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E-LOBSTER

Electric losses balancing through integrated storage and power electronics towards increased synergy between railways and electricity distribution networks

Deliverable D6.4
First Stakeholders' vision document

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List of Abbreviations

Abbreviation	Description
AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
DC	Direct Current
DSO	Distribution System Operator
EC	European Commission
EES	Electrical Energy Storage
EISS	Electrical Installations and Safety Systems Subcommittee
ENTSO-E	European Network of Transmission System Operators for Electricity
EPBD	Energy Performance in Buildings Directive
ESS	Energy Storage System
EU	European Union
EUDSO	European Entity for Distribution System Operators
EVs	Electric Vehicles
ICT	Information and Communication Technologies
KER	Key Exploitable Result
kV	Kilo volt
MS	Member State
MV	Medium Voltage
NECPs	National Energy and Climate Plans
NT	Non-technical
PT	Public Transport
PV	Photovoltaic
R+G	Rail to Grid
R&D	Research and Development
RES	Renewable Energy Sources
sSOP	Smart Soft Open Point
T	Technical
TRL	Technology Readiness Level
TSO	Transmission System Operator
V	Volt
WP	Work Package

Executive Summary

The overall scope of the H2020 E-LOBSTER project is to propose an innovative Railway to Grid Management system which, combined with advanced power electronics and storage technologies (the smart Soft Open Point and the electric storage developed in the framework of the project), will be able to reduce electricity losses in both the power distribution and the railway distribution networks. In particular, the system will be able to make the best use of the available energy on both the grids by increasing their mutual synergies and maximizing the consumption of local RES production through electric energy storages and at the same time by creating synergy with charging stations for electric vehicles.

In this public report, the points of view of different stakeholders who are interested in the E-LOBSTER technology and applications is presented. Actually, in the framework of the project, two Stakeholder Groups have been set-up: the first one dealing with the electrified public transport (PT) operators whereas the second one involving electrical distribution networks operators (DSOs) and technology providers. This document gathers the view of the PT operators attending the E-LOBSTER workshop held on 20th of November 2019 in Madrid.

The main scope of the workshop was to develop synergies between the developers of the E-LOBSTER technology and the companies, national/local authorities, or other stakeholders that are potentially interested in the project solutions. Furthermore, the expectation of the of E-LOBSTER developers was to establish a collaboration to be kept during the whole duration of the project, in order to have an active participation in the discussions and relevant feedbacks on the solutions developed. In particular, specific objective is to steer the project results according to the stakeholder's expectation in order to favour the market perspective of the project.

The document summarizes the presentations and main discussions that took place during the workshop, by focusing at the beginning on the objectives of the project and the technical solutions and by moving then on the policy framework and the potential business opportunities as well as the replication perspectives. In the last part of the document the feedback provided by the stakeholders both during the discussions and through a questionnaire was reported.

A second workshop targeting electrical distribution networks operators (DSOs) and technology providers will be organized in the next months in order to complete the stakeholder visions on the E-LOBSTER solutions at this stage of the project.

1 Introduction

The main objective of the E-LOBSTER project is to develop and demonstrate up to TRL 6 in relevant environment (a real underground railway in Madrid connected to a local power distribution network with a high penetration of RES) an innovative, economically viable and easily replicable Electric Transport-Grid Inter-Connection System that properly managed will be able to establish mutual synergies between power distribution networks, electrified urban transport networks (metro, trams, light railways etc.) and charging stations for electric vehicles.

In particular, E-LOBSTER is demonstrating tools and technologies, software and hardware to assess the source of losses of both the networks (transport and electricity distribution networks) prioritising techniques for their minimisation via a coordinated control of the power supply for electrified transport and recharge stations for electric cars and towards the maximisation of the local consumption of Renewable Energy Sources (RES) production thanks to the use of Electrical Energy Storage (EES) and advanced power electronics devices.

In its concept, E-LOBSTER project is proposing an innovative Railway to Grid Management system which, combined with advanced power electronics, will be able to reduce electricity losses in both the power distribution network and the railway distribution network. The system will be able to make the best use of the available energy on both the grids by increasing their mutual synergies and maximizing the consumption of local Renewable Energy Sources (RES) production through electric energy storages.

This document aims to summarise the different points of view of different stakeholders who are interested in E-LOBSTER technology and applications.

In particular, in the framework of the project, two Stakeholder Groups have been established: the first one is related to electrified public transport (PT) operators whereas the second one involves electrical distribution networks operators (DSOs) and technology providers.

In order to interact and to get valuable insights from the stakeholders, three meetings (the first one with electrified public transport (PT) stakeholders, the second one with electrical distribution system operator (DSOs) and technology providers and the third one with both groups) have been planned within the duration of the project1.

The main aim of these meetings is to develop synergies between the developers of the E-LOBSTER technology and the companies, national/local authorities, or other stakeholders that are likely to invest in it. Thus, at the same time, the following benefits are expected to be reached:

a. Regarding the expectations of E-LOBSTER developers in relation to stakeholders:
    - To obtain active participation in the meetings and discussions.
    - To follow the E-LOBSTER progress and to assess the results of the projects in a constructive manner.
    - To enlarge the E-LOBSTER concept from PT operator’s, DSO’s and technology provider’s point of view and contribute to define a replication strategy across EU after the project end.
    - To facilitate the dissemination E-LOBSTER outcomes through different communication channels (e.g. website, social media, newsletters, etc.).
    - To steer the project results according to the stakeholder’s expectation in order to favour the market perspective of the project
b. Regarding the stakeholders:
    - Information on the latest research and innovation results from E-LOBSTER.

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[1] Due to the COVID-19 Lockdown in 2020, the Project could not proceed with the DSO workshop planned on 5th of May in Brussels. Alternative solutions are being studied to develop an on-line workshops

- Networking opportunities and exchange with other stakeholders, mainly across Europe.
- Possible technical visits and presentations.
- Timely advantage of the most innovative technological solutions

Once these synergies have been set, the main goals that are expected to be obtained after the meetings and with the feedback provided by the stakeholders are, among others, the following:

- Try to increase the economic impact of the project by receiving the contributions of stakeholders to the definition of the roadmap for marketability and exploitation of the E-LOBSTER solution.
- The exchange of expertise and collection of needs, challenges and opportunities to design the scale up of the E-LOBSTER concept in different cities and operational conditions.
- To exchange feedback related to technical progress of the E-LOBSTER solution.
- To analyse the regulatory and legislative obstacles in existing energy roadmaps in Europe and propose recommendations for future E-LOBSTER replication.
- To set discussions from multi-modal PT operators (rail and bus) DSOs and technology providers, to cover complementary aspects related to E-LOBSTER business opportunities.

The following document summarizes the presentations and main discussions that took place during the E-LOBSTER Electrified Public Transport Stakeholder Group Meeting that took place on the 20th of November 2019 at FFE´s headquarters in Madrid, and the answers given by the participants to the related questionnaire on the issues tackled during the meeting (see annex I).

The E-LOBSTER Public Transport Stakeholder Group meeting was aligned to UITP's Electrical Installations and Safety Systems Subcommittee (EISS) under UITP's Metro Assembly, which took place between 20th -22th November 2019 in Madrid. Thanks to good collaboration with EISS body of UITP, the E-LOBSTER's Stakeholder Meeting was made a part of their working agenda. This opportunity immensely helped E-LOBSTER consortium members to have a group of experts across globe albeit mainly European and receive their feedback in terms of technics, operations, business and legislative aspects during the discussions held in the meeting.

The meeting gathered the E-LOBSTER partners (RSSB, University of Birmingham, University of Newcastle, FFE, RINA Consulting, Metro de Madrid and UITP) as well as PT Operators.

The following graphic shows an overview of the nationalities of the stakeholders who attended the first workshop.

Figure 1: E-LOBSTER workshop participant nationality

The workshop gathered 36 participants among which 15 were E-LOBSTER project partners and 21 were Public Transport Stakeholders. The companies represented at the meeting cover Italian, Spanish, Finnish, Czech, French, British, Austrian, Russian, Canadian, Brazilian and Belgian nationalities.

During the session, the E-LOBSTER consortium made a series of presentations with an overview of the project, its concepts, objectives, an overview of the European regulatory framework and the viability of the project from the users' point of view. The presentations triggered the discussions with the PT Operators, which gave their feedback on the aim and objectives of the E-LOBSTER concept. In particular, the online tool Mentimeter (https://www.mentimeter.com/) was used to break the ice with the workshop attendees and engage them more easily in the debates. In this sense, the agenda content[2] was as follows:

- Overview and objectives of the project and technical discussions;
- Policy developments and business opportunities for the E-LOBSTER project;
- Technical discussions (Technical scenarios and challenges).

After the workshop, a project questionnaire (created using Google Forms) was sent to E-LOBSTER stakeholders in order to ask them feedbacks and suggestions about the project. The outcomes of the questionnaire are included in section 5 of this deliverable. As background information for the stakeholders, the E-LOBSTER booklet (available here http://www.e-lobster.eu/wp/wp-content/uploads/2019/07/elobster-stakeholders-final.pdf) was created highlighting the project background, the concept, project main enabling technologies, the most interesting public deliverables for the stakeholders, the main project milestones, the main impacts of E-LOBSTER.

[2] Agenda of the event is included inside the appendix section

2 Overview and objectives

Before introducing the views and inputs of stakeholders with respect to the project, it is important to provide the big picture of the E-LOBSTER project and its main objectives in terms of technical and non-technical specifications.

2.1 Overview

The E-LOBSTER project aims to develop an electric transport-grid inter-connection system that allows targeting synergies between power distribution networks, electrified urban transport networks, and charging stations for electric vehicles. At the same time, it tries to demonstrate tools and technologies for the assessment of the source of losses, the minimisation of electricity losses, maximisation of consumption of renewable energy sources production and electric energy storage.

To accomplish all these goals, E-LOBSTER proposes an advanced railway to grid (Railway + Grid) management system. It will be able to reduce electricity losses in both the networks, maximizing the use of local RES generators for both applications, and making them interact one each other in a mutual synergy strategy.

Therefore, E-LOBSTER mainly has three areas of action to build a robust and reliable rail to grid management system based on power electronics, advanced control, and electrical storage systems, which are the following:

- Railway and transport engineering expertise.
- Electrical engineering expertise.
- Information and communication technology (ICT) expertise.

Therefore, the diagram of functioning is set as it follows:

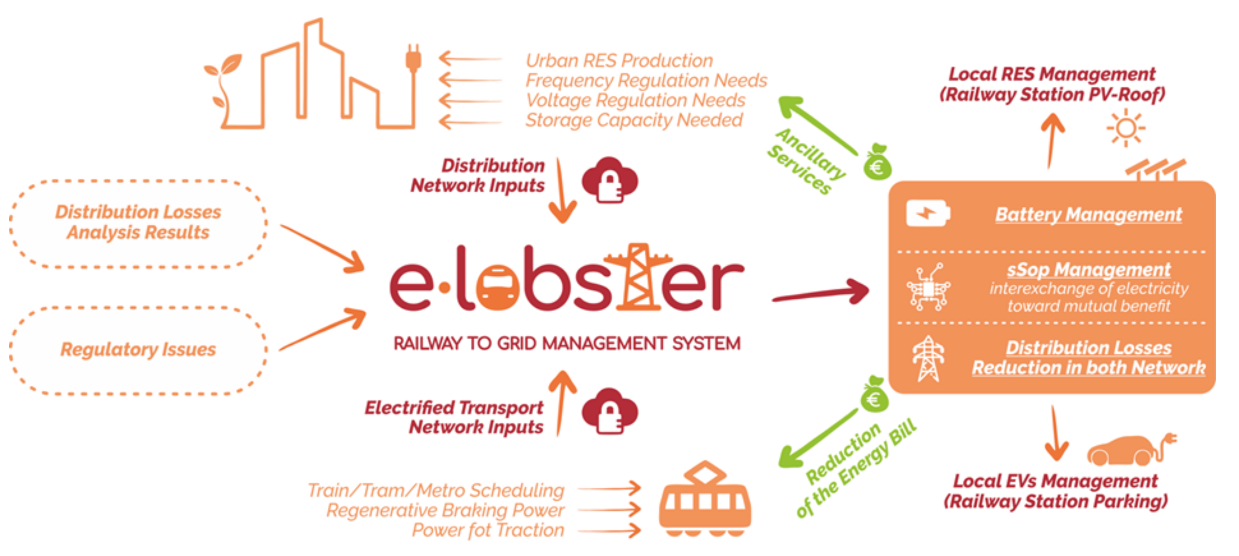

Figure 2 Diagram of E-LOBSTER functioning

Consequently, the management system may be summarised following the next points:

a. To control the smart soft open point (sSOP), the battery, and the exchange of electricity between the distribution and the railway networks.
b. To optimise the available energy on both the rail and grid intended as mutual key points of interest through a holistic approach.
c. To consider all the energy players (consumers, producers, and storage) not as isolated elements, but as a whole.
d. This smart and coordinated approach will improve energy savings, reduce electrical losses, and demonstrate the business case of the new technologies.

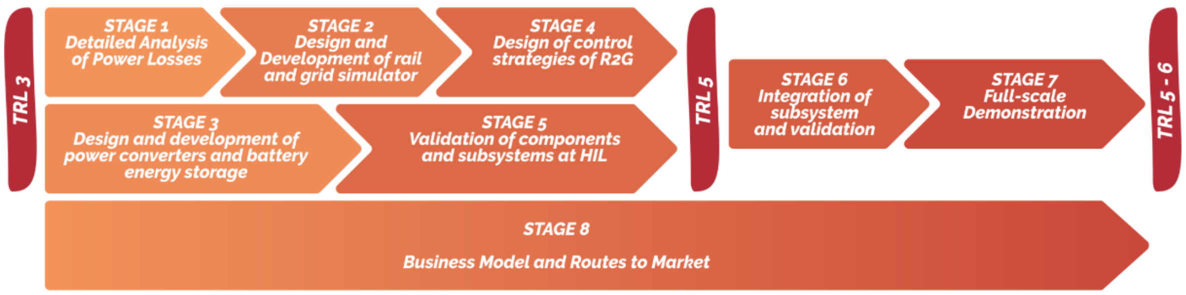

Figure 3 Technology readiness levels of E-LOBSTER

Once the management system and the goals are set, it is important to point out the drivers and solutions that will allow the project to tackle the challenges, which are mainly energy losses savings in the rail grid.

Besides the energy losses, there are some other challenges to face:

- To fill the requirements set by the European standards and regulations.
- Real-time parameters from local energy grids.
- Environmental constraints.
- Suitable new business models to foster the e-LOBSTER replication all around Europe.

The proposed solution to these challenges from e-LOBSTER technology lies in:

- The untapped legal regulation potential via the inter-connection of the grids through high-efficiency power electronics.
- The maximization of local production (RES and regenerative braking).
- Time optimal shift management thanks to EES and electrical vehicles.
- The reduction of losses due to the transportation of electricity in both the networks.

2.2 Objectives

Once solutions for the previous challenges have been proposed, the E-LOBSTER impact is depicted in the following figures.

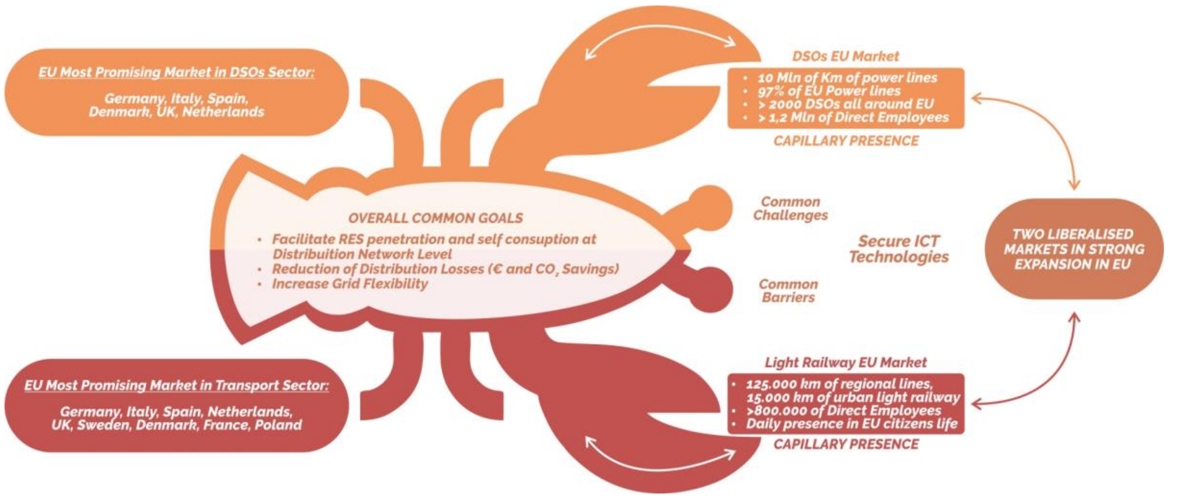

Figure 4 Overall common goals of E-LOBSTER and impact

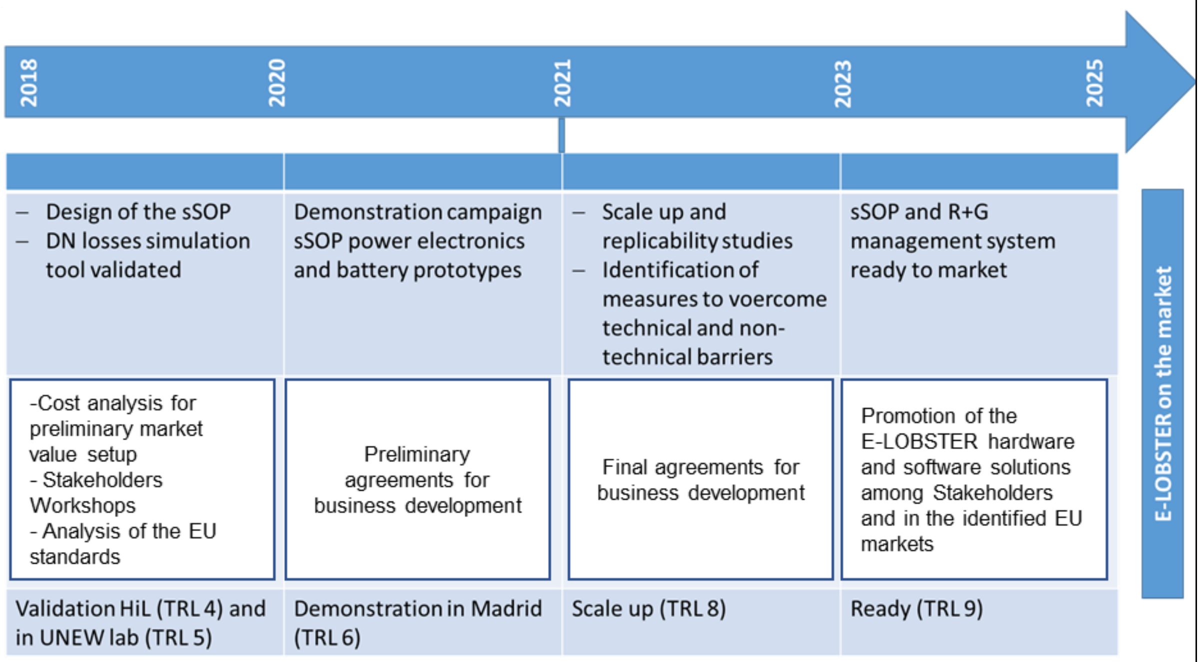

Figure 5 E-LOBSTER roadmap towards the marketability

On the other hand, the objectives of the project may be split into two types: technical (T) and non-technical (NT):

T1 To develop an innovative unique tool for the assessment of losses and energy consumption of power distribution networks and railway electrification networks validated through real data.

T2 To develop and validate advanced 3-way smart Soft Open Points based on back-to-back AC/AC power converters.

T3 To develop and validate a new real time optimised railway to grid/grid to railway (R+G) energy management aiming to optimize the interaction between electrified transport and distribution networks using shared assets.

T4 Identification and validation of the most suitable storage technologies for the mutual synergy interconnection of electrified transport and distribution network increasing the penetration of RES and promoting EVs solutions transferring the knowledge and expertise of the automotive sector to the power distribution and railway sectors.

T5 Step by step/TRL by TRL demonstration of the E-LOBSTER innovative solutions and technologies:

- Validation of the sSOP, the Battery and the R+G Management System in Newcastle University Smart Grid laboratories (TRL5).
- Demonstration of the sSOP and the R+G Management System in a real test case in Metro of Madrid premises (TRL6).

NT1 To design the scale up of the E-LOBSTER concept (feasibility studies) and define a road map for the marketability and exploitation of the E-LOBSTER KERs through suitable business models (contractual and incentives framework) for Public Transport Operators, Public Transport Managers or DSOs.

NT2 To analyse the current regulatory, standard, policy framework for the identification of measures for replication.

NT3 Preparation of a “Best Practice Handbook” to guarantee an appropriate degree of cybersecurity for the protection of the data from both DSOs and Public Transport operator for the interaction in terms of inter-exchange of electricity.

NT4 To create a unique network of stakeholders and project supporter to foster E-LOBSTER solutions marketability.

3 Policy framework and business opportunities

Before and during the session dedicated to the policy framework and to the business opportunities, E-LOBSTER stakeholders were encouraged to take part in a series of live polls through Mentimeter tool in order to understand their background.

For example, as you can see in the following image, the majority of stakeholders who attended the first workshop had some basic knowledge about the regulatory and legislative framework of their countries concerning energy/electricity.

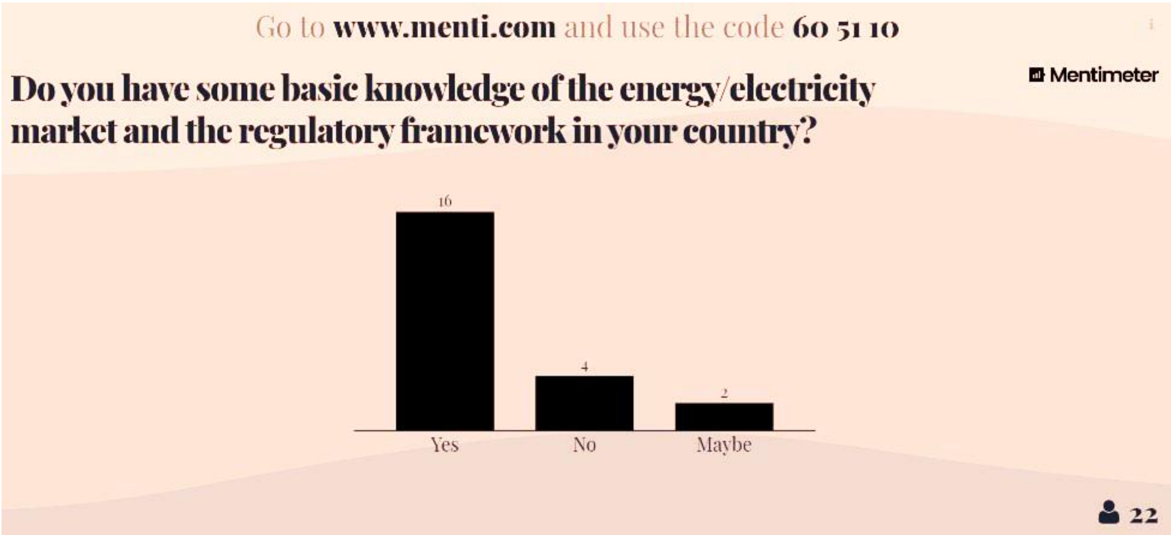

Figure 6: Example of live poll related to the policy background of our stakeholders

The aim of this section is to provide an overview of the main European policies in terms of energy and electricity, as regulation and directives that rule them, in order to set the floor for those stakeholders interested in the E-LOBSTER project, to identify the business opportunities and the potential to replicate the E-LOBSTER technologies.

The policy framework has both a reason and several advantages regarding the commercial view of the project. Regarding the reasons, on one hand, an update to the energy rules was indispensable to keep the European Union on track to meet the 2020 climate targets and set new ambitious ones up to 2030. On the other hand, the changing in the last decades of the energy landscape required a modernisation of the electricity market design to adapt to new market framework (increasing shares of renewable energy generation, decentralised energy generation, and storage and new technologies to be integrated into the energy system without risking security of supply).

In this context, the EU agreed a comprehensive update of its energy policy through the package called "Clean energy for all Europeans package"[3].

Regarding the advantages:

- The clean energy package[4] provides a modern framework for the transition towards cleaner and more sustainable energy.

[4] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

- The package establishes a stable environment to stimulate the necessary investments and the modernised rules can also provide the energy industry with new business opportunities and potential innovative business models.
- The package puts the consumer at the centre of the energy transition and empowers them to participate actively in the market.

3.1 Policy framework and directives

The “Clean energy for all Europeans package” consists of eight legislative acts that after political agreement by the Council and the European Parliament in 2018 and at the beginning of 2019, enables all of the new rules to be in force by the middle of 2019 and the EU countries have about years to implement the new directives into national law. The eight parts of the overall “Clean energy for all Europeans package” are:

- Renewable Energy
- Energy Efficiency
- Energy Performance in Buildings
- Governance of the Energy Union
- Electricity Regulation
- Electricity Directive
- Risk Preparedness
- ACER

3.1.1 Directive on the promotion of the use of energy from renewable sources (2018/2001/EU)

This Directive establishes a common framework for the promotion of energy from renewable sources. It sets a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy in 2030. It also lays down rules on financial support for electricity from renewable sources, on self-consumption of such electricity, on the use of energy from renewable sources in the heating and cooling sector and in the transport sector, on regional cooperation between Member States, and between Member States and third countries, on guarantees of origin, on administrative procedures and on information and training. It also establishes sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels and a new binding renewable energy target of at least 32% for renewable energy sources in the energy mix by 2030, which can be increased upwards, subject to revision in 2023.

The new Directive also updates the targets for the use of renewable energy in the heating and cooling as well as in the transport sector.

To ensure the target achievement, MS can put into place support schemes for renewable energy. The schemes have to be non-distortive, market-based and must allow producers to respond to market price signals. One of the key objectives of the Clean Energy Package is to put consumers at the heart of the energy transition. To facilitate this goal the new Renewable Energy Directive gives citizens, who produce their own renewable energy, a clear right to consume, store or sell their generated energy, including through power purchase agreements.

3.1.2 Energy Efficiency Directive ((EU)2018/2002)

The directive on energy efficiency amending the previous one entered in force on 21st December 2018.

The energy efficiency is a key objective in the package as energy savings are considered probably the best way of saving money for consumers and for reducing greenhouse gas emissions. In this context, the EU has defined as targets of at least 32.5% energy efficiency by 2030. The 2030 target can be increased subject to a review in 2023.

On the other hand, metering and billing rules (in particular for multi-apartment and multi-purpose buildings), have been modified to provide clearer rights for consumers on their billing information.

Member States have to transpose the Energy Efficiency Directive into national laws by 25 June 2020, except for metering and billing provisions, which have to be transposed by 25 October 2020.

3.1.3 Energy Performance of Buildings Directive (2018/844/EU)

Buildings are considered responsible for about 40% of energy consumption and 36% of CO2 emissions in the EU. By taking into account these figures, buildings are the single largest energy consumer in Europe and the EU, by improving their energy performances, expects to achieve its energy and climate goals. The energy performance in buildings directive (EPBD) defines the specific measures for the building sector to cope the challenges, by updating many clauses and provisions of the previous EPBD dated 2010.

The Directive aims at achieving a highly energy efficient and decarbonised building stock by 2050 and to create stable investment conditions to foster investments into the renovation of buildings. The Directive encourages the deployment of automation and control systems in buildings for a more efficient operation as well as the rollout of charging points for electric vehicles.

Member States have until 10 March 2020 to transpose the Directive into national laws. This Directive is reflected in the use and savings of electrical power that affect to metro stations, which will be able to benefit the energy that comes from the regenerative braking of trains.

3.1.4 Governance of the energy union

The package defines a robust governance system for the energy union that has to be used by each Member State to draft integrated 10-year national energy and climate plans (NECPs) for 2021 to 2030. The scope is to outline how the targets on all dimensions of the energy union will be achieved, including a longer-term view towards 2050.

The governance Regulation is inforce since the 21st of December 2018 and all Member States were expected to submit their draft NECPs by early 2019. It applies to all five dimensions of the Energy Union: energy security, internal energy market, energy efficiency, decarbonisation, and R&D & Land competitiveness.

3.1.5 Electricity regulation (EU) 2019/943 and Directive (EU 2019/944), Risk preparedness an the Agency for the Cooperation of Energy Regulators (ACER)

This part of the package has the objective to establish a modern design for the EU electricity market, adapted to the new realities of the market in order to make them more flexible, more market-oriented and better placed to integrate a greater share of renewables. Briefly, the electricity market design elements consist of four dossiers.

Incentives for consumers to become more active and to contribute to keep the electricity system stable are other aspects that the market has to face. With the specific objectives to address these issues, the EU has updated the Electricity Directive (2009/72/EC) and the Electricity Regulation (EC/714/2009), introduced a new regulation on risk preparedness, and enhanced the role of the Agency for the Cooperation of Energy Regulators (ACER).

The recast Electricity Regulation sets out general principles for the operation of the electricity market, including market-based prices, more flexibility, customer participation and cross-border electricity flows.

There are some key topics to be tackled:

1. <u>Balancing:</u> The Regulation establishes that most of all market participants are responsible for imbalances in the system, taking into consideration that balancing capacity must be

procured separately from balancing energy. Besides, transmission system operators ('TSOs') have to procure balancing capacity based on market-based principles.

2. Short-term and long-term markets.
3. Dispatch and redispatch.
4. Congestion management and capacity allocation.
5. Capacity mechanisms.
6. ENTSO-E, TSOs and DSOs: roles of TSOs and the European Network of Transmission System Operators for Electricity ('ENTSO-E') are strengthened and clarified. In addition to their already existing tasks, TSOs have to establish regional coordination centres by 1 July 2022, while the regional coordination centres will be responsible for the coordination of capacity calculation, security analysis, restoration support, adequacy forecasts or for facilitating the regional procurement of balancing capacity.

   The recast Electricity Regulation also establishes new tasks for DSOs, including the creation of a European entity for distribution system operators ('EUDSO’). This EUDSO has to promote operation and planning of distribution networks, facilitate integration of RES, distributed generation and storage resources and facilitate flexibility. On the other hand, DSOs have to support of the development of data management, cybersecurity and data protection.

   Therefore, EUDSO and ENTSO-E have to cooperate on the development and implementation of network codes as well as in identifying best practices
7. Network codes and guidelines: electricity Regulation refines the rules for developing network codes and guidelines and extends the areas for which the European Commission can establish them.

   The overall scope of the recast Electricity Directive of the Clean Energy Package aims at completing the internal electricity market and addressing new market challenges. To facilitate the completion of the internal electricity market, Member States have to remove barriers to cross-border electricity trade and consumer participation. Thus, prices will be set on market-based criteria and Member States shall facilitate flexibility and ensure third-party access in an on-discriminatory manner.
8. Empowerment of consumers: an essential element of the new electricity market design is the empowerment of consumers to participate actively in the market. Regarding this idea, Member States have to define measures to allow consumers to participate in the market directly, or through aggregation. In such a way, customers can sell self-generated electricity, including through power purchase agreements, and they can choose to take part in energy efficiency schemes. In return, active consumers have to pay network charges and bear the financial responsibility for imbalances they cause. Those customers, who own an energy storage facility have the right to be connected to the grid, are not subject to double charges or disproportionate licensing requirements or fees.
9. Demand response: the new Electricity Directive requires Member States to allow and facilitate demand response measures through aggregation. This aggregation is the combination of multiple customer loads or generated electricity for sale, purchase or auction in an electricity market.

   Market access for participants engaged in aggregation must be non-discriminatory. Its participants engaged in aggregation are responsible for the imbalances they cause and for financial compensation to other market participants for costs incurred through demand response activities.
10. Smart Meters: the Directive encourages Member States to deploy smart meters, subject to a positive cost-benefit analysis, also considering that customers are granted a right to request a smart meter.

Smart meters must meet minimum requirements on function, technology and interoperability, including to measure actual electricity consumption and provide easy access to historical consumption data. Therefore, MS have to provide for rules on data management and data exchange. Customers who have installed smart meters are entitled to request a dynamic electricity-pricing contract.

11. DSOs, TSOs and national authorities: the recast Electricity Directive establishes new tasks for DSOs, in particular with regard to the procurement of non-frequency ancillary services, flexibility, data management and the integration of electromobility.

    Procurement of ancillary services shall be market-based, transparent and non-discriminatory. For the procurement of other relevant services effective participation of all market participants shall be made possible, including for those participants engaged in storage, demand response or aggregation.

    Member States shall incentivise DSOs to procure flexibility services, including the procurement from distributed generation, demand response or energy storage. Regarding the integration of electromobility, they shall facilitate grid connection and can only own, develop, manage or operate recharging points for electric vehicles subject to narrow conditions.

    On the other hand, the tasks of TSOs have been slightly extended to include the procurement of ancillary services, the digitalisation of transmission systems and data management.

    TSOs and DSOs are still subject to unbundling requirements established by the old Electricity Directive (2009/72/EC). They can only own develop, manage or operate energy storage facilities under very limited conditions.

3.2 Roadmaps relevant with respect to transport sector

The European roadmaps regarding transport sector has the following milestones. In 2011, the Commission came forward with three strategic roadmaps relevant with respect to transport sector:

- Roadmap for moving to a competitive low carbon economy in 2050.
- Energy Roadmap 2050.
- Roadmap to a Single European Transport Area –Towards a competitive and resource efficient transport system (commonly referred to as the Transport White Paper).

These Roadmaps presented fundamental aspects of the transition to a low carbon economy in 2050, cost-efficient GHG emissions reduction milestones for 2030, more energy efficiency, higher shares of renewable energy and energy infrastructure development for the transition towards a competitive, sustainable, and secure energy system. They covered all sectors of the economy, with a clear emphasis on energy and transport. Without setting an obligatory objective, the White Paper on Transport also establishes the aim of reducing 60% CO_2 emissions in transportation by 2050.

The Energy Roadmap 2050 launched in 2015 aimed at analysing the synergies between the decarbonisation objectives and other energy policy priorities, by setting broader goals covering five topics: energy security, internal energy market, energy efficiency, decarbonisation (including renewable energy development), research, development and competitiveness. In March 2016 the EU Commission presented the “Communication on the implementation of the Paris Agreement commitments”, followed by “A European Strategy for Low-Emission Mobility” adopted in July 2016. The Strategy confirmed the 2011 White Paper goals: “by mid-century, greenhouse gas emissions from transport need to be at least 60% lower than in 1990 and be firmly on the path towards zero by 2050. Emissions of air pollutants from transport that harm our health need to be drastically reduced without delay”.

The Low-Emission Mobility strategy proposed an Action Plan based on:

- Higher efficiency of the transport system.

- Low-emission alternative energy for transport.
- Low-and zero emission vehicles, including both legislative and non-legislative action.

The Commission has acted by adopting proposals on most of the actions listed in the Action Plan of the Strategy, notably through the adoption of the:

- Clean Energy for All Europeans package already illustrated
- European Mobility Packages: the first Mobility Package in May 2017, the second Mobility Package in November 2017 and the third Mobility package in May 2018.

3.3 Case studies and policy challenges of E-LOBSTER

After the complete overview on the current policy framework, it is worth to mention that after the second year of the project, preliminary designs of full-scale E-LOBSTER will be performed on three specific case studies in three different rail applications and EU countries:

– One tramway.
– One railway.
– One regional train.

Regarding the replication potentialities, several points are considered as challenge considering the E-LOBSTER project policies.

1. <u>Potentiality of replication in different countries</u>: considering the current technical specifications, it is necessary to verify the degree of relevance of the three-case studies and the added value for possible replications specifying the most likely types of potential services enabled by E-LOBSTER.
2. <u>Specific market needs</u>: markets that have been previously considered throughout the research of the E-LOBSTER project, also considering possible links between the likely future legislative framework considering new market needs and the business opportunities that will arise linked to it.
3. <u>Evaluations of the interest of investing in the shared assets proposed (Electrical Storage System, power electronics) and collateral services</u>: Within this point, it is considered of interest the most likely services to be invested in. For instance, in terms of storage and customer engagement, considering the changes introduced by the new electricity directive, which may open a new business branch, and its link with the integration of a smart net for EV charge.

4 Technical discussions

In this section, the main discussion is about the different possible layouts of e-LOBSTER installation in the facility, identifying the most important technical challenges, and getting feedback from the stakeholders in order to focus the research on those topics that arouse more interest.

4.1 Overview of the technical objectives of the research

First of all, it is important to keep in mind the diagram of E-LOBSTER technology functioning, as it may be observed in the next figure.

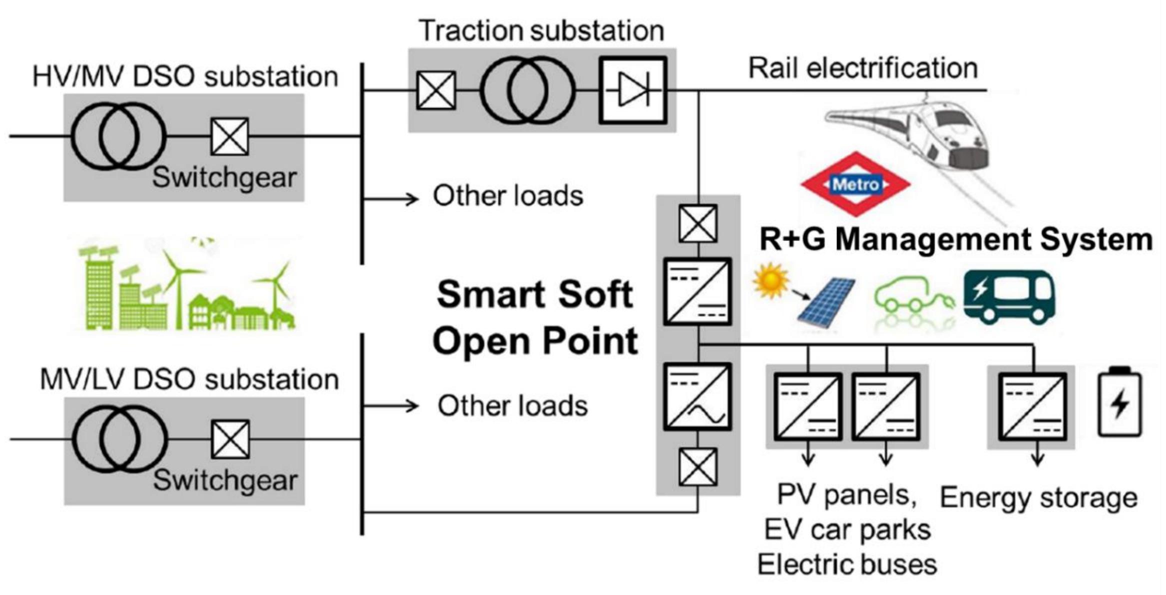

Figure 7 Diagram of E-LOBSTER functioning

The E-LOBSTER project aims to manage the flow of electrical energy between the operator of high, medium, and low voltage distribution systems, the rail electrification grid, and the RES, EV car parks and energy storage.

To do so, there are several different configurations regarding the connection of the sSOP to the grid and the other elements that are part of the system. These configurations result of two different scenarios as it may be observed.

The Figure 7 tries to depict the lay out of the whole facility that includes the high voltage (HV), medium voltage (MV), and direct current (DC) grid. Besides, the elements that take part in the facility are represented and may be easily recognised (local loads, EV connections, RESs, transformers and rectifiers, etc.). Once the general view of the facility is set, then two different layouts are included regarding the connection of the sSOP.

In the general view, the DC voltage level is variable for each specific installation, but typical values are 600 V (trams and metro systems), 750 V (trams, metro systems and railways), 1500 V (metro systems and railways) and 3000 V (railways). The sections of the DC electrification can be isolated (single-end and dual-end feeding) or more commonly interconnected.

- The DC supply voltage is generated by transformer rectifier substations that convert AC power from a medium voltage (MV) bus bar (11 kV or 15 kV) into DC power.

- The MV bus bars are connected together via one or more MV cables that run approximately in parallel with the railway track. There are various possibilities of the connection of these cables and the most common are the mesh feeding and the open ring feeding
- The DSO network can operate at various voltage levels depending on the location of the connection. Possible values are 20 kV, 33 kV and 45 kV.

There are basically two kinds of lay out feeding:

- The mesh feeding, where the bus bars are interconnected, so the DSO feeders operate in parallel. The advantage is that the equivalent impedance of the MV rail network is smaller, so the DSO network is less affected by the traction load more suitable for heavy railways.
- The open ring feeding, where at least one disconnector switch between two consecutive DSO supply points is open. The advantage is that the protection system is simpler because the power flow is unidirectional. The disadvantage is that the impedance is higher

On the other hand, railways need power for their auxiliary systems and station loads. This can be taken from the same network, but it is often taken from other networks of the DSO, especially for low-voltage loads, e.g. 400 V. This network is connected to the MV network of the DSO and it is often a different node from that of the traction power.

Therefore, this low voltage network, which in the following will be called local network for its limited extension, can be considered independent from the railway electrification network. The local network can feed a number of loads of various customers and can host renewable energy sources, energy storage and charging stations of electric vehicles (EVs).

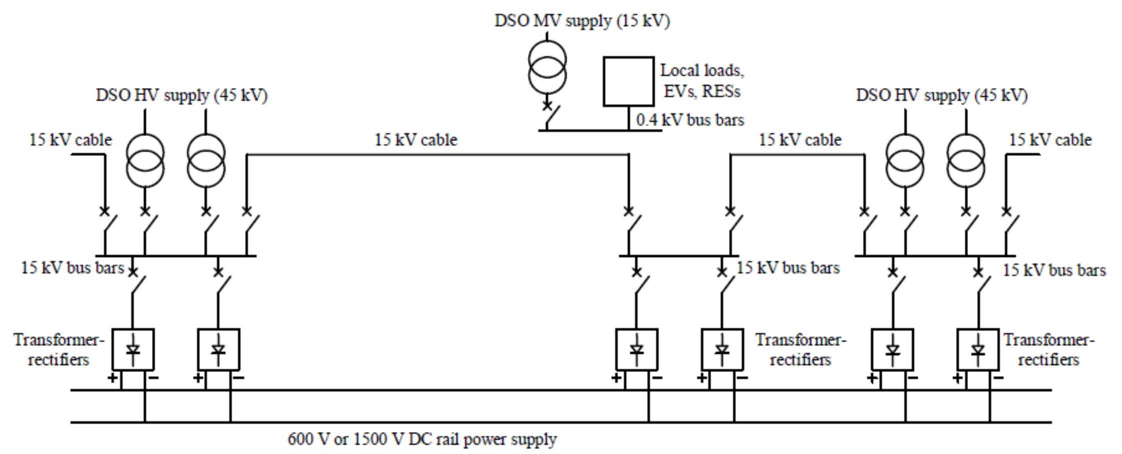

Figure 8 Linear diagram of E-LOBSTER electrical configuration

a. Maximum rail regeneration: the power converter is connected to the railway electrification system on the rail power supply, to the local distribution network and to the energy storage. Therefore, it is a three-way converter with DC/DC/AC output. In particular, the three individual converter modules are DC/DC (DC-bus to rail), DC/DC (DC-bus to storage) and DC/AC (DC-bus to grid).

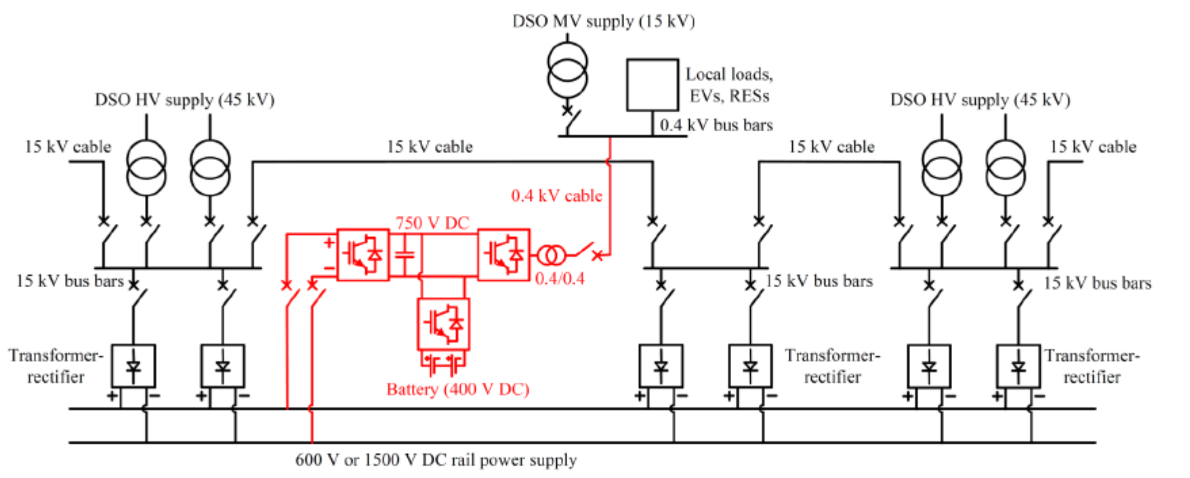

Figure 9 Linear diagram of E-LOBSTER electrical configuration for maximum rail regeneration

For this connection scheme, the following mode of operations are possible:

1. Railway traction network supports the local grid during periods of large loads and no trains;
2. Battery supports the local grid during periods of large loads but the railway is in use;
3. Railway traction network recharges the battery when there is no significant load on the local grid and no trains or when a train is braking;
4. The local grid recharges the battery when there is no significant load or there is availability of energy generation from renewable energy sources.

b. Balancing the HV DSO grid: the power converter is connected to the MV network of the railway electrification system and to the energy storage. The three individual converter modules are DC/DC (DC-bus to storage), DC/AC (DC-bus to 15 kV busbar connected to DSO HV supply 1), and DC/AC (DC-bus to 15 kV busbar connected to DSO HV supply 2). The connection of the sSOP can be done at only one site by taking advantage of the existing circuit breakers for the sectioning of the 15 kV cable. In this case, by connecting the two DC/AC modules to the input and output of the circuit breaker, there is no need to deploy any additional cable, with significant savings on the installation costs.

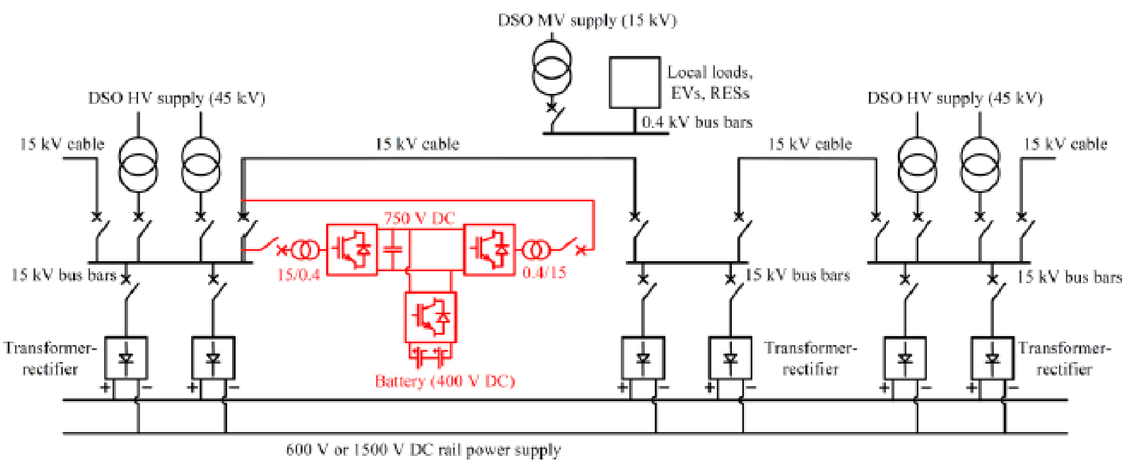

Figure 10. Linear diagram of E-LOBSTER electrical configuration for balancing the HV DSO grid

The main objective of this scheme is to balance the HV feeders of the DSO and the converter operates more similarly to a SOP. The DSO will actually see the connection as a closed ring, connected flexibly via the power converter. There are no benefits for the local grid, no possibility of improving the conditions for the generation of renewable power sources and no additional possibility of regenerative braking for the trains. The following mode of operations are possible:

1. The HV feeder on the left provide some power to the traction substations supplied by the feeder on the right and vice versa.
2. The HV feeders recharges the battery depending on their loading level
3. The battery supports either HV feeder when the other does not have enough spare capacity.
4. The battery supports the railway reducing the power of the HV feeders

c. Balancing the HV DSO grid and the railway: the four individual converter modules are, DC/DC (DC-bus to storage), DC/DC (DC-bus to railway), DC/AC (DC-bus to 15 kV busbar connected to DSO HV supply 1) and DC/AC (DC-bus to 15 kV busbar connected to DSO HV supply 2).

The DC bus is shared with local charging stations for EVs (e.g. parking lots around the railway) and local renewable power generators (e.g. photovoltaic panels on the roof of stations).

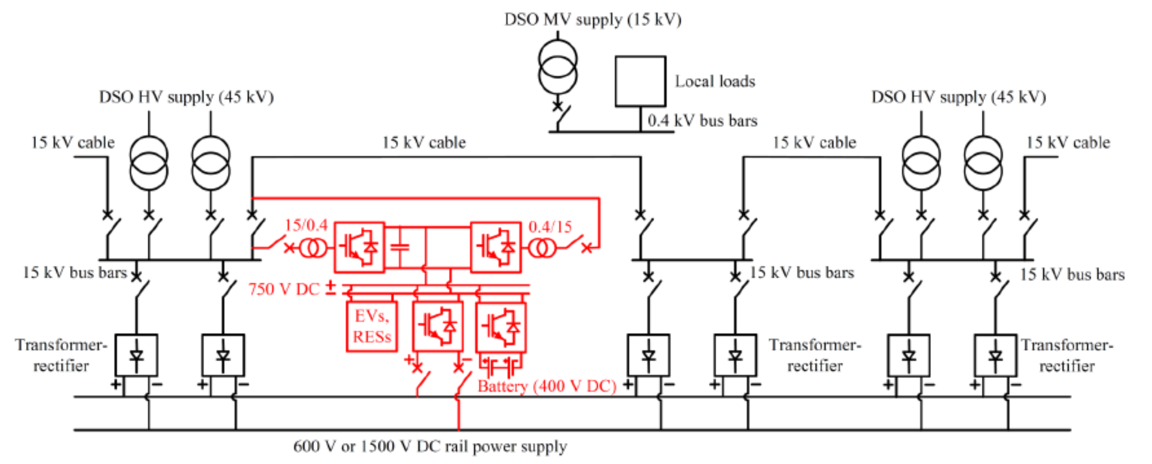

Figure 11 Linear diagram of E-LOBSTER electrical configuration for balancing the HV DSO grid and the railway

For this connection scheme, the following mode of operations are possible in addition to those already presented:

1. The battery is recharged when a train is braking.
2. Local EVs can be recharged by the 15 kV network or the battery or the electrification network
3. The battery supports the railway electrification;
4. Renewable power generators contribute to the supply of the railway or recharge the battery if the power generated is in excess of the railway requirements.

4.2 Identification of the technical challenges for the adoption of the research results

The following points aim to summarise the technical challenges faced by E-LOBSTER project. Between them, it is possible to highlight those that enable to reach the main goals of the project:

1. Bidirectionality of DC electrification networks: as E-LOBSTER uses a smart open point to enable the recuperation of train breaking grid, the point is to specify the largest benefit considering this characteristic, also focusing on the optimal use from a railway infrastructure and distribution grid perspective.
2. Energy storage in power distribution grids: the use of a battery energy storage in order to interface the railway net with the electrical grid suggests several challenges. For instance, energy storage for railway systems, the most suitable energy storage for this application, integration of renewable resources, and synergies between railways and EV charging.
3. Renewable sources for railways: this topic focuses on one of the main features of E-LOBSTER project and the challenges that come from it. For example: the main issues of feeding the railways directly from renewable sources, be the technical challenges of having customers selling renewable energy directly to the railway, or Who should operate the energy storage.
4. The use of railway assets for EV charging: which is a possible source of business and reinforces the idea of smart city in an environment where synergies are to be found. For instance: what types of EVs are best suited for railway charging, what are the main requirements to ensure that this is technically safe, or what is the main technical challenge to ensure that railway service is not disrupted

5 Contribution from stakeholders of the E-LOBSTER project and conclusions

At the end of the sessions related to the project presentation, E-LOBSTER stakeholders were invited to give a general opinion about the project. With the aim of obtaining this information with the highest level of objectivity and anonymity, several live polls arose as the most proper way of questioning about different topics that match with the advantages that E-LOBSTER is supposed to provide.

The first question dealt with the opinion at first glance that the project caused to the stakeholders, which had the following answers.

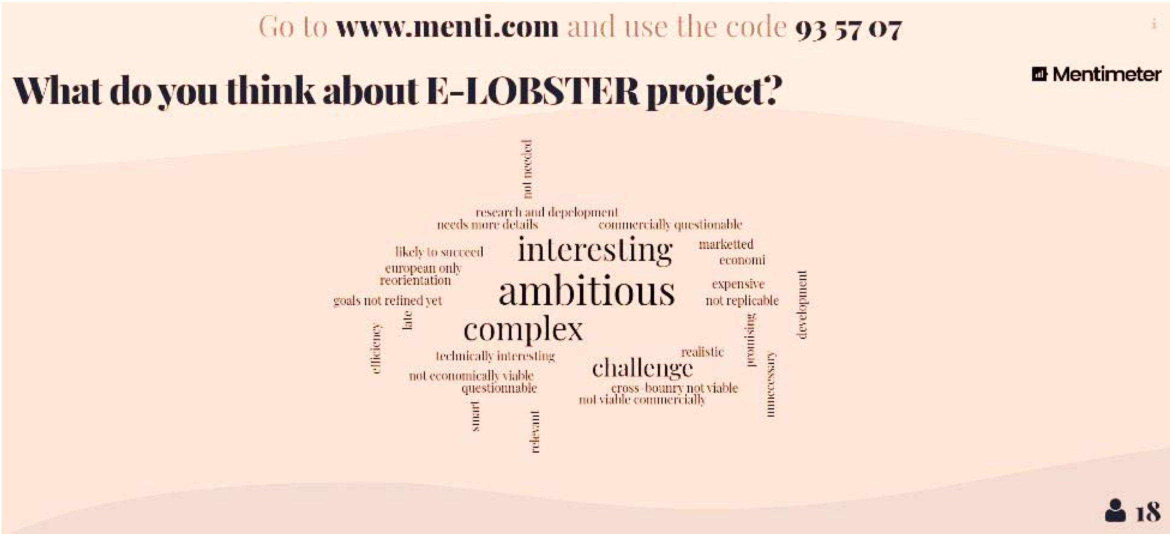

Figure 12: E-LOBSTER stakeholders' opinion about the project

The main words associated with E-LOBSTER by the stakeholders are "interesting", "ambitious", "complex" and "challenge". This poll was followed by a series of points of discussions on the E-LOBSTER presentations. Also the PTOs were given the opportunity to further complement their answers through an online questionnaire, that was available after the meeting (see the annex of this document). The main findings are summarised in the following paragraphs.

PT Operators underlined that, taking into account the current institutional and economic situation (due to tariffs), for most PTOs, it is preferable to give back the energy to their own network (rather than dealing with the complexity of an external organization). In this sense, the E-LOBSTER consortium explained that not only the E-LOBSTER concept allow specific economic gains derived from the energy market, but also from providing extra power to the grid and the opportunity to have a more updated and robust DSO Network with less costs. PT Operators underlined the need to take into account safety issues when developing the E-LOBSTER concept.

Also, and related to the previous discussion on the E-LOBSTER concept, PTOs underlined that from an organisational and administrative perspective it was more interesting for them to focus on its own network rather than having the complexity of dealing with an external organisation requiring contracts and agreements.

A debate on the energy storage technologies used by the E-LOBSTER project then took place. The experience of the PTOs with flywheels, batteries and hydrogen technologies was put into place, where the benefits and cost were underlined (experience with batteries in trams and flywheels was exposed). A PTO underlined that the E-LOBSTER system could be used for coordinating operations inside a multimodal operator, as for example overnight charging of buses may be seen as a lucrative way in which to use the system.

In the end, the topic of energy losses regarding the application of inverters and converters on the E-LOBSTER device and its installation between the railway network and the electrical grid, resulted in the discussion of the feasible number of conversion and inversion steps needed to make use of the energy in a feasible way.

5.1 Business opportunities and replicability

From the point of view of some of the stakeholders that are related with PTO companies, for the time being, it may not be too interesting to use the energy that comes from braking, at least in cases of no emergency and at this stage of the project, without an accurate cost benefit analysis and a definitive indication about the payback period. Consequently, an interesting issue, as this involves a likely business opportunity, would be to sell the energy generated by the train braking. Therefore, the question would be whether some costumers may be interested in purchasing the energy from the metro operator or not.

The main issue considering this idea is the related extra costs that would cause this energy to be more expensive than the energy from the public grid. This is an existing problem even in liberalised energy markets, like Germany and Austria. Some other stakeholders supported the idea of not selling the braking energy directly to customers, **but to charge the batteries of EV**. This approach could be very interesting to the E-LOBSTER project, as it will allow a better use of the energy and contribute to the efficiency of the whole electric system. Specific business models could be envisaged on this context, by considering for instance a unique subscription for the metro and for charging the EV battery.

On the other hand, braking energy could be injected into the local LV grid, instead of into MV grid, in order to use it in the very same metro station. Besides, in this case, the transport operator would control the energy, not the TSO nor the DSO, which provides new business opportunities.

Supporting this concept and considering the railway operator, they may not need to upgrade their power grids in order to avoid drops in voltages if the energy from braking is used, which also will depend on train timetable, frequencies and headway. This last point also allows the operator to recognise valley and peak hours in order to optimise energy management and to avoid problems related to power traction requirements.

As a counterpart, once the problems related to this first application of E-LOBSTER device have been identified, it is important to consider the following notion; E-LOBSTER project is designed to create synergies in the city, so the opportunities that it involves need to be looked at with an holistic perspective. For example, far from only focusing on the braking energy price, it would be more fruitful to consider how this source of energy might fit in the concept of smart city.

5.1.1 Market issues

This section gives an overview of the answers given by the stakeholders to the online questionnaire.

When giving feedback to the question **"Are there some specific market needs?"**, there were two contributions from PTOs that must be highlighted. One respondent underlined that the E-LOBSTER concept could be great for the development of EV, E-buses and batteries. The other mentioned the opportunity to work on bus and private car ultra-speed charging stations along high-ways parallel to railways. On the other hand, another response underlined the need of having a clear and compelling business case for the E-LOBSTER system to approach the market needs.

To the following question **"By taking into account the changing introduced by the new electricity directive in terms of storage and customer engagement, who could be interested in investing in the shared asset (Storage, sSOP) proposed by E-LOBSTER?** Three very interesting answers were submitted by PTOs:

- “Not the railway companies because it is not yet a customer need. Probably a private company that will sell charging services”.
- “Transport companies which have some electro mobility, transport operators in cities and shared mobility cars”
- “EV charge developers and manufacturers”

Looking at the answers provided to the question “**In your opinion, which kind of business models could be envisaged for the project solutions?”**, there are different business models that were envisaged by the PTOs: i) The possibility to charge EV near a station in the suburbs. ii) Different partners from various business, i.e. energy suppliers with e-taxis, car sharing, e-buses. Another kind of business could be power electronics suppliers. iii) Rail operators could offer EV charging services at very competitive prices next to service stations, both powered by catenary power (no new HV connections needed).

When asked “**Which kind of potential services enabled by E-LOBSTER could be considered an added Value?”,** different answers with contributions were received, summarized in the following: i) The possibility to charge EV near a station in the suburbs. ii) Charging and support with different European directives to the stakeholders. Iii) Green power for EV.

In relation to “**How do you evaluate the possibility to integrate smart charging of Electric Vehicles in the overall concept?**”, The main opinions expressed through the questionnaire:

- “It makes sense to recharge electro-buses and partial electro-buses with dynamic recharging with regard to the need for high outputs. Also, Personal electromobility - so far we do not consider usage of traction energy for charging personal vehicles. Local area distribution of low voltage is sufficient”
- “It is essential when you are talking about charging system and energy management.”
- “Smart charging would be easily integrated”

When asked “**From a business perspective, which kind of services could be enabled and who could be interested to provided it**”, answers underlined that “it should be a state administration to harmonize that everything is done under the protection of the new framework”. There was also an answer concerning that E-LOBSTER should focus on “inter-urban bus operators”

5.1.2 Potential in terms of replication

When addressing to replicability issues concerning the E-LOBSTER concept, there are different views. Those go from the most positive views that include the following:

- “In my country are increasing electric vehicles so in some years we will have several second life batteries, and they could be used for safe the grid.”
- “Yes, technical specifications would be fulfilled in our country (underlining that the pilot will be done in Spain)”

To the opinion of some PTOs, closer to the day-to-day operation issues

- “No unless there is a substantial cost - benefit or is driven by public policy objectives or obligations”
- “Considering the current situation in my city, we are not ready yet for this kind of system. Our inverter to get regenerative braking energy back to the grid is still not in service and we are currently electrifying more than 50% of our bus depot. Moreover, the system would be

more useful in the case of a suburban train but our suburban train lines are very critical and it is difficult to install new systems on them."

Concerning the most **suitable areas of application, taking into account the 3 case studies defined by the E-LOBSTER** there were two very interesting opinions:
First, a PTO underlined that the most suitable area would be "Suburban trains because they generate a lot of regenerative braking energy and there is a good frequency of trains. A station could be close to a EV charging parking or bus depot as well as storage because there is more space than in the city center", whilst other expressed that the use of batteries to balance the grid would be ideal and the segment for application should be the Sub-urban/regional train

There are some specific technical specifications that could be an added value for the replications in the different countries. Three issues were expressed in this sense by PTOs.: i) It could be an added value if it is possible to use the stored energy for the railway. For example, to avoid unloading measures if a substation is not working. ii) Smart control of consumption and accumulation with regard to the agreed capacity iii) Establish a standard voltage to use the same methods in each country.

5.2 Policy developments concerning the E-LOBSTER concept

Electrical vehicles are one of the main issues on which synergies can be built, serving as an ancillary ESS and at the same time, integrating transport services. The following information was delivered by the PTOs through the online questionnaire:

It is important to set **the current framework concerning the electricity market** in the countries where the stakeholders come from.
For example, in France, the distribution grid is nationally managed, so that infrastructure costs are evenly distributed for everyone. This system does not encourage micro-grids to run independently. In the Czech Republic, on the other hand, the energy market is liberalised, which means that everyone can freely exchange their own produced energy with the supplier. However, in the case of Spain, there is a strong opposition from electrical companies to inject energy into their grid.

The stakeholders also gave their opinion related to the **new rules that have been introduced by the clean package**. In the case of Czech Republic, more emphasis is placed on usage of renewable sources. In Prague, the Public Transit company only considers the usage for local non-traction consumption in the complexes, and, furthermore, an emphasis on energy savings. Some stakeholders consider that those rules are the best way to boost best practice to improve different energy systems, nevertheless, it must be supported and developed by member states.
Finally, a request to ease the way to use the energy that is in no use, regarding the ease to interconnect different kind of public transport like busses and taxis to railways or trams was underlined.

Regarding any **other European Directives and regulations** that could help or hinder the implementation of E-LOBSTER Solutions in the stakeholders' transport network, the Energy Audits for Europe Assessment of the transposition of Article 8 of the Energy Efficiency Directive (2012/27/EU) into Member State legislation were mentioned.

5.3 Energy storage systems regarding its application to E-LOBSTER project

Energy storage systems are the main solution these days to solve the issue of how to manage energy flows that are not continuous, like braking energy obtained from trains. As said in the previous section, instead of injecting this energy straight into the MV grid, another solution may be to store it in ESSs, which also allows integrating the concept of EV as energy emissary/receptor and the use of PV as energy source. The stakeholders agreed on the intrinsic potential of battery technologies as they are expected to be the best solution, even considering supercapacitors or flywheels.

Furthermore, according to their experience they provided some valuable insights in order to avoid some potential issues. For instance, it was reported that ESS having been installed in some facilities in London, it caused some unexpected extra costs due to the ground size needed for battery cells installation and the related high cost of land in a densely populated city. In this context, accurate cost benefit analyses are suggested in order to evaluate case by case the viability of the solution according to the local condition. Moreover, it would be necessary to optimise the size of battery packs (better ratio capacity/ground space occupied). In any case, batteries are expected to be the best solution, even considering supercapacitors or flywheels. However, it would be necessary to optimise the size of battery packs (better ratio capacity/ground space occupied) in order to avoid the issue previously highlighted.

Regarding the ESS application, some other stakeholders provided their experience, highlighting that some local Governments, like the Madrid council, are rather interested in the electrification of the city, what will need from ESS service to support EV services (cars, buses and motorcycles). The most prominent managing plan considering this, is that the public institution would provide the infrastructure while the railway/electrical operators would be in charge of managing the energy source. Stakeholders from Paris and Vienna are also interested in this kind of technology, considering fast charging and tram as the most promising technologies.

Regarding the questionnaire, there were two main questions that could help to set a tendency:

a) The main challenges related to energy storage in railway systems:
   - Those related with inherent cost of battery cells and packs, and the cost of the ground that is necessary to place them. Besides, the needs in terms of large capacity and high current density would mean to install a significant number of series-connected and parallel-connected cells. Moreover, the reliability and recyclability have to be evaluated.
   - Coupling the batteries to the network: previous projects dealing with batteries and inverters experienced some issues
   - When it comes to consider fire regulations and space needs that come from it, enormous underground zones are needed and efficiency is low, economically affecting metros and trams performance.
   - Some others claimed that PTOs owning ESS like batteries may not be the proper solution. Other solutions like providing the surplus energy to other stakeholders or trying to disengage batteries from railway systems might be more feasible in the short-mid-term.

b) The type of energy storage that would be the most suitable for railways:
   - According to the feedback provided by the stakeholders, there are three main types of storage systems raising special interest: batteries, supercapacitors and flywheels. Of course, there are several differences between these technologies, each one with its own proper applications depending on the system where they are supposed to be implemented (trams, commuter trains, metros, etc.).

5.4 Energy losses and its relationship with converters and inverters

It is an issue that has been briefly mentioned, due to its influence on energy efficiency. Taking into consideration that the facility of a metro involves a series of power conversion and electrical phase inversion, because of its configuration and the use of AC and DC current, which means a substantial amount of energy losses.

The transmission between the substation and the train grid and station power supply is also considered within the energy losses issue. However, it is not expected to be reduced, at least from the perspective of E-LOBSTER, while it is possible to reduce some inversion or conversion steps, considering that the higher the electrical power is managed, the higher the losses are.

Nevertheless, power semiconductor technology, its fabrication process and design improvements are fast advancing to further reduce the semiconductor internal resistance and switching losses, and to increase their potentials in terms of higher voltages, higher power density, and better switching performance.

The final idea is to increase the efficiency of the power conversion system, and hence the amount of the power generated/converted to the most effective utilization of electric energy, especially at megawatt levels.

5.5 Renewable sources for railways

Renewable energy is considered as an additional solution to provide more stability to the system, and providing another source of energy to the smart grid. According to other projects and the studies that are included as a part of E-LOBSTER project, photovoltaic energy is regarded as the most useful and feasible source to be installed in the facility.

The main questions that arose related to this topic had the following answers from stakeholders:

i- The most important technical challenges when customers sell renewable energy directly to the railway are:
- Dependability of energy being available
- The energy that is supposed to be sold, could only be the one stored in batteries, due to the fact that renewable sources could not meet the stability and quality level that is necessary for traction power. Therefore, the combination of renewable sources with energy storage systems could be the only alternative to reach the stability of the energy supply needed.
- It would be necessary to develop a technical standard to face the installation of these facilities ensuring its feasibility.

ii- Who would be the most proper entity to operate and to manage energy storage system?
- It has to be an entity with relevant expertise
- Either the railway infrastructure manager that operates the whole system, or a different company that operates energy storage and the renewable sources. Regarding the railway, the generated braking energy is seen as an ancillary service that is not vital to operate.
- Energy should be available for the main Power Provider in each country to balance the network.
- The railway operator is considered to be, from other stakeholders' point of view, the most proper manager.

5.6 Using railway assets for EV charging

Inside the questionnaire dedicated to PTOs, their feedback was requested concerning the usage of railway assets for electric vehicle charging. In this sense, three questions were outlined:

What types of EVs are best suited for railway charging (private cars, taxi, buses, etc.)? In this sense, although some stakeholders expressed that this was dependent upon the context, system topology and economics, the main commentaries and experiences were related to the E-Buses.
"Buses would be the most logical but our experience in our city is that they need energy mostly at night when the railway is not generating any. So maybe private cars during the day would be better (in a parking near a station) because if it is a small parking it would not need as much energy as a whole bus depot."
"Charging of the eletrobuses is already in use from tram traction network. We are currently considering charging from the metro usage. For the future it is necessary to consider smart charging control during peak of energy usage".
"Busses are the best because they have more capacity and you can stop them when it should be necessary to charge."

What are the main requirements to ensure that this is technically safe? A series of opinions were outlined: i) Connections engineered in accordance with recognised safety and technical standards ii) Good separation between the network so that a default on the EV charging station could not affect the railway. Iii) A need to measure some elements like energy generated per hour, dimension correctly the installation and separate the consumer to the supplier, in case of any issue, all the parts could work with their own energy supplied. iv) Use communication standards and electrical and EMC regulations.

What is the main technical challenge to ensure that railway service is not disrupted?
On the technical challenges regarding this section, very precise opinions were outlined that should be taken into account when approaching the charging of EVs on the E-LOBSTER concept:

- Equipment reliability, protection and disconnection arrangements
- Filtering high frequency signals.
- Ensure the energy supplied and improve technical inspections of safety in the energy stations.
- Isolate the railway system by switching off the EV chargers if anything fails

6 Conclusions and next Steps on E-LOBSTER Stakeholder Engagement

This report illustrates the vision of the E-LOBSTER stakeholders, and in particular the PT operators attending the workshop held on 20th of November 2019 in Madrid.

Actually, the document summarizes the presentations and main discussions that took place during the workshop, by focusing at the beginning on the objectives of the project and the technical solutions and by moving then on the policy framework and the potential business opportunities as well as the replication perspectives. In the last part of the document, the feedback provided by the stakeholders both during the discussions and through a questionnaire was reported.

E-LOBSTER continues its stakeholder engagement activities by enlarging and facilitating its contacts with European DSOs and technology provider companies in view of organising a dedicated workshop with this second group of stakeholders.

In this context, it is worth to mention that the E-LOBSTER DSO and technology provider stakeholders' group workshop was scheduled to take place on 5th of May 2020 aligned to the INNOGRID 2020 event in Brussels organised by E.DSO and ENTSO-E associations. However, COVID-19 outbreak all around the world prevented to make these plans happen.

In view of the uncertainties that are veiling the assumptions in organising a physical E-LOBSTER DSO workshop, the E-LOBSTER consortium at the extraordinary General Assembly on 11th May 2020 has decided to organise a virtual workshop in a webinar format at the end of June and beginning of July. The best possible organisation is being worked in the meantime by the E-LOBSTER team.

Due to the postponement of E-LOBSTER DSO workshop, the DSO and technology provider stakeholder's views which were supposed to be included in this report will be assembled in the next version of the document.

7 ANNEXES

Agenda of the E-LOBSTER Electrified Public Transport Stakeholders Group Meeting

E-LOBSTER Electrified Public Transport Stakeholders Group Meeting

Wednesday, 20 November 2019

09:00 – 15:45

Fundación de los Ferrocarriles Españoles (FFE), Santa Isabel, 44 · 28012 Madrid, Spain
Click here for the meeting location
Meeting organiser: Efe Usanmaz, UITP

09:00 – 09:30	*WELCOME COFFEE*	
09:30 – 09:40	**Opening of the Meeting** ○ E-LOBSTER partners says hello!	E-LOBSTER project partners
09:40 – 09:50	**Get to know each other** ○ Tour de table: Brief introduction and interests in participation to the Stakeholder group	ALL
09:50 – 10:20	**E-LOBSTER – Main Goals** ○ Introduction to the project objectives and goal with the Stakeholder groups Q&A	Giannicola Loriga, RINA Consulting
10:20 – 10:30	**Stakeholder Group Guidelines** ○ Participation, expectation and contributions ○ Administrative procedures Q&A	Efe Usanmaz, UITP
10:30 – 12:00	**E-LOBSTER Technical Discussions** ○ Presentation of E-LOBSTER's technical scenarios and challenges ○ Roundtable discussions on technical results: Integration of renewable resources; synergies between metro and electric buses charging power to develop smart transport solutions Q&A, discussions and feedback	Session Chair: Pietro Tricoli, University of Birmingham
12:00 – 12:45	*LUNCH BREAK*	
12:45 – 14:00	**Discussions on the Policy Developments and Business Opportunities related to E-LOBSTER (Part I)** ○ Presentation of challenges & opportunities identified in 2019 EU Electricity Directive and Energy Efficiency Policies in the Transport Sector	Session Chair: Giannicola Loriga, RINA Consulting Session Co-Chair: Mike Tatton, RSSB

	○ Presentation of E-LOBSTER Business Opportunities (Replication of E-LOBSTER solution) ○ The link between the future legislative framework and the business opportunities for the future replication of the E-LOBSTER solution Q&A, discussions and feedback	
14:00 – 14:15	*COFFEE BREAK*	
14:15 – 15:30	**Discussions on the Policy Developments and Business Opportunities related to E-LOBSTER (Part II)** ○ Discussions on the link between the future legislative framework and the business opportunities for the future replication of the E-LOBSTER solution ○ Collection of needs, challenges and opportunities identified by Public Transport Operators point of view Discussions and feedback	Session Chair: Giannicola Loriga, RINA Consulting Session Co-Chair: Mike Tatton, RSSB
15:30 – 15:45	**Next steps & Closure of the Meeting**	Efe Usanmaz, UITP
15:45 – 17:45	**Technical Visit organised by UITP EISS Sub-Committee:** ○ Central Control Room: Traffic, Power, Security and Stations control centres, Alto del Arenal station (Line 1)	ALL
17:45 – 19:00	**Free time**	ALL
19:30 – 21:30	**Evening Networking Cocktail organised by UITP EISS Sub-Committee** ○ Reception at Rosales Room (Hotel Courtyard by Mariott Madrid Princesa)	ALL

H2020-LCE-2016-2017

EUROPEAN COMMISSION

Innovation and Networks Executive Agency

Grant agreement no. 731249

E-LOBSTER

Electric losses balancing through integrated storage and power electronics towards increased synergy between railways and electricity distribution networks

Stakeholders Project Survey

E-LOBSTER Technical scenarios and challenges

Bidirectionality of DC electrification networks

E-LOBSTER use a smart soft open point to enable recuperation of train braking energy in the grid.

For what use case (trams/metro trains/sub-urban trains) you see the larger benefit in doing this?

What would be the optimal use of regenerative braking energy from a railway perspective? And from a power distribution grid perspective?

Energy storage in power distribution grid

E-LOBSTER use a battery energy storage to interface the railway with the grid.

What are the main challenges related to energy storage in railway systems?

What type of energy storage would be most suitable for railways?

Renewable sources for railways

E-LOBSTER will ensure that railways use more energy from renewable sources.

What would be the main issues of feeding the railways directly from renewable sources?

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What would be the technical challenges of having customers selling renewable energy directly to the railway?

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Who should operate the energy storage (if needed)?

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Using railway assets for EV charging

E-LOBSTER will enable to use railway electrification lines for charging electric vehicles.

What types of EVs are best suited for railway charing (private cars, taxi, buses, etc.)

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What are the main requirements to ensure that this is technically safe?

What is the main technical challenge to ensure that railway service is not disrupted?

Policy Developments and Business Opportunities related to E-LOBSTER

Electricity market at national level

Which is the current framework in your countries?

How do you consider the new rules introduced by the clean package?

Transport policy and legislative/regulatory framework

Do you have any other relevant aspect with respect to the transport policy/regulatory framework to underline?

Are there any other European Directives and regulations that you think might help or hinder the implementation of E-LOBSTER Solutions in your transport network?

Replication potentialities

By taking into account the current technical specifications, do you see any potential in terms of replication with respect to your country?

Among the 3 case studies, which one could be relevant in your context?

Are there some specific technical specifications that could be an added value for the replications in your countries?

Are there some specific market needs?

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Link between the future legislative framework and the business opportunities

By taking into account the changing introduced by the new electricity directive in terms of storage and customer engagement, who could be interested in investing in the shared assed (Storage, sSOP) proposed by E-LOBSTER?

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In your opinion, which kind of business model could be envisaged for the project solutions?

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Which kind of potential services enabled by E-LOBSTER could be considered an added value?

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How do you evaluate the possibility to integrate smart charging of Electric Vehicles in the overall concept?

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From a business perspectives, which kind of services could be enabled and who could be interested to provided it?