Gdynia

Use case set up report

Pillar A

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Authors	Mikolaj Bartlomiejczyk (PKT) Marcin Wolek (UG) Marta Woronowicz (PKT)
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Reviewed by	Yannick Bousse (UITP) Wolfgang Backhaus (Rupprecht Consult)

SUMMARY SHEET

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Abstract	This report includes separately information on use cases in Gdynia (Poland), namely A.9 and A.10. It includes context, objectives, risks, detailed description of bot use cases, work plan and expected results.
Keywords	Gdynia, hybrid-trolleybus
Critical risks	Political risks (incl. potential lack of politicians' support for further public transport electrification, political changes on local/regional level, political changes leading to decrease independence of self-governance)

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0.1		First draft	UNIWERSYTET GDANSKI (UG)	
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CONTRIBUTING PARTNERS

Company	Names	Company Info
PRZEDSIEBIORSTWO KOMUNIKACJI TROLEJBUSOWEJ (PKT)	MIKOLAJ BARTLOMIEJCZYK, PhD MARTA WORONOWICZ,MA	*PKT (Przedsiebiorstwo Komunikacji Trolejbusowej), realizes passenger trolleybus transport on 12 day lines in Gdynia and Sopot, which together with Gdansk form a Tricity agglomeration in the north of Poland. It covers 5 million vehicle km a year and maintains 43 km of traction network. Currently its fleet consists of 91 trolleybuses.* *Since 2005 the company has been very active in EU co-funded projects and in 2014 it received European Commission Regiostars Award in the category Citystar – Investment Projects in Sustainable Urban Public Transport. At the moment apart from ELIPTIC PKT is also a partner in CIVITAS DYN@MO project.*
UNIWERSYTET GDANSKI (UG)	MARCIN WOLEK, PhD, PROF. OLGIERD WYSZOMIRSKI, PROF. KATARZYNA HEBEL, ALEKSANDER JAGIELLO	UNIWERSYTET GDAŃSKI ***11*** *faculties,* ***71*** *fields of study,* ***201*** *specialities,* ***1,670*** *scientific and teaching staff,* ***26,896*** *students,* ***18*** *doctoral studies* *Founded in 1970.The largest educational institution in the Pomerania region, including eleven faculties with over thirty thousand students, doctoral students and post-graduates, who are taught by one thousand seven hundred academic staff.* *Today, the Faculty of Economics of the University of Gdansk is an academic center with full academic rights. It has over 4000 students on different types of studies, including doctoral. It provides rich offer of lectures in foreign languages, International Business specialisation in English, variety of computer labs and*

terminals open to the public
and Thomson Reuters Data Suite computer lab and dealing room.

Chair of Transportation Market is one out of five chairs involved in research on transport and logistics at Faculty of Economics. It was founded in 1991 and currently is one of the leading units in research of public transport in Poland. It cooperates with variety of scientific institutions but is well known of its practical aspects of research. Its research activity focuses on economics of urban and railway transport, marketing research, marketing management in transport and transformation of transport markets.

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LIST OF ABREVIATIONS

PKT	Przedsiebiorstwo Komunikacji Trolejbusowej
UG	UNIWERSYTET GDANSKI
EUC	ELIPTIC Use Case
Ni-Cd	Nickel–cadmium
Li-Ion	Lithium-ion
PKA	Przedsiębiorstwo Komunikacji Autobusowej
PKM	Przedsiębiorstwo Komunikacji Miejskiej
ZKM	Zarząd Komunikacji Miejskiej
SKM	Trójmiasto: Strona główna
CNG	Compressed natural gas
FP7	Seventh Framework Programme

1. Executive Summary

An overview of public transport market in Gdynia was provided to create a base for detailed description of actions to be taken within ELIPTIC project.
PKT Gdynia sp. z o.o. (PKT) is a municipal trolleybus operator with 91 trolleybuses and ca. 5 mio vehicle-kilometres per year, having a 26% in general supply of public transport in Gdynia. PKT is executing tasks organized by public transport authority, ZKM Gdynia. It offers modern vehicles (including converted diesel buses) in the framework of competitive public transport system.
PKT implemented hybrid-trolley with Ni-Cd batteries, and modern Li-Ion batteries. The vehicles with Li-Ion batteries were introduced on the first section of the network (2 km) without catenary in May 2015.
PKT is involved in 2 Eliptic Use Cases (EUC). In the first one (A9), PKT will research an opportunity for the extension of the existing trolleybus service based on lithium-ion battery traction (ca. 4-5 km without catenary). The vehicle will be loaded conventionally under the network on its way back to Gdynia. The electric energy saving potential will be measured.
Replacing diesel bus lines by extending trolleybus network with trolley-hybrids is EUC A10. Within A10, the potential for extending the current trolleybus network will be analysed based on energy studies identifying potential (current diesel bus) routes. The concept of trolley-hybrid buses running in autonomous mode on battery traction is a key element of that study.
To get proper and comparable data a sets of KPIs were prepared.

2. Partner Contribution

Company	Sections	Description of the partner contribution
PRZEDSIEBIORSTWO KOMUNIKACJI TROLEJBUSOWEJ (PKT)		
UNIWERSYTET GDANSKI (UG)	All sections	Draft of document
UITP	All sections	Review of the document
RUPPRECHT	All sections	Review of the document

3. Context conditions

3.1. Economic, geographical and urban context of the Use Case

Gdynia is a modern city located at the Baltic coast with almost 250 thousand inhabitants. It is an important centre of maritime economy, international trade, science and academic education, culture and tourism. One of the most important economic engines is the harbour, including two container terminals. There is a ferry terminal as well, providing a link to Karlskrona (Sweden). Gdynia lies at a crossroads of the Pan-European Transport Corridor VI and the future Via Hanseatica. It is also a node of road, rail and sea, and soon - air transportation. Gdynia has regular liner shipping with Scandinavia, the UK, Germany, the Mediterranean and the two Americas.
The main naval port is located in Gdynia.
Gdynia, together with Gdansk and Sopot forms the core of the metropolitan area with more than 1 mio. inhabitants. It is one of the most important and competitive metropolitan areas in Poland.
The rate of unemployment was 6.4% in 2013. The number of business entities increased – there were 37 408 business entities based in Gdynia in 2013.
In Poland, Gdynia is frequently cited as a city of success, a city in which people of initiative, entrepreneurial spirit, active and daring ones dwell.

3.2. PT service context

There are 250.000 inhabitants in the city of Gdynia. The length of public roads equals 395,5km, while the length of public transport routes is 244,4 km.

A metropolitan mode of transport is Rapid Urban Railway (SKM). Public transport is partially integrated, although Gdansk and Gdynia maintain their own public transport authorities.
Gdynia's public transport strategy follows the Swedish model of public transport market organisation with regulated competition and independent public transport authority – ZKM Gdynia. There are two municipal bus operators (PKA and PKM), one municipal trolleybus operator (PKT Gdynia) and five other bus operators, which have ca. 20% share in public transport market.
Data collected by the public transport authority (2015) shows that the majority of journeys, some 45,5%, made by respondents were carried out by car of which they themselves were the drivers. The bus proved to be the mode of public transportation chosen most often (in 1/5 of the cases). The share of trolleybuses amounted to 1/10 of all journeys, and was similar to that of pedestrian journeys. The share of travel by bike amounted to only 1.6% of all journeys, although it is steadily increasing (Fig. 1). It should also be pointed out that the trolleybus services operate mostly within the city centre on the two main transport corridors of the city. The range of operations is also

similarly restricted in the case of the urban rail (its destinations being Gdansk and Wejherowo), whilst the bus network is much more developed.

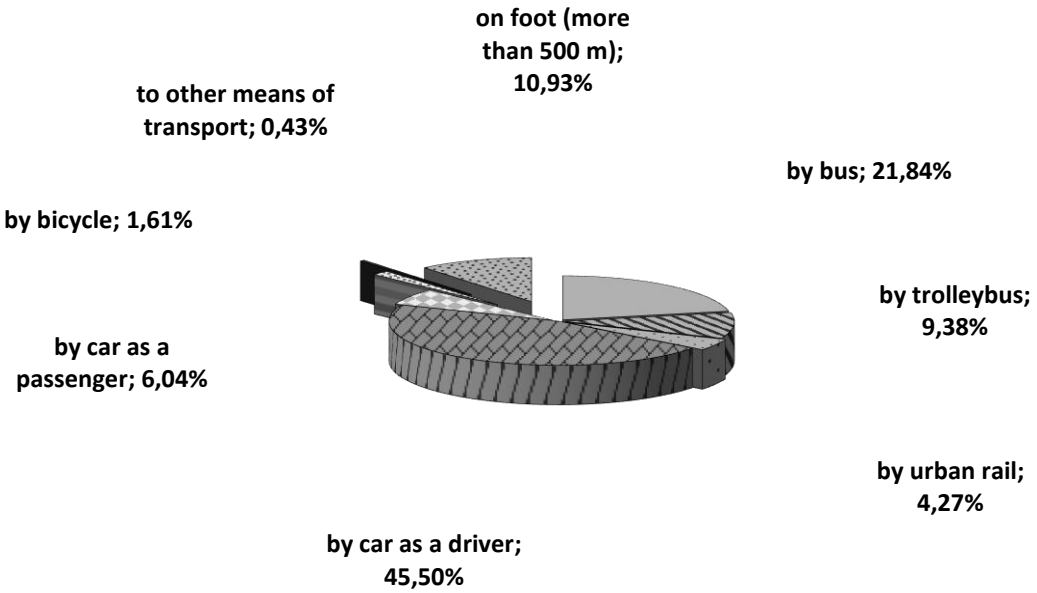


Fig. 1. Modal split on the basis of journeys carried out by the inhabitants of Gdynia on the day prior to research in 2015.
Source: K. Hebel, M. Wolek: The Perception of Modes of Public Transport Compared to the Travel Behaviour of Urban Inhabitants in the Light of Market Research. "Scientific Journal of Silesian University of Technology". Series Transport. 2016, 90, 11-21. ISSN: 0209-3324. DOI: 10.20858/sjsutst.2016.90.1.

Today, Gdynia's urban transport system which is based on buses, trolleybuses and suburban light rail can be described as green, efficient and accessible. For example, 77% of all citizens live within five minute walking distance to a bus stop. Both the vehicles and the network are systematically modernized to provide the best quality for the passengers. Operators of public transport in the city make considerable efforts to increase the competitiveness and the quality of service provided, not only complying to local community demands but also to operate environmentally friendly vehicles. Clean public transport vehicles operated in the city – mainly the modern fleet of trolleybuses (26% of total amount of vehicle-kilometres of public transport) and CNG buses (14% of total amount of vehicle-kilometres of public transport) – contribute not only to the reduction of environmental pollution caused by emissions of exhaust flames but also to a decrease of the noise level in the area and therefore a better quality of life for the city's inhabitants. This includes also the conversion of second hand diesel buses to trolleybuses to obtain the most efficient fleet in Poland at the most competitive cost[1].

[1] B. Decker, H. Hecimovic, M. Wolek: Sustainable Urban Mobility Planning in Central and Eastern Europe: case examples from Poland and Croatia. „Procedia-Social and Behavioral Sciences" 2012 nr 48, pp. 2748–2757.

Despite the continuous improvement of public transport quality, there is a strong increase of individual cars, particularly since the EU accession in 2004. Based on the results of the marketing research conducted by the public transport authority, almost 3/4 of Gdynia's households had access to a private car in 2013. The number of private cars in Gdynia increased by 18% between 2009 and 2014. The individual motorisation index increased from 440 (2009) to 521 cars per 1000 inhabitants in 2014.
The city's transport policy is mainly oriented to solve the most relevant mobility problems in a sustainable way.

A great advantage however is that 77% of all Gdynia inhabitants live within a 5 min. walk from a bus/trolleybus stop so the city is quite well connected.
Trolleybus transport has been operated in the city of Gdynia for 72 years and at the moment it constitutes over 26% of the whole public transport supply in Gdynia and Sopot. 91 trolleybuses run ca. 5 million vehicle kilometres a year on 12 day lines on ca. 90 km of traction supplied by 10 substations. There are only 2 other trolleybus cities in Poland: Tychy in the south and Lublin in the east of Poland.

Thanks to the modern battery and charging technology the trolleybus transport development possibilities are immense as the vehicles can now also be used as a regular e-bus transport without the necessity of building wired infrastructure, which poses a great possibility of further public transport electrification.

3.3. Information about the Use Case

Task 2.9: Gdynia (PL) Use Case

Gdynia A9: Opportunity of (re)charging of ebuses connecting Tri-city agglomeration based on trolleybus infrastructure
PKT (trolleybus operator) will research the opportunity for extending the existing trolleybus service based on lithium-ion battery traction (ca. 4-5 km without catenary).
The trolleybus will be loaded conventionally under the network on its way back to Gdynia. The electric energy saving potential will be measured. The local research partner UG will analyse the cost-benefit ratio of such electric service development plans.

Gdynia A10: Replacing diesel bus lines by extending trolleybus network with trolley-hybrids
The potential for the extension of current trolleybus network will be analysed based on energy studies identifying potential (current diesel bus) routes. The concept of trolley-hybrid buses running in an autonomous mode on battery traction is a key element of that study. 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.

4. Objectives

4.1. Objectives of the Use Case

The predominant objective of the two use cases realized by PKT and UG is to explore the possibilities of further public transport electrification in the cities of Gdynia and Sopot without the necessity of building wired infrastructure. This objective is of dual direction: the first one is to analyse the trolleybus battery technology for creating new unwired trolleybus lines as well as e-bus charging point options (which in the future could also be used by individual transport users), while the second one will focus on the possibility of replacing current diesel bus lines with trolleybus-battery hybrid vehicles.

4.2. Expected impacts

The described Use cases would have strong impacts on the following performance domains:

- Energy performance of electric public transport;
- Environmental performance having impact for the whole area being serviced;
- Promotional performance of public transport as innovative, low-emission and low-noise component of public services.

4.3. Use Case KPIs

Table: KPIs selected for A9 ELIPTIC Use Case

KPI ID (from WP3)	KPI	description
Ost1	Driving staff	Staff involved in driving activities
Ost2	Drivers workload	Workload required to drive a vehicle
Ost3	Maintenance staff	Amount of personnel with maintenance duties divided by the amount of vehicles composing the fleet
Osu2	Service coverage	Consistency of the service
Oma1	Vehicles failures	Monthly events recorded per vehicle and per travelled km
Oma9	Durability of vehicles	Lifetime of a vehicle

Oma10	Ratio of non-working vehicles	Amount of unproductive vehicles due to technical failures, breakdown, etc.
Eco1	Operating cost (general)	Monthly expenditure due to staff, energy, maintenance management, to purchase external goods and services, to financial costs, depreciation, and taxes
Eco6	Vehicle capital costs (for all different vehicles: E-bus / diesel bus, 12m / 18m version etc.)	Capital costs for vehicle owned
Eco7	Vehicle capital costs without battery	Capital costs for vehicle owned without battery
Eco8	Battery capital cost	Capital cost for vehicle traction battery
Eco18	Residual value of vehicles (10-years)	sale value of the vehicles after **10** years of operational lifetime
Eco19	Residual value of vehicles (15-years)	sale value of the vehicles after **15** years of operational lifetime
Eco20	Residual value of battery	sale value of the battery at end of life
Eco23	Electricity costs for vehicles	Total costs for electricity
Eco24	Electricity costs for traction	Total costs for electricity due to traction operations
Eco25	Electricity costs for non-traction	Total costs for electricity to operate non traction equipment's (auxiliaries, etc).
Eco27	Fuel costs	Total costs for fuel purchase
Ecn 2	Fuel Mix	Energy monthly used per type of fuel, per vehicle type
Ecn 3	Usage of clean vehicles	Level of exploitation of clean fleets per type of fuel (water-diesel emulsion, biodiesel, bioethanol, biogas, CNG, LPG, electricity)
Ecn 10	Electricity from renewable sources consumption	Total amount of electricity from renewable sources consumed

Table: KPIs selected for A10 ELIPTIC Use Case

ID of KPI (from WP3)	KPI	Description
Ost1	Driving staff	Staff involved in driving activities

Ost2	Drivers workload	Workload required to drive a vehicle
Ost3	Maintenance staff	Amount of personnel with maintenance duties divided by the amount of vehicles composing the fleet
Osu2	Service coverage	Consistency of the service
Oma1	Vehicles failures	Monthly events recorded per vehicle and per travelled km
Oma9	Durability of vehicles	Lifetime of a vehicle
Oma10	Ratio of non-working vehicles	Amount of unproductive vehicles due to technical failures, breakdown, etc.
Eco1	Operating cost (general)	Monthly expenditure due to staff, energy, maintenance management, to purchase external goods and services, to financial costs, depreciation, and taxes
Eco6	Vehicle capital costs (for all different vehicles: E-bus / diesel bus, 12m / 18m version etc.)	Capital costs for vehicle owned
Eco7	Vehicle capital costs without battery	Capital costs for vehicle owned without battery
Eco8	Battery capital cost	Capital cost for vehicle traction battery
Eco18	Residual value of vehicles (10-years)	sale value of the vehicles after **10** years of operational lifetime
Eco19	Residual value of vehicles (15-years)	sale value of the vehicles after **15** years of operational lifetime
Eco20	Residual value of battery	sale value of the battery at end of life
Eco23	Electricity costs for vehicles	Total costs for electricity

Eco24	Electricity costs for traction	Total costs for electricity due to traction operations
Eco25	Electricity costs for non-traction	Total costs for electricity to operate non traction equipment's (auxiliaries, etc).
Eco27	Fuel costs	Total costs for fuel purchase
Ecn 2	Fuel Mix	Energy monthly used per type of fuel, per vehicle type
Ecn 3	Usage of clean vehicles	Level of exploitation of clean fleets per type of fuel (water-diesel emulsion, biodiesel, bioethanol, biogas, CNG, LPG, electricity)
Ecn 5	Fossil fuel (liquid) consumption	Total amount of fossil fuel consumed (liquid)
Ecn 6	Fossil fuel (gas) consumption	Total amount of fossil fuel consumed (gas)
Ecn 9	Electricity consumption	Total amount of electricity consumed
Ecn 10	Electricity from renewable sources consumption	Total amount of electricity from renewable sources consumed

5. Risks

Potential risks include:

- Problems in software and equipment delivery due to delays on the part of the producer.
- Unfavourable local political situation, e.g. potential lack of politicians' support for further public transport electrification, or diesel bus community lobbying, political changes on local/regional level.
- Political changes leading to decrease independence of self-governance.

6. Detailed description of the Use Case

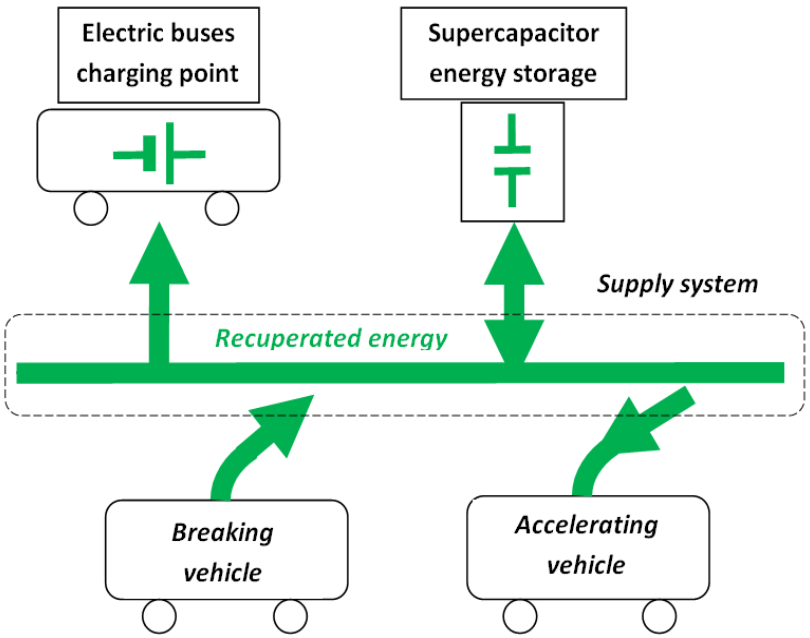
6.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

Task 2.9: Gdynia (PL) Use Case

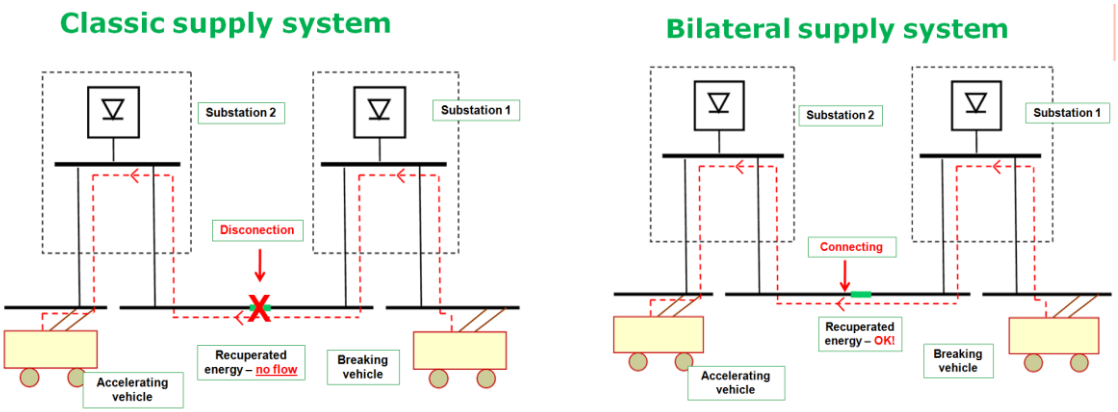
Gdynia A9: Opportunity of (re)charging of ebuses connecting Tri-city agglomeration based on trolleybus infrastructure

PKT, responsible for trolleybus transport services in Gdynia and Sopot (two cities out of the three cities which together with Gdansk at the Baltic Sea coast form the Tri-city agglomeration), and will analyse possibilities how to electrify public transport services in the Tri-City area.

In the future, PKT expects to create a loop for any electric vehicles to park and load (i.e. among others trolleybuses with modern Lithium- Ion batteries). Thus, in a second step, PKT will study the potential to place such a loop close to Ergo Arena as well as the possibility of extension of traction trolleybuses running to one of the 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). To realise these plans, PKT will analyse the electric energy saving potential by means of increasing the efficiency of recovery (optimisation of energy balance and management). The main target of the provided research will be increasing the efficiency of breaking energy recuperation. The saved energy, which will be saved can be used for charging of the electrical vehicles. The ideal of it is presented on the picture below.



The main way for reaching it will be the implementation of the bilateral supply system, which will increase the ways of recuperated energy load flow. In a classical supply system the supply area of substations are separated, which makes it impossible for energy to flow from the supply area of one substation to another and makes recovery energy exchange difficult. In a bilateral supply system all supply areas are galvanic connected which increases the ways of re-using energy, what is presented below.



The local research partner UG will analyse the cost- benefit ratio of such electric service plans incl. the evaluation of the electric energy savings based on measurements made by PKT.
The order of operations within A9 is as follows:
1. Measurements of voltage levels and energy losses in the vehicle braking resistors
2. Evaluation of the measurements
3. Determination of unused energy level
4. Simulation of trolleybus supply system with ebus charging points

5. Characterisation of technical parameters and requirements for ebus charging points

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

PKT will analyse 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 with CIVITAS- DYNAMO (FP7) 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. Such an operation runs since May 2015 within CIVITAS DYNAMO project but will be extended, and data will be provided for actions within ELIPTIC project.
Based on the extended test for trolleybus line 21 an initial set of requirements (technical and economical) will be prepared. It would serve as a background for more detailed analysis of further electrification of public transport services in the Tri-City area.
In close cooperation with PKT, the UG will analyse (from economic point of view) the possibility of extension of off-traction trolleybuses running to one of Gdansk districts. The economic analysis will be based on electric energy saving potential by means of increasing the efficiency of recovery (optimisation of energy balance and management) made by PKT.

6.2. Use Case constraints

Foreseen challenges:
- Gdynia A9: The power available in trolleybus supply system strongly depends on the local conditions (e.g. the distance to the nearest traction substation). In unfriendly situation this power couldn't be enough for ebus charging. It is needed to analyse the availability in the supply system in several points.
Foreseen difficulties:
- Gdynia A10: limited benefits of integrating the trolleybus infrastructure with the charging stations caused by fact that only 50% of trolleybuses are equipped with regenerative breaking / energy recuperation devices.

6.3. Use Case monitoring criteria

Monitoring criteria and actions include:

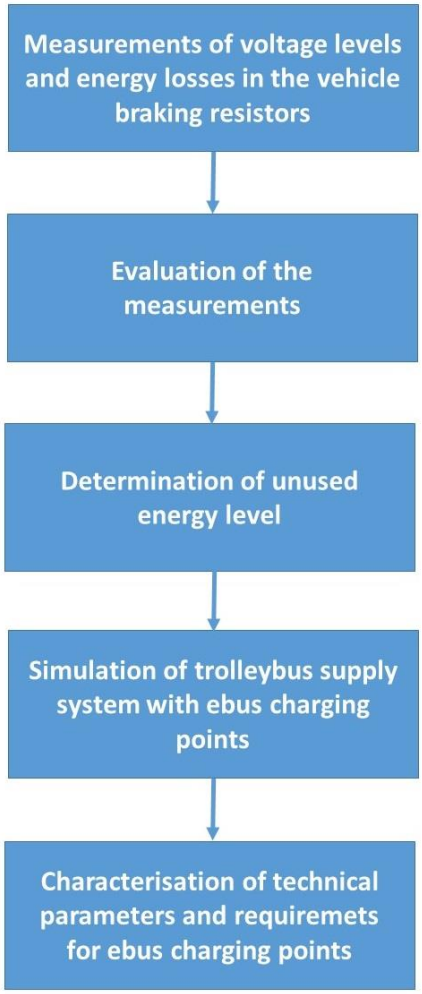
- Ex ante identification of potential risks and delays;
- Periodic meetings of PKT and UG staff;
- Execution of deadlines resulting from ELIPTIC Use Case structure:
    - Use Case Background and Set-up;

- Use Case Monitoring checklists;
- Use Case Monitoring phone conferences;
- Use Case Execution;
- Use Case Evaluation.

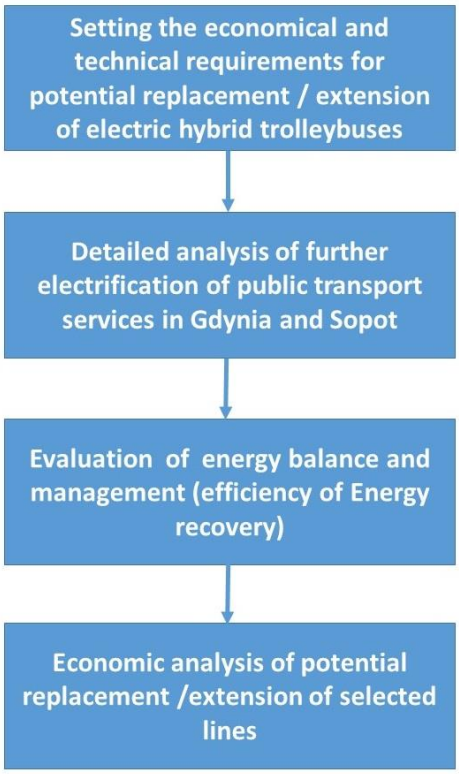
7. Use case work plan

7.1. Use Case development logic

A flow-chart of working activities according to A9 use case is presented below.



A flowchart for A10 use case is presented below.



7.2. Work plan

7.2.1. Work plan for A9

Number	Action	Staff 1	Staff 2	Staff 3	Start-month	End-month	Duration
1	Preparation for measurements	Mikolaj Bartlomiejczyk			June 2015	February 2016	8 months
2	Purchase and preparation for usage of measurement system equipment and software	Mikolaj Bartlomiejczyk			March 2016	May 2016	2 moths
3	Conducting measurements	Mikolaj Bartlomiejczyk			June 2016	December 2016	5 months
4	Doing a supply system simulation	Mikolaj Bartlomiejczyk			June 2016	December 2016	5 months
5	Results validation	Mikolaj Bartlomiejczyk			January 2017	June 2017	6 months

6.	Initial economic evaluation	Marcin Wołek,	Olgierd Wyszomirski	Katarzyna Hebel	September 2016	December 2016	
7	Economic evaluation	Marcin Wołek,	Olgierd Wyszomirski	Katarzyna Hebel	January 2017	July 2017	

7.2.2. Work plan for A10

Nr.	Action	Staff 1	Staff 2	Staff 3	Start-month	End-month	Duration
1	State-of-the art report on public transport in Gdynia with detailed data on particular bus and trolleybus lines	Marcin Wolek	Katarzyna Hebel	Olgierd Wyszomirski	Oct 2016	Nov 2016	2 months
2	Designing sets of technical requirements	Mikolaj Bartlomiejczyk					
3	Designing sets of economic requirements	Marcin Wolek	Katarzyna Hebel	Aleksander Jagiello	Jan 2017	March 2017	3 months
4	Selection of lines to be replaced and/or selection of lines to be extended	Marcin Wolek	Mikolaj Bartlomiejczyk	Aleksander Jagiello	April 2017	June 2017	3 months
5	CBA for selected lines	Marcin Wolek	Aleksander Jagiello	Olgierd Wyszomirski	Sept 2017	Oct 2017	2 months

7.3. Detailed timeline

- Purchase and preparation for usage of measurement system equipment and software: 31 May 2016 (A9)
- Concluding measurements: 31 December 2016 (A9)
- Concluding evaluation of measurements: 30 June 2017 (A9), CBA for selected lines – October 2017 (A10)

8. Expected results

The following technical results will be achieved thanks to the conducted analysis:

1) E-bus charging points will be determined,
2) Electric energy scaling potential will be determined,
3) Technology of charging point construction will be proposed. The emphasis will be put on the characterization of technical requirements for ebus charging station and testing the capability of trolleybus system from the point of view of charging station.

The following economic results will be achieved thanks to conducted analysis:

4) Economic evaluation of particular solutions,
5) Pre-feasibility study for introduction of modern e-vehicles into public transport market in Gdynia-Sopot area.