetary savings of this concept are under investigation. A comparison of the energy saving potential to other partner cities like Bremen is thinkable within WP4. The Business case will show, under which preconditions the operation of such a system could be useful.

WP 4 Method of investigation:

STIB will model the system to identify the sections of the network with the greatest potential for braking energy recovery and analyze the possibilities of a technical realization. The technological concept will be investigated by a SWOT analysis.

The results will become part of a general comparison with the different energy storage technologies for recuperation to increase energy efficiency of existing electric public transport systems within Pillar B use cases.

3.8 Szeged

Partner	SZKT, USZ
Date and participants of 1st Workshop	04.03.2016, SZKT, Szeged, Hungary - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - SZKT: Zita Kardos, Attila Náday, Norbert Újhelyi - USZ: Istvan Tibor Toth
Data Collection	No detailed field data available at the moment
Planned methodologies	- Feasibility study - Demonstration test - SWOT analysis - Simulation
Reviewed by	Norbert Újhelyi, 19.05.2016

3.8.1 Use Case Description

Szeged A11 Replacing diesel bus lines by extending trolleybus network with trolley-hybrids

The Szeged use case will be modelling the case of replacing diesel bus lines with extension of the trolleybus network with trolley-hybrids without the need for additional infrastructure. In 2013 SZKT purchased battery equipped trolleybuses that will be used in the demonstration. The charging will come from the existing catenary network and the battery trolley buses will run in accumulator mode in between the existing and extended network. At first SZKT will to conduct a feasibility study to explore possible/alternative route definitions, the effects of such a system on the traffic, external effects, the determination of external partners and the definition of important indicators. After the results of the feasibility study, the demonstration preparation would involve the following sub tasks:

- Selection of the test route from the alternatives

- Definition of the transport service based on the traffic and technical parameters

- Definition of the demanded vehicle fleet

- Definition of test period and time

- Authorization of the test. (Partner: Municipality, Authority)

- Temporary infrastructure installations (bus-stations, current collector, connector device to catenary system)

- Measuring device/system preparations (vehicle and catenary system)

Once the demonstration is in the execution phase, the following sub tasks will be completed: equipment preparation (vehicle, data measurement/collection), staff training (drivers, technical assistance, traffic assistance) and the test run.

Summarized Scenario description:

The main aspect of this Use Case is to investigate and show how the existing trolley-bus network can be extended with trolley-hybrids, in order to replace diesel bus lines. Therefore, trolley-hybrids will be tested in real operation.

Business case/purpose:

The use case scenario targets to show how the concept of converting an existing diesel-bus line into an electric, operated with Trolley-Hybrids, can be a Business Case. The energy for recharging the battery will be taken from the catenary. The outcomes of the test operation and planned simulation will outline the preconditions (costs, technical reliability, availability of technical solutions for automatic wiring etc.) that have to be met to create a promising business case for this scenario.

Method of investigation:

The main method will be to use the vehicles in real operation (at first at good conditions) and draw conclusions from that demonstration test. Comprehensive data regarding energy consumption etc. is collected. The results will be fed into WP4 and as input to the simulation serving as evaluation/validation. If they provide good results, they can be used to further estimate the operational behavior at bad conditions (cold/hot weather).

Further steps:

Timeframe	Action
Apr '16 – 2nd Workshop	Simulations of line 77
Sep '16 – Apr '16	2nd workshop: - Discussion on Use-Case progress, Test results - Discussion on further development
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

Szeged C6 Multipurpose use of infrastructure for (re)charging trolley-hybrid-buses, e-bikes and e-cars

SZKT will install, remodel and test the first public electrical multipurpose charging station for trolley-hybrid-buses, e-bikes and e-cars in the city of Szeged based on the results of a feasibility study. At first SZKT will study the favorable site for such a multipurpose charging station and then test and demonstrate its use with trolley-hybrid-buses and e-bikes. The evaluation of this multipurpose use will lead to concepts for electric intermodal e-mobility concepts (interchange e-bike and trolleybus).

This first multipurpose charging station would support the existing long term transport strategy plan of the Municipality in Szeged. The ELIPTIC use case will promote e-traffic modes in the future mobility of Szeged and draw the attention of Szeged's Municipality for these tested electro-mobility development possibilities. The order of tasks will be conducted as follows:

- Needs analysis of EV charger; possibilities of local EV-transport; available technological level; tendencies in the use of EV in local transport

- Analysis of the legal environment of the EV chargers

- Technological parameters determination in the scope of possible electric vehicle types, charging mode, rechargeable hybrid trolleybuses

- Examination of the possible connections between the electric PT system and individual users

- Potential demonstration

- Planning design documentation; electric, traffic and infrastructure design

- Multipurpose EV charger installation and monitoring of use

Scenario description:

Analysis of the planning process of a multi-mobility hub incl. electric means of transport.

Business case/purpose:

The use case aims to show under which preconditions (availability of charging stations, clarification of legal issues, public acceptance) this scenario can be a future business case.

The results will serve as input for a generic concept-description, comprising and comparing the different approaches that are under investigation within the ELIPTIC project.

Method of investigation:

The results of a first feasibility study, dealing with legal issues (comparable to Leipzig, Barcelona etc.) and technical possibilities (availability of charging stations to connect to the PT DC grid with floating voltage) will be used for a potential procurement within the project runtime.

The results will serve as input for a generic concept-description, comprising and comparing the different approaches that are under investigation within the ELIPTIC project. This will be accompanied by a SWOT analysis of the technological concept.

3.9 Gdynia

Partner	PKT, Uni Gdansk
Date and participants of 1st Workshop	16.03.2016, PKT Gdynia - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - PKT: Marta Woronowicz, Mikolaj Bartlomiejczyk - Univ. Gdansk: Marcin Wolek
Data Collection	Data available from CIVITAS-DYNAMO
Planned methodologies	- Feasibility study - Cost-Benefit-Analysis - SWOT analysis - Simulation
Reviewed by	Mikołaj Bartłomiejczyk, 24.05.2016

3.9.1 Use Case Description

A8 Opportunity of (re)charging of e-buses connecting Tri-city agglomeration based on trolleybus infrastructure

PKT, responsible for trolleybus transport services in Gdynia and Sopot (two cities out of the Tri-city agglomeration which they form together with Gdansk at the Baltic Sea coast), and will analyze possibilities how to electrify public transport services in Tri-City area. PKT identified already a line to analyze an extension of the existing trolleybus infrastructure and in a first step, the trolleybus will leave the catenary network in Sopot to service the Ergo Arena, a big venue sports stadium (12.000 spectators) with lithium-ion battery traction and then return under the trolleybus network. The distance without network to be covered is ca. 4-5 km. The trolleybus will be loaded conventionally under the network on its way back to Gdynia.

In the future PKT would expect to create a loop for electric vehicles to park and load any electric vehicles (i.e. among others trolleybuses with modern lithium-Ion batteries). Thus, in a second step, PKT will study potential localization of such a loop close to Ergo Arena as well as the possibility of extension of off-traction trolleybuses running to one of Gdansk districts closing the loop with a meeting/charging point based on Gdansk's tram system (+ potential usage of the tram substation in Pomorska street in Gdansk for the trolley-hybrid-bus and other e-vehicles in future).

Scenario description:

The main aspect of this Use Case is to investigate and show how the existing trolley-bus network can be extended with trolley-hybrids, in order to replace diesel bus lines. A comprehensive feasibility study with the aim to identify measures to improve the energy efficiency of the trolleybus network as a basis for such an extension will be carried out. The connection of two supply segments in order to optimize recuperation potential within the network will be analysed in more detail (the communication software between the substations needs to be adjusted).

Business case/purpose:

The use case scenario targets to show how the concept of extending existing trolley-bus lines by using trolley-hybrids can be a Business Case. The energy for recharging the battery will be taken from the catenary. In order to improve the energy efficiency through optimised energy recuperation, two supply segments will be connected, giving the chance to charge traction-batteries from braking energy in a wider area.

Method of investigation:

PKT will analyze the electric energy saving potential by means of increasing the efficiency of recovery (optimization of energy balance and management). The local research partner UG will analyze the cost-benefit ratio of such electric service plans incl. the evaluation of the electric energy savings based on measurements made by PKT. This will be accompanied by a SWOT analysis with regard to the technological concept.

A9 Replacing diesel bus lines by extending trolleybus network with trolley-hybrids

PKT will analyze its trolleybus network based on energy studies identifying potential (current diesel bus) routes for extending the existing trolleybus network based on trolley-hybrid buses running in autonomous mode on battery traction. The feasibility study can be (partly) validated on CIVITAS-DYNAMO data evaluating the running demonstration for extending trolleybus operation on line 21 to service the new central area in Gdynia (extension by 2 km) without catenary connection. Two new trolleybuses equipped with innovative Lithium-Ion batteries and two other classic vehicles with older Ni-Cd batteries will service this extended line. The re-routed line is operational since March 2015.

Based on this experience, PKT (supported by UG) will evaluate possibilities (incl. CBA / emissions reduction) for further extension/replacement of diesel bus lines with battery-trolleybus including in new metropolitan areas for this type of service. This use case includes both a feasibility study and demo, as PKT will demonstrate in CIVITAS-DYN@MO the feasibility of such a concept and can validate the feasibility on "real" data.

Scenario description:

Extending the trolley-bus service by using trolley-hybrids in order to replace diesel bus lines.

Business case/purpose:

The use case scenario targets to show how the concept of converting/replacing an existing diesel-bus line into an electric, operated with Trolley-Hybrids, can be a Business Case. The energy for recharging the battery will be taken from the catenary. The outcomes of a feasibility study and test operation will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

Method of investigation:

"PKT will analyze its trolleybus network based on energy studies identifying potential (current diesel bus) routes for extending the existing trolleybus network based on trolley-hybrid buses running in autonomous mode on battery traction. The feasibility study can be (partly) validated on CIVITAS-DYNAMO data evaluating the running demonstration for extending trolleybus operation on line 21 to service the new central area in Gdynia (extension by 2 km) without catenary connection."

Based on this experience, PKT (supported by UG) will evaluate possibilities (incl. CBA / emissions reduction) for further extension/replacement of diesel bus lines with battery-trolleybus including in new metropolitan areas for this type of service.

Based on a preselection of UG, one pre-selected line will be simulated – fed by data from the running CIVITAS measure - in order to evaluate the approach in depth.

Further steps:

Timeframe	Action
Sep ’16 – Apr ’17	2nd workshop: - Discussion on Use-Case progress, Test results - Discussion on further development
1st – 3rd workshop	Simulation of a line after preselection by UG
Sep ’17 – Apr ‘18	3rd workshop: - discussion on results of Use Case investigation - final business case

3.10 Warsaw

Partner	MZA, PIMOT
Date and participants of 1st Workshop	17.03.2016, MZA Warsaw - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner, Thomas Nemeth - MZA: Katarzyna Kwiatkowska, Janusz Bosakirski - PIMOT: Joanna Kalbarczyk, Wieslaw Zielinski
Data Collection	- when timing permits, a demonstration of the newly installed charging infrastructure will be realized and usage data will be collected during demonstration.
Planned Methodology	- Feasibility Study - Simulation
Reviewed by	Janusz Bosakirski, 12.04.2016

3.10.1 Use Case Description

A5: Use of tram infrastructure for recharging e-buses

The ELIPTIC use case for Warsaw coincides with the long-term development strategy of MZA for the years 2014 -2024 – which involves major investments for environmental friendly buses. MZA will conduct a feasibility study to analyse the potential of using energy from the city's tram infrastructure to opportunistically charge e-buses. The study will explore existing possibilities for (re)charging of e-buses via use of tram infrastructure within terminus stops (end of the line) common for the buses and trams at the tangent/intersecting points of existing infrastructure. In the case of feasibility of such a concept, MZA intend to use one of their newly tendered e-buses to trial the use case realization of a further step, which involves e-bus adaptation to enable power to be sourced from the tram catenary (infrastructure).

Testing and demonstration will require:

• design and construct proper hardware: charger with adaptive voltage module adjusting the voltage out of the catenary towards the required e-bus parameters;

• design and construct necessary technical infrastructure for the tangent / intersecting points of existing infrastructure – incl. negotiations and agreements, permits, acquire or clarify unidentified ownership of land around designated location where the infrastructure is to be laid down or adapted, e.g. creation of a common emergency network for TW and MZA Warszawa to repair and fix possible failures of the catenary (high voltage) – would require separate agreement to determine terms and conditions of such joint maintenance force; designation of charging stations for e-buses at the terminus/end of the line.

For the envisaged solution research has to be undertaken regarding

a) the schedule in terms of sufficient charging time (e.g. not exceeding 15 up to 20 minutes),

b) alternatives for plug-in charging, as this will be more flexible due to possibility of using various types of charger parameters in order to adapt the electric current from the one sourced from the tram catenary to the one used in the e-bus and

c) determining the e-bus route to (incl. e.g. distance, time adjusted in relation to the technical capabilities of the e-bus and coverage of supercharged batteries).

The envisaged solution will also affect user safety and safety regulations. The research partner PIMOT will research on quality, technical and operational issues related to the planned use case.

Scenario description:

Planning, construction and operation of a charging station for electric busses, taking energy from the tram-network (from the substation), which is operated by a different company. An electric bus line using this new charging station will be simulated

Business case/purpose:

The use case scenario targets to show how the concept of operating e-buses with opportunity charging, taking energy from the substation of the tram-network, can be a business case in the near future. The outcomes of a feasibility study and subsequent test-operation will outline the preconditions (costs, technical reliability, etc.) that have to be met to create a promising business case for this scenario.

Method of investigation:

MZA, assisted by PIMOT, will primarily conduct a feasibility study (clarifying legal issues, choosing the technology etc.) and then build a charging station in the course of the project. This will be accompanied by a SWOT analysis with regard to the technological concept of the charging station. Furthermore, a simulation of an electric bus line using this charging station will be realised, in order to show the benefits of this approach.

Further steps:

Timeframe	Action
Sep '16 – Apr '17	2nd workshop: - Discussion on Use-Case progress - Discussion on further development
Apr '16 – 2nd/3rd workshop	Simulation of line using the new charging point
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case

3.11 Lanciano

Partner	ASSTRA, FAS
Date and participants of 1st Workshop	11.04.2016, WebMeeting - Bremen SUBV: Hendrik Koch - Rupprecht Consult: Wolfgang Backhaus - RWTH Aachen: Fabian Meishner - ASSTRA: Victoria Usai, Daniela Carbone - FAS: Fulvio Quattroccolo, Sandro Imbastaro
Data Collection	-
Planned Methodology	- Feasibility Study - SWOT analysis - Cost-Benefit-Analysis
Reviewed by	Sandro Imbastaro, 20.05.2016

3.11.1 Use Case Description

B3: Light rail (tram) operation for rural rail track

The use case will focus on a feasibility study that will analyse the implementation of a new urban tramway system by upgrading the existing rail network of the Ferrovia Sangritana. The aim of the use case is to provide an urban tramway through the use of train routes of the Ferrovia Adriatico Sangritana with the intention to use the railway line San Vito Marina - Lanciano - Crocetta for tram-type services.

The objective is to reuse the existing railway infrastructure that is no longer used to provide a tram-type service, characterised by high accessibility by users (thanks to the low floor), high commercial speed (the result of high performance in acceleration and deceleration) and less impact on traffic and roads in the town (as railway-type street crossings will not be required). Furthermore, in order to overcome potential interference with other existing infrastructure, the study will consider the potential for introducing energy storage systems. The feasibility study aims to demonstrate that such a system can increase the accessibility of inland areas and the relationships between neighbouring towns, discourage car use, improve local air quality, enhance the accessibility of local public

Scenario description:

A feasibility study regarding the reuse of existing railway infrastructure to provide a tram-type service is carried out. The aim is to show the benefits of introducing such a service.

Business case/purpose:

The use case scenario targets to show how the concept of reusing existing railway infrastructure for a tram-service can be a business case. The outcomes of a feasibility study will outline the preconditions (user potential, costs, etc.) that have to be met to create a promising business case for this scenario.

Method of investigation:

The feasibility study will be carried out by FAS. The evaluation will be accompanied by a SWOT analysis and cost-benefit calculation provided by ELIPTIC-partners.

Further steps:

Timeframe	**Action**
Sep '16 – Apr '17	2nd workshop: - Discussion on Use-Case progress - Discussion on further development
Sep '17 – Apr '18	3rd workshop: - discussion on results of Use Case investigation - final business case