H2020-LCE-2016-2017

EUROPEAN COMMISSION

Innovation and Networks Executive Agency

Grant agreement no. 774392

E-LOBSTER

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

Deliverable D3.2
Report on the existing policy framework

Document Details

Due date	31-08-2019
Actual delivery date	30-08-2019
Lead Contractor	RINA-C
Version	Final rev0
Prepared by	RINA-C
Input from	RINA-C, FFE, RSSB
Reviewed by	RINA-C
Dissemination Level	Public

Project Contractual Details

Project Title	Electric losses balancing through integrated storage and power electronics towards increased synergy between railways and electricity distribution networks
Project Acronym	E-LOBSTER
Grant Agreement No.	774392
Project Start Date	01-06-2018
Project End Date	30-11-2021
Duration	42 months

The project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 774392.

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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 will demonstrate 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 this context, the scope of this report is to describe the existing policies and regulatory frameworks of the energy market at European level with a special focus then at National level on the countries where the members of the consortium are located and where the demonstration activities will be implemented.
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.
Thus, the E-LOBSTER project can be seen as a contributor to all climate change and emissions reduction policies. Actually, a variety of measures aiming to achieve an integrated energy market, security of energy supply and a sustainable energy sector are at the core of the EU's energy policy[1].
At the highest level is the "Paris Agreement[2]" (2015) which builds upon the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992. The agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. The central aim is to keep global temperature rise below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.
The EU has set itself a long-term goal of reducing greenhouse gas emissions by 80-95%, when compared to 1990 levels, by 2050 as set out in the Energy Roadmap 2050. The EU acknowledges that to achieve these goals, investments are needed in low-carbon technologies, renewable energy, energy efficiency, and grid infrastructure, all topics relevant with respect to E-LOBSTER.
Individual Member States have set out their own individual plans to meet this target, and their individual local needs.
By taking into account the interdisciplinary approach of E-LOBSTER, the main policy areas investigated includes electricity, energy market, energy efficiency, transport and Smart Cities.
In chapter 2, a description of the EU Energy Roadmap 2050 and of the Energy Union Strategy is carried out as well as of the long-term vision for a modern, competitive and climate-neutral economy by 2050: "A Clean Planet for All".
In chapter 3, an overview of the "Clean energy for all Europeans package" is provided.
In chapter 4, an accurate analysis of the New Electricity Directive is performed.

[1] http://www.europarl.europa.eu/factsheets/en/sheet/68/energy-policy-general-principles
[2] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Chapter 5 is devoted to the analysis of the electricity market and regulatory framework at National level on the countries where the demonstration activities will be implemented (Spain) as well as on the other countries represented by the project partners (Italy, UK).
Chapter 6 provides an overview of the transport policies.
Chapter 7 deals with policies related to Smart Cities.
The conclusions are reported in chapter 8.

2 EU energy roadmap, Energy Union Strategy and Strategic long-term Vision

On 15 December 2011, the EC released the Communication "Energy Roadmap 2050"[3]. The EU has set its long term goal of reducing greenhouse gas emissions by 80-95% by 2050 with respect to 1990.
In the Energy Roadmap 2050, the EC investigated the challenges to be faced for achieving the EU decarbonisation objective by ensuring at the same time security of energy supply and competitiveness. The Energy Roadmap 2050 has been the starting point for developing a long-term European framework together with all stakeholders[4].
To achieve the objective, relevant investments on the long term were envisaged to be needed in particular in new low-carbon technologies, energy efficiency, renewable energy, and grid infrastructure and for this reason, specific policies had to be defined[5].
In particular, in the Energy Roadmap 2050 of 2011, the European Commission defined the following potential decarbonisation scenarios[3] [6]:

- High energy efficiency: Strong political commitment towards high energy savings. It included for instance more stringent minimum requirements for new buildings as well as appliance, high renovation rates existing buildings, energy savings obligations on energy utilities etc. by allowing to decrease energy demand of 41 % by 2050 with respect to 2006.
- Diversified supply technologies: In this context, no specific technologies were preferred and the different energy sources could compete without specific support measures. In this framework, decarbonisation was envisaged to be driven by carbon pricing assuming public acceptance of both nuclear and carbon capture and storage (CCS).
- High renewable energy sources (RES). In this context, strong support measures were envisaged for RES leading to a very high share of RES (97% of share of RES in electricity consumption reaching)
- Delayed carbon capture and storage (CCS): Similar to the diversified supply technologies scenario but assuming that CCS was delayed, leading to higher shares for nuclear energy with decarbonisation driven by carbon prices rather than technology push.
- Low nuclear. Similar to the diversified supply technologies scenario but assuming that no new nuclear (besides reactors at that time under construction) was being built resulting in a higher penetration of CCS.

The projections carried out by the European Commission, the Member States and stakeholders and their analysis indicated some trends, challenges, opportunities and structural changes needed to design the policy measures to provide the appropriate framework for investors. According to this analysis and by combining the different scenarios the 2050 energy roadmap identified some key conclusions:

- The scenarios indicated that decarbonisation of the energy system is possible and can be less costly than current policies in the long run
- All decarbonisation scenarios indicated a transition from the current system, with high fuel and operational costs, to an energy system based on higher capital expenditure and lower fuel costs.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0885&from=EN
[4] https://ec.europa.eu/eurostat/web/energy/legislation
[5] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-energy-strategy
[6] https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf

- All scenarios indicated that electricity will have to play a much greater role than 2011 (almost doubling its share in final energy demand to 36–39 % in 2050) and will have to contribute to the decarbonisation of transport (other relevant topic with respect to E-LOBSTER).
- Most scenarios suggested that electricity prices was expected to rise until 2030, but declining then.
- In all scenarios, expenditure on energy and energy-related products (including for transport) was likely to become a more important element in household expenditure (16 % in 2030, and decreasing then to above 15 % in 2050)
- Significant energy savings would need to be achieved in all decarbonisation scenarios. (Primary energy demand were expected to decrease of 16–20 % by 2030 and 32–41 % by 2050 with respect to 2005).
- RES were expected to increases substantially in all scenarios, achieving at least 55 % in gross final energy consumption in 2050, up 45 percentage points from 2011 level at around 10 %. The share of RES in electricity consumption were expected to reach 64 % in a high energy efficiency scenario and 97 % in a high renewables scenario that includes significant electricity storage to accommodate varying RES supply even at times of low demand.
- Carbon capture and storage was expected to play a pivotal role in system transformation
- Nuclear energy will be needed to provide a significant contribution in the energy transformation process in those Member States where it is pursued.
- Decentralisation and centralised systems increasingly interact

Concerning the aspects related to transforming the energy system, the key conclusions of the 2050 Energy Roadmap were:

- Energy saving and managing demand is a responsibility for all
- Switching to renewable energy sources: the analysis of all scenarios shows that the biggest share of energy supply technologies in 2050 comes from renewables. Actually, increasing the share of renewable energy and using energy more efficiently were considered crucial, irrespective of the particular energy mix chosen[5]
- Gas will be critical for the transformation of the energy system and it will play a key role in the transition
- Key role is played by smart technologies, storage and alternative fuels
- Higher public and private investments in R&D and technological innovation are crucial in speeding up the commercialisation of all low-carbon solutions
- A European approach is expected to result in lower costs and more secure energy supplies when compared to individual national schemes. With a common energy market, energy can be produced where it is cheapest and delivered to where it is needed[5].

On 25 February 2015, the European Commission adopted the Energy Union Strategy (COM/2015/080 final), which is focused on the following aspects[7]:

- Security, solidarity and trust: a key point is to diversify the EU energy sources and to assure energy security by relying also on solidarity and cooperation between EU countries
- Fully integrated internal energy market: it is fundamental to enable the free flow of energy through the EU by relying on reliable infrastructure and without technical/regulatory barriers
- Energy efficiency: it is of paramount importance to improve energy efficiency as in this way it will be reduced dependence on energy imports, lower emissions and at the same time, there will be new opportunity, jobs and growth.

[7] https://ec.europa.eu/energy/en/topics/energy-strategy/overview#content-heading-0

- Climate action, decarbonising the economy: EU is committed to a quick ratification of the Paris Agreement[2] and to confirm its leadership in renewable energy
- Research, innovation and competitiveness: it is a priority to support breakthroughs in low-carbon and clean energy technologies through research and innovation that should drive the energy transition and improve competitiveness.

In a nutshell, the scope of the Energy Union is to make energy more secure, affordable and sustainable. It should facilitate the free flow of energy across borders and a secure supply in every EU country. In this framework, new technologies and infrastructure should contribute to cut household bills and creating new jobs and skills, as companies expand exports and boost growth. It will lead to a sustainable, low carbon and environmentally friendly economy, putting Europe at the forefront of renewable energy production, clean energy technologies, and the fight against global warming.

On 28 November 2018, the European Commission presented the strategic long-term vision for a modern, competitive and climate-neutral economy by 2050: "A Clean Planet for All"[8].
Actually, the European Union has demonstrated a continuous commitment to long-term strategies and objectives for the clean energy transition, having set already in 2010 the targets for 2020 and by introducing targets for 2030 in the Clean energy for all Europeans package from 2016 (See chapter 3)[9].
These goals provide the European Union with a stable policy framework on, renewables and energy efficiency, greenhouse gas emissions by giving to investors more certainty and by confirms the EU leadership in the sector. In this context, EU funding supports the building of a modern, interconnected energy grid across Europe.
In particular, the long-term strategy indicates how Europe can pursue climate neutrality by investing into effective technological solutions, by empowering citizens and by coordinating actions in specific areas (e.g. industrial policy, finance, research and development), while ensuring social fairness for a just transition. It will build on the new energy policy framework established under the Clean energy for all Europeans package that it will be relevant with respect to E-LOBSTER implementation.
More in details, the EC vision for a climate-neutral future covers almost all EU policies and is in line with the Paris Agreement target related to the global temperature increase[9].
It is important to specify that instead of setting targets, the strategy promote joint actions in 7 specific strategic areas[10]:

- energy efficiency
- deployment of renewables
- clean, safe and connected mobility
- competitive industry and circular economy
- infrastructure and interconnections
- bio-economy and natural carbon sinks
- carbon capture and storage

In the document, the vision for each one of the building block is illustrated:

- To maximise the benefits of energy efficiency, including zero emission buildings
- To maximise the deployment of RES and the use of electricity to decarbonise the energy supply in Europe;
- To foster clean, safe and connected mobility
- A competitive EU industry and the circular economy to reduce GHG emission

[8] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN
[9] https://ec.europa.eu/energy/en/topics/energy-strategy/overview#content-heading-0
[10] Going Climate Neutral by 2050, "A strategic longterm vision for a prosperous, modern, competitive and climateneutral EU economy", Brochure, pag. 9-pag.13

- To develop a suitable smart network infrastructure
- To take advantage of the benefits of bio-economy and create essential carbon sinks
- To cope with remaining CO_2 emissions with Carbon Capture and Storage (CCS)

At the same time, the long-term strategy has the objective to ensure that the energy transition is socially fair and as well as to guarantee the competitiveness of the EU economy and industry on global markets, securing high quality jobs and sustainable growth in Europe.

3 EU energy policy framework – "Clean energy for all Europeans"

In order to favour the transition towards cleaner energy and to implement the EU's Paris Agreement[2] for reducing greenhouse gas emissions, the EU agreed a comprehensive update of its energy policy. The comprehensive package is called "Clean energy for all Europeans package"[11] and, as already mentioned in chapter 2, it represents a significant step towards the implementation of the "Energy Union Strategy"[12] which has been adopted in 2015. 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 1/2 years to implement the new directives into national law.

The eight legislative acts and the overall legislative process of the "*Clean energy for all Europeans package"* are illustrated in the table below.

Table 1: Clean energy for all Europeans package - legislative process[13]

	European Commission Proposal	EU Inter-institutional Negotiations	European Parliament Adoption	Council Adoption	Official Journal Publication
Renewable Energy	30/11/2016	Political Agreement	13/11/2018	04/12/2008	21/12/2018 - Directive (EU) 2018/2001
Energy Efficiency	30/11/2016	Political Agreement	13/11/2018	04/12/2018	21/12/2018 - Directive (EU) 2018/2002
Energy Performance in Buildings	30/11/2016	Political Agreement	17/04/2018	14/05/2018	19/06/2018 - Directive (EU) 2018/844
Governance of the Energy Union	30/11/2016	Political Agreement	13/11/2018	04/12/2018	21/12/2018 - Regulation (EU) 2018/1999
Electricity Regulation	30/11/2016	Political Agreement	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/943
Electricity Directive	30/11/2016	Political Agreement	26/03/2019	22/05/2019	14/06/2019 - Directive (EU) 2019/944
Risk Preparedness	30/11/2016	Political Agreement	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/941

[11] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans
[12] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/building-energy-union
[13] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans#content-heading-4

ACER	30/11/2016	Political Agreement	26/03/2019	22/05/2019	14/06/2019 - Regulation (EU) 2019/942

The package will have relevant impact and benefits from the consumer point of view as well as from an environmental and economic perspective. Moreover, the Electricity Directive will have a remarkable impact on the E-LOBSTER solutions too. However, before accurately analyse the Electricity Directive in Chapter 4, a brief summary of the acts is presented in the following paragraphs.

3.1 Renewable energy

The EU, having the goal to show global leadership on renewables, has set an ambitious and binding target of achieving 32% for renewable energy sources in the energy mix by 2030. The recast renewable energy directive entered into force in December 2018 should support the achievement of the target.

3.2 Energy efficiency

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, relative to a 'business as usual' scenario.

3.3 Energy performance in buildings

Buildings are considered responsible for about 40% of energy consumption and 36% of CO_2 emissions in the EU. By taking into account these figure, 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. In this context, 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.

3.4 Governance regulation

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 force since the 21st of December 2018 and all Member States were expected to submit their draft NECPs by early 2019. The Commission published an analysis of each draft plan with recommendations to be taken into account and as next step the Member States have to finalise the NECPs by the end of 2019.

3.5 Electricity market design

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. In a nutshell, the electricity market design elements consist of four dossiers:

- A new electricity regulation
- Electricity directive
- Risk preparedness and a regulation
- Agency for the Cooperation of Energy Regulators (ACER).

4 New Electricity Directive 2019 Analysis

The new Electricity Directive dated 14th June 2019, is relevant for defining the regulatory framework of the E-LOBSTER solutions, therefore an accurate analysis will be carried out in this chapter.

4.1 Background[14] on the EU the Electricity market Directive and key aspects

On 30th November 2016, the European Commission proposed a revised Electricity market directive[15] and an Electricity market regulation[16] on the EU energy market design. The scope was to support the energy markets including more renewables and better managing energy flows across the EU, by empowering at the same time consumers. The proposal included a new Regulation on Risk Preparedness and a revised Regulation on the Agency for the Cooperation of Energy Regulators (ACER). The previous most recent legislation was related to 2009. However, since then, the electricity market has largely changed.

The key drivers towards the new directive were several: currently the electricity share produced by RES is expected to grow from 25% to 55% in 2030, and in this context, markets need to be improved to meet the needs of RES and at the same time to attract investments in the resources, and in particular energy storages that could support the variable energy production. Furthermore, the market has to provide the right incentives for consumers in order to favour them on becoming more active and on contributing to keep the electricity system stable.

In this framework, the new directive includes measures ensuring that state interventions (designed to guarantee that there is sufficient energy available) are used only when really needed and without distorting the internal electricity market.

It is relevant to highlight that the new rules of the revised directive have the objective to pay special attention to consumers by giving them more choice and greater protection. Actually, through the new rules, consumers will be able to become active players in the market, in particular thanks to use of smart meters, price comparison tools, dynamic price contracts as well as citizens' energy communities. Moreover, at the same time, vulnerable consumers will be guarantee by better protections.

In a nutshell, the new Electricity Regulation opens up electricity markets to renewables, energy storage, demand response scheme and it introduce stricter and harmonised rules for capacity mechanisms by allowing also to meet the EU objectives of emission reduction and security of supply. By improving the regional coordination, it will be guarantee the market functioning and competitiveness by making at the same time the system more stable.

Concerning the Risk-preparedness Regulation, it will increase the resilience of the EU electricity system and the Regulation on the Agency for the Cooperation of Energy Regulators (ACER) will enhance the role of ACER of coordinating regulatory authorities of Member States.

[14] http://europa.eu/rapid/press-release_IP-19-1836_en.htm

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0864R%2801%29

[16] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0861R(01)&from=EN

4.2 Electricity market design

As mentioned in the previous paragraph, one of the main objectives of the "Clean energy for all Europeans" package is to update the design of the EU electricity market[17] by taking into account the relevant changes in technology in the last years and the expected ones in the coming years.
By considering the current figures, the share of electricity produced by RES is expected to grow from the current 25% to more than 50% in 2030. In this context, the EU rules have to be updated to make easier the integration of renewables into the grid. Furthermore, electricity has to be still produced and delivered in sufficient quantities also by considering the variability of renewables sources and the need to cover the demand at any time. As mentioned before, markets need to be improved to meet the needs of renewable energies and attract investment in the resources. Special attention has to be paid to energy storage systems (one of the main topic of E-LOBSTER) that can compensate for variable energy production. Incentives for consumers to become more active and to contribute to keeping 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) and introduced a new regulation on risk preparedness and enhanced the role of the Agency for the Cooperation of Energy Regulators (ACER) as illustrated in the next paragraphs.

4.3 Updating the Electricity Directive and Electricity Regulation

As already explained, the new electricity Directive and Regulation replace the old Electricity Directive (2009/72/EC) and the previous Electricity Regulation (EC/714/2009). The aim is to at adapt market rules to new market scenarios. They introduce new limits for power plants eligible to receive subsidies as capacity mechanisms (confirming the phasing out of subsidies to generation capacity emitting 550gr CO2/kWh or more). However, one of the most relevant aspect of the new directive is that the consumer is put "at the centre of the clean energy transition". As a matter of fact, the new directive enables the active participation of consumers by putting in place at the same time a strong framework for assuring the consumer protection.
In a nutshell, the new rules will favor the investments necessary to provide security of supply by decarbonising at the same time the European energy system.
Updating the design of the EU electricity market will have remarkable impact on achieving the objective of EU to be leader in energy production from renewable energy sources by allowing more flexibility to accommodate an increasing share of renewable energy in the grid. The increase of production from renewables and increased electrification is fundamental to achieve carbon neutrality by 2050. Furthermore, the new electricity market design is expected to contribute to the creation of jobs and growth by having a relevant social impact.

4.4 Risk preparedness

The Regulation on Risk Preparedness requires Member States to redact plans able to face future electricity crises and to consider the appropriate tools to be implemented to prevent and to manage these potential crises.

[17] https://ec.europa.eu/energy/en/topics/markets-and-consumers/market-legislation/electricity-market-design

The background of this new initiative is strictly connected to an independent report from May 2015 highlighting on the basis of previous experience that Member State reactions to potential crises were focused on the national context only by neglecting cross-border effects and increasing energy bills.
On the contrary, the new Regulation requires that Member States to identify by using common approach all possible crisis scenarios at national and regional levels and then redact plans based on these scenarios. In particular, this preparation requires EU countries to cooperate and coordinate each others. Furthermore, the new regulation establishes a new framework for a more systematic monitoring of security of supply issues via the Electricity Coordination Group. The new rules will guarantee efficient preparedness against electricity crises and effective management by ensuring that markets can continue to work.

4.5 The Agency for the Cooperation of Energy Regulators (ACER)

By considering the changes introduced in the EU electricity market by the "Clean energy for all Europeans" package, the role and the tasks of ACER was enhanced in particular as far as the area of security of supply is concerned. As a matter of fact, the original role of ACER was related to coordination, advising and monitoring.
The new role envisages new competences in those areas where fragmented national decisions of cross-border relevance could determine problems for the internal Energy Market.
In this framework, ACER has to oversight on the future regional entities (i.e. "Regional Coordination Centers") where TSOs will be able to decide on those issues where a major coordination among national actions are needed in order to avoid to negatively affect the market and consumers.

4.6 Analysis of the Electricity Directive

As already illustrated in the introduction, the main scope of E-LOBSTER project is to develop and demonstrate an innovative Electric Transport-Grid Inter-Connection System that properly managed is 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 aims to demonstrate tools and technologies to monitor and analyse 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 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 is .
In this context, an accurate analysis of the key aspects of the Directive (EU) 2019/944 of the European Parliament and of the council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) was carried out in under to understand the future regulatory framework of the project.
In the preamble of the Directive and in particular, in item 5 and item 6, it is specified that
(*item 5) "… by taking advantage of new technology, new and innovative energy service companies should enable all consumers to fully participate in the energy transition, managing their consumption to deliver energy efficient solutions which save them money and contribute to the overall reduction of energy consumption"*
(item 6) "…the move away from generation in large central generating installations towards decentralised production of electricity from renewable sources and towards decarbonised markets requires adapting the current rules of electricity trading and changing the existing market roles", furthermore there is *"…the need to organise electricity markets in a more flexible manner and to fully*

integrate all market players – including producers of renewable energy, new energy service providers, energy storage and flexible demand…"
highlighting in this way, since the beginning the key role of the new technologies in the future electricity market and the relevance of decentralised production of electricity from renewable sources as well as the integration of the of all the market players (producers of renewable energy, service providers, energy storage and flexible demand etc.) fully in line with the E-LOBSTER philosophy proposing shared assets (in particular storage) based on renewable energy.
In the preamble, the remarkable role of the consumers and the need of tool for supporting their active participation to the energy market is underlined as well
(item 10) "Consumers have an essential role to play in achieving the flexibility necessary to adapt the electricity system to variable and distributed renewable electricity generation. Technological progress in grid management and the generation of renewable electricity has unlocked many opportunities for consumers. …However, the lack of real-time or near real-time information provided to consumers about their energy consumption has prevented them from being active participants in the energy market and the energy transition. By empowering consumers and providing them with the tools to participate more in the energy market, including participating in new ways, it is intended …that Union's renewable energy targets are attained"

Furthermore, with respect to E-LOBSTER, it is worth to underline the emphasis put in the preamble of the Directive on the low emission mobility, electro-mobility and charging stations
(item 40) "The Commission … stresses the need for the decarbonisation of the transport sector and the reduction of its emissions, especially in urban areas, and highlights the important role that electro-mobility can play in contributing to those objectives. Moreover, the deployment of electro-mobility constitutes an important element of the energy transition. Market rules … should therefore contribute to creating favourable conditions for electric vehicles of all kinds. … they should ensure the effective deployment of publicly accessible and private recharging points for electric vehicles and should ensure the efficient integration of vehicle charging into the system...
In this framework, Demand response, the smart integration of EVs and charging stations (one of the topic of E-LOBSTER) are considered playing a key role
(item 41) "…Demand response is pivotal to enabling the smart charging of electric vehicles and thereby enabling the efficient integration of electric vehicles into the electricity grid which will be crucial for the process of decarbonising transport.."

Again, among the topics relevant with respect to E-LOBSTER, some specific aspects of consumers (with reference to store and sell self-generated electricity but also to the contribution of the system costs) and the role of new technologies as well as the need to overcome specific barriers (legal, commercial etc.) are specified (item 42, 43).
(item 42) "…Consumers should be able to consume, to store and to sell self-generated electricity to the market and to participate in all electricity markets by providing flexibility to the system, for instance through energy storage, such as storage using electric vehicles, through demand response or through energy efficiency schemes. New technology developments will facilitate those activities in the future. However, legal and commercial barriers exist…for example, disproportionate fees for internally consumed electricity, obligations to feed self- generated electricity to the energy system, and administrative burdens, such as the need for consumers who self- generate electricity and sell it to the system to comply with the requirements for suppliers, etc. Such obstacles, which prevent consumers from self-generating electricity and from consuming, storing or selling self-generated electricity to the market, should be removed while it should be ensured that such consumers contribute adequately to system costs. Member States should be able to have different provisions in their national law with respect to taxes and levies for individual and jointly-acting active customers, as well as for household and other final customers…"

(item 43) "Distributed energy technologies and consumer empowerment have made community energy an effective and cost-efficient way to meet citizens' needs and expectations regarding energy sources, services and local participation. Community energy offers an inclusive option for all consumers to have a direct stake in producing, consuming or sharing energy. Community energy initiatives focus primarily on providing affordable energy of a specific kind, such as renewable energy, for their members or shareholders rather than on prioritising profit- making like a traditional electricity undertaking. By directly engaging with consumers, community energy initiatives demonstrate their potential to facilitate the uptake of new technologies and consumption patterns, including smart distribution grids and demand response, in an integrated manner…"

Some more general aspects but having a remarkable relevance with respect to E-LOBSTER are mentioned in items 51, 52, 53, 54, 55 dealing in particular with the modernization of the distribution networks evolving towards smart grids, incentives and the needs to push for technologies like smart metering supporting the active role of the consumers (and allowing identification of network losses, key aspect for E-LOBSTER). Special attention is paid also to interoperability aspects and standards.
(item 51) "Member States should encourage the modernisation of distribution networks, such as through the introduction of smart grids… encouraging decentralised generation and energy efficiency..."
(item 52) "Engaging consumers requires appropriate incentives and technologies such as smart metering systems. Smart metering systems … allow them to receive accurate and near real-time feedback on their energy consumption or generation, and to manage their consumption better, to participate in and reap benefits from demand response programmes and other services, and to lower their electricity bills. Smart metering systems also enable distribution system operators to have better visibility of their networks, and as a consequence, to reduce their operation and maintenance costs and to pass those savings on to the consumers in the form of lower distribution tariffs..."
(item 53) "… deployment of smart metering systems, it should be possible to base this decision on an economic assessment… should take into account the long- term benefits of the deployment of smart metering systems to consumers and the whole value chain, such as better network management, more precise planning and identification of network losses. Should that assessment conclude that the introduction of such metering systems is cost-effective only for consumers with a certain amount of electricity consumption…"
(item 55) "… the smart metering systems to be deployed by Member States in their territory should be interoperable, and should be able to provide data required for consumer energy management systems… Member States should have due regard to the use of relevant available standards, including standards that enable interoperability on the level of the data model and the application layer, to best practices and the importance of the development of data exchange, to future and innovative energy services, to the deployment of smart grids and to the internal market for electricity… the smart metering systems … should be equipped with fit-for-purpose functionalities that allow consumers to have near real-time access to their consumption data, to modulate their energy consumption and, to the extent that the supporting infrastructure permits, to offer their flexibility to the network and to electricity undertakings and to be rewarded for it, and to obtain savings in their electricity bills..."

Moreover, in the preamble of the Directive special attention is paid with respect to one of the key stakeholders with respect to E-LOBSTER, the Distribution system Operators (DSOs) and their roles
(items 61) "Distribution system operators have to cost-efficiently integrate new electricity generation, especially installations generating electricity from renewable sources, and new loads such as loads that result from heat pumps and electric vehicles… distribution system operators should be enabled, and provided with incentives, to use services from distributed energy resources such as demand response and energy storage, based on market procedures, in order to efficiently operate their networks and to avoid costly network expansions. Member States should put in place appropriate measures such as

national network codes and market rules, and should provide incentives to distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid… should also introduce network development plans for distribution systems in order to support the integration of installations generating electricity from renewable energy sources, facilitate the development of energy storage facilities and the electrification of the transport sector, and provide to system users adequate information regarding the anticipated expansions or upgrades of the network…"
In particular, with reference to storage facilities, one of the key topics of E-LOBSTER, indications and constraints about the ownership are provided:
(item 62) "System operators should not own, develop, manage or operate energy storage facilities. In the new electricity market design, energy storage services should be market-based and competitive. Consequently, cross-subsidisation between energy storage and the regulated functions of distribution or transmission should be avoided. Such restrictions on the ownership of energy storage facilities is to prevent distortion of competition, to eliminate the risk of discrimination, to ensure fair access to energy storage services to all market participants and to foster the effective and efficient use of energy storage facilities, beyond the operation of the distribution or transmission system..."
(item 63) "Where energy storage facilities are fully integrated network components that are not used for balancing or for congestion management, they should not, subject to approval by the regulatory authority, be required to comply with the same strict limitations for system operators to own, develop, manage or operate those facilities. Such fully integrated network components can include energy storage facilities such as capacitors or flywheels which provide important services for network security and reliability..."

Finally, with reference to closed distribution system
(item 66) "Where a closed distribution system is used to ensure the optimal efficiency of an integrated supply that requires specific operational standards, or where a closed distribution system is maintained primarily for the use of the owner of the system, it should be possible to exempt the distribution system operator from obligations which would constitute an unnecessary administrative burden because of the particular nature of the relationship between the distribution system operator and the system users. Industrial sites, commercial sites or shared services sites such as train station buildings, airports, hospitals, large camping sites with integrated facilities, and chemical industry sites can include closed distribution systems because of the specialised nature of their operations.

By moving on the analysis of the core part of the Directive, in chapter 1 ("Subject matter and definitions"), it is clearly illustrates its subject matter: (Article 1) *"…establishes common rules for the generation, transmission, distribution, energy storage and supply of electricity, together with consumer protection provisions, with a view to creating truly integrated competitive, consumer- centred, flexible, fair and transparent electricity markets…".*

Furthermore, special attention in chapter 1 is paid to the Active customers, in particular, according to Article 15, Member States shall ensure that *"…final customers are entitled to act as active customers without being subject to disproportionate or discriminatory technical requirements, administrative requirements, procedures and charges, and to network charges that are not cost-reflective…"*

Moreover, according to the same article Member States shall ensure that active customers are:
"…entitled to operate either directly or through aggregation… to sell self-generated electricity, including through power purchase agreements (14.6.2019 L 158/150 Official Journal of the European Union EN)… to participate in flexibility schemes and energy efficiency schemes… to delegate to a third party the management of the installations required for their activities, including installation, operation, data handling and maintenance, without that third party being considered to be an active customer…

subject to cost-reflective, transparent and non-discriminatory network charges that account separately for the electricity fed into the grid and the electricity consumed from the grid… contribut(ing) in an adequate and balanced way to the overall cost sharing of the system… financially responsible for the imbalances they cause in the electricity system; to that extent they shall be balance responsible parties or shall delegate their balancing responsibility …"

Furthermore, by focusing on a topic of interest with respect to E-LOBSTER as the ownership of storage facilities, again in article 15, Member States shall ensure that: *"…active customers that own an energy storage facility have the right to a grid connection within a reasonable time after the request, provided that all necessary conditions, such as balancing responsibility and adequate metering, are fulfilled… are not subject to any double charges, including network charges, for stored electricity remaining within their premises or when providing flexibility services to system operators… are not subject to disproportionate licensing requirements or fees… are allowed to provide several services simultaneously, if technically feasible…".* It is worth, in this context to underline the clause indicating that they have not to be subjected to any double charges (including network charges) for electricity stored in the system and remaining in their premises or when providing flexibility services to system operators.

Article 17 deals with Demand response through aggregation, and in this context Member States shall ***"…****allow and foster participation of demand response through aggregation… allow final customers, including those offering demand response through aggregation, to participate alongside producers in a non-discriminatory manner in all electricity markets… ensure that transmission system operators and distribution system operators, when procuring ancillary services, treat market participants engaged in the aggregation of demand response in a non-discriminatory manner alongside producers on the basis of their technical capabilities… ensure that their relevant regulatory framework contains the right for each market participant engaged in aggregation, including independent aggregators, to enter electricity markets without the consent of other market participants [..], non-discriminatory and transparent rules that clearly assign roles and responsibilities to all electricity undertakings and customers [..], an obligation on market participants engaged in aggregation to be financially responsible for the imbalances that they cause in the electricity system…".*

Relevant with respect to E-LOBSTER are article 19 and 20 dealing with Smart metering systems and their functionalities. In particular, it is recommended *"…smart metering systems that are interoperable, in particular with consumer energy management systems and with smart grids, in accordance with the applicable Union data protection rules…* Furthermore, smart metering systems shall "*…accurately measure actual electricity consumption and shall be capable of providing to final customers information on actual time of use… Validated historical consumption data shall be made easily and securely available and visualised to final customers on request and at no additional cost. Non-validated near real-time consumption data shall also be made easily and securely available to final customers at no additional cost, through a standardised interface or through remote access, in order to support automated energy efficiency programmes, demand response and other services… meter operators shall ensure that the meters of active customers who feed electricity into the grid can account for electricity fed into the grid from the active customers' premises…".*

Article 31 defines the Tasks of distribution system operators (DSOs), one of the key stakeholders of E-LOBSTER. In particular, DSOs shall **"**… *be responsible for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency… shall provide system users with the information they need for efficient access to, including use of, the system… act as a neutral market facilitator in*

procuring the energy it uses to cover energy losses in its system in accordance with transparent, non-discriminatory and market-based procedures, where it has such a function…". Moreover, in this framework, Member State may require the DSOs (when dispatching generating installations) "*… to give priority to generating installations using renewable sources or using high-efficiency cogeneration, in accordance with Article 12 of Regulation (EU) 2019/943"*.

Concerning the Incentives for the use of flexibility in distribution networks, article 32 defines that Member States shall *"…provide the necessary regulatory framework to allow and provide incentives to DSOs to procure flexibility services, including congestion management in their areas, in order to improve efficiencies in the operation and development of the distribution system… the regulatory framework shall ensure that distribution system operators are able to procure such services from providers of distributed generation, demand response or energy storage and shall promote the uptake of energy efficiency measures, where such services cost-effectively alleviate the need to upgrade or replace electricity capacity and support the efficient and secure operation of the distribution system. DSOs shall procure such services in accordance with transparent, non-discriminatory and market-based procedures unless the regulatory authorities have established that the procurement of such services is not economically efficient or that such procurement would lead to severe market distortions or to higher congestion…"*

Furthermore, DSOs *shall "…establish the specifications for the flexibility services procured and, where appropriate, standardised market products for such services at least at national level. The specifications shall ensure the effective and non-discriminatory participation of all market participants, including market participants offering energy from renewable sources, market participants engaged in demand response, operators of energy storage facilities and market participants engaged in aggregation…. exchange all necessary information and shall coordinate with transmission system operators in order to ensure the optimal utilisation of resources, to ensure the secure and efficient operation of the system and to facilitate market development… shall be adequately remunerated for the procurement of such services to allow them to recover at least their reasonable corresponding costs, including the necessary information and communication technology expenses and infrastructure costs".*

One potential key topic with respect to E-LOBSTER is the Integration of electro-mobility into the electricity network faced in article 32. In particular, Member States shall *"…provide the necessary regulatory framework to facilitate the connection of publicly accessible and private recharging points to the distribution networks… ensure that distribution system operators cooperate on a non-discriminatory basis with any undertaking that owns, develops, operates or manages recharging points for electric vehicles, including with regard to connection to the grid…"*. Besides, DSOs shall *"…not own, develop, manage or operate recharging points for electric vehicles, except where distribution system operators own private recharging points solely for their own use*". With respect to the latter, it is important to highlight that as derogation, Member States may allow DSOs *"… to own, develop, manage or operate recharging points for electric vehicles, provided that all of the following conditions are fulfilled: 1) other parties, following an open, transparent and non-discriminatory tendering procedure that is subject to review and approval by the regulatory authority, have not been awarded a right to own, develop, manage or operate recharging points for electric vehicles, or could not deliver those services at a reasonable cost and in a timely manner;*
2) the regulatory authority has carried out an ex ante review of the conditions of the tendering procedure under point 1 and has granted its approval; 3) DSO operates the recharging points on the basis of third-party access … and does not discriminate between system users or classes of system users, and in particular in favour of its related undertakings"

Regarding the Ownership of energy storage facilities by DSOs, this topic is coped by Article 36. In particular, DSOs "…shall not own, develop, manage or operate energy storage facilities". However, as derogation, Member States may allow DSOs *"… to own, develop, manage or operate energy storage facilities, where they are fully integrated network components and the regulatory authority has granted its approval, or where all of the following conditions are fulfilled: 1) other parties, following an open, transparent and non-discriminatory tendering procedure that is subject to review and approval by the regulatory authority, have not been awarded a right to own, develop, manage or operate such facilities, or could not deliver those services at a reasonable cost and in a timely manner; 2) such facilities are necessary for the distribution system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the distribution system and the facilities are not used to buy or sell electricity in the electricity markets; and 3) the regulatory authority has assessed the necessity of such a derogation and has carried out an assessment of the tendering procedure, including the conditions of the tendering procedure, and has granted its approval. The regulatory authority may draw up guidelines or procurement clauses to help distribution system operators ensure a fair tendering procedure"*

Chapter 5 of the Directive, deals with general rules applicable to Transmission System Operators (TSOs). In particular, article 40 defines the tasks of transmission system operators that shall be responsible for "*…ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity, operating, maintaining and developing under economic conditions secure, reliable and efficient transmission system with due regard to the environment, in close cooperation with neighbouring transmission system operators and distribution system operators; …contributing to security of supply through adequate transmission capacity and system reliability; …managing electricity flows on the system, taking into account exchanges with other interconnected systems. To that end, the transmission system operator shall be responsible for ensuring a secure, reliable and efficient electricity system and, in that context, for ensuring the availability of all necessary ancillary services, including those provided by demand response and energy storage facilities, insofar as such availability is independent from any other transmission systems with which its system is interconnected; … procuring ancillary services to ensure operational security; … data management, including the development of data management systems, cybersecurity and data protection, subject to the applicable rules, and without prejudice to the competence of other authorities".*

In *Article 42, the* Decision-making powers regarding the connection of new generating installations and energy storage facilities to the transmission system are defined. In particular, TSO"…shall establish and publish transparent and efficient procedures for non-discriminatory connection of new generating installations and energy storage facilities to the transmission system… shall not be entitled to refuse the connection of a new generating installation or energy storage facility on the grounds of possible future limitations to available network capacities, such as congestion in distant parts of the transmission system.. shall not be entitled to refuse a new connection point, on the ground that it would lead to additional costs resulting from the necessary capacity increase of system elements in the close-up range to the connection point".

Concerning the Ownership of energy storage facilities by TSOs, this topic is dealt in article 54 where it is explicitly indicated that TSOs shall "not own, develop, manage or operate energy storage facilities". It is important to underline that as derogation with respect to this point, Member States "*may allow transmission system operators to own, develop, manage or operate energy storage facilities, where they are fully integrated network components and the regulatory authority has granted its approval, or where all of the following conditions are fulfilled: 1) other parties…have not been awarded a right to own, develop, manage or operate such facilities, or could not deliver those services at a reasonable cost and in a timely manner; 2) such facilities or non-frequency ancillary services are necessary for the*

transmission system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the transmission system and they are not used to buy or sell electricity in the electricity markets; ….and 3) the regulatory authority has assessed the necessity of such a derogation…".

5 Overview of electricity market at national level

In this chapter, the regulatory framework of the energy markets at National level is analysed for the countries where the members of the consortium are located (potential countries for replication activities) with a special focus on Spain where the demonstration activities will be implemented.

5.1 Spanish market and regulation

The overview of the national electricity market of Spain in terms of relevant aspects with respect to E-LOBSTER should deal with specific constraints that differentiate each country in the European Union. One of these aspects is, for instance, the specific legislation that rules concepts like the injection of electrical power into the grid, self-consumption, storage of energy, etc. In Spain, this legislation is steered by the so called “Reales decretos” (RD) that are official documents published in the BOE (Spanish official bulletin, literally translated).

Consequently, this section will be split into two main parts, which cover a general overview of the electrical sector in Spain. The first one aims to summarise how the electrical grid and market works in this country. The second one deals with those regulations that affect the most to E-LOBSTER goals and that could restrict the pilot that is supposed to take place at *Metro de Madrid* facilities, and its possible future applications.

Regarding the first part, the electrical market in Spain is influenced by European regulation in terms of liberalisation and commercialisation, nevertheless, each country has its own peculiarities. In Spain, part of the electrical grid is still regulated by the central Government in order to be able to cover all the fixed costs. On the other hand, part of the network is regulated by the market itself, where producers and consumers work within a competitive environment. The main activities that are included in the electrical grid management may summarise in:

Generation: the capacity of generation is liberalised and each company choses the technology to install and the amount of energy to produce.

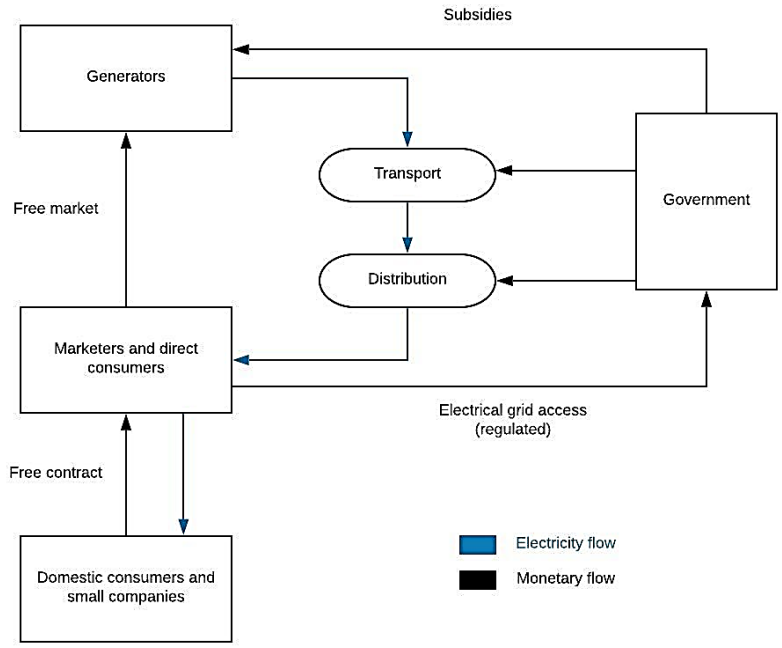
Transport: it is regulated and REE (Spanish Electrical Grid) has the monopoly of transport and operation.

Distribution: private companies manage it under central, regional and local Government regulation.

Consumption: the prices are liberalized and there is a role known as electrical marketer, which is between the electrical system and the consumers.

It is important to consider that this situation is constantly changing and it will keep changing. In order to have a big picture about the situation of the electrical market in Spain, and to try to foresee its evolution, it may be interesting to study this evolution since the market became liberalised.

The liberalisation started with the proclamation of the Electrical Sector Law *(Ley del Sector Eléctrico*, LSE) 54/1997. This is the first definition that does not consider the electrical supply as a public service, but as guarantee of supply. This law designed a new frame for each of the four activities within the electrical grid (generation, transport, distribution and consumption). Transport and distribution were liberalised regarding the access of third party services to the network. Nevertheless, the Government regulates the payment for this connection, in order to avoid abuse of power due to the existence of only one network. Before this date, it was ruled by a set of laws and regulations known as Marco Legal Estable, which means that it was totally controlled by the state. In terms of generation and transport, the Government possessed the control. On the other hand, the distribution grid was managed by electrical companies, whose fixed and variable costs were completely covered by the consumers.



Once the general view of the grid and its own characteristics have been explained, it is also important to understand how the task of its operation and regulation is accomplished. In Spain, there two operator that manage the electrical system of the Iberian Peninsula. One of them is the previously mentioned REE, and the other is OMIE (Energy Iberian Markets Organisation).

Organisation of Iberian Energy Markets (OMIE): it is one of the Spanish Power Market regulators and it performs as Market Operator (MO), who manages the financial and economic sector of the market. OMIE manages wholesale electrical market, which is divided into the daily and intraday. The unique and main activity within these markets is the sale and purchase of energy. This sale and purchase is done in different markets that will be further explained after. Its roles are the following:

- Market functioning
- Market Rules and Adhesion Contract
- Giving information to Market Managers, trading agents and third parties
- To keep independency, transparency, and impartiality principles.

Electrical Grid of Spain (REE): it is in charge of the safety and continuity of power supply, and, therefore, of the coordination of the generation and transport. Since 2007, it has become the only transmission system operator (TSO) of the Spanish electrical system. Its roles are the following:

- To keep its independency from the rest of TSO
- To be impartial and transparent
- To adopt the best practices for a proper corporate management.
- To search for corporate excellence
- To keep and protect the environment.
- To contribute to a sustainable energy future
- To offer a safety, efficient and quality service.
- To create value for all its stakeholders
- To boost the dialogue, integration and social development.

Furthermore, among the relevant actors, the regulator **CNMC (National Commission of Market and Competency)** has to be considered too. Actually, CNMC it is the regulator of the national Electrical System and its main goals are to keep the effective competency, impartiality and transparency. Overview of system requirements.
The electrical market in Spain is mainly concerned by problems in matching the sale and demand, due to the well-known issues concerning the energy storage, which currently has no proper solution. Considering this, it is time for a general explanation of how the short-term power market or SOPT market works in Spain.

a. **Daily market**: it is where around the 80% of the total daily energy is negotiated. This market has a deadline of 24 h and is structured in only one session. Trading agents report sale or purchase offers to the operation manager (OMIE). Besides, trading agent can report only one offer per day and offer unit. Once all the offer has been managed, then, for each time period and zone, the operation manager distribute the energy demand between the different provider units.
b. **Intraday market**: this market has the goal of managing the sale and demand of energy that is supposed to be produced in the next hours after the definitive feasible daily program is set.
c. **Restrictions market**: these technical restrictions of the system are managed after the daily market appeal, after intraday market sessions and, if possible, in real time. The definition of restriction is the situation that results from the non-compliance of safety criteria of the system that requires the modification of the operation programs. Restriction types are the following:
    - Overload in transport grid facilities.
    - Congestion in international connection.
    - Low voltages in transport grid.
    - Lack of reserves in the generation plan.
d. **Power reserve market**: as its own name indicates, it is the market where a power reserve is negotiated in order to assure supply safety in the electrical system.
e. **Secondary regulation reserve:** the main goal of this market is to keep the stability of the electrical system in terms of frequency deviations and values of exchange with external system that are part of the Union for the Co-ordination of Transmission of Electricity according to planned values.
f. **Deviation management market**: this market manages the possible deviations related to generation-consumption in the range between two intraday market sessions.
g. **Tertiary regulation market**: this market deals with the use of the reserve power and its restoration.
h. **Ancillary services**: this market manages the regulation of frequencies or exchange power.

Hereafter, specific information about the peculiarities of Spanish grid in terms of injection of energy to the grid, self-consumption, energy storage, etc. will be developed in order to cover all the points that are related with the main aim of E-LOBSTER project. As it was previously explained, *Reales Decretos* (RD) rule the electrical market in Spain. Considering this, in order to be able to set the frame that shall be considered to understand the possible limitations of E-LOBSTER applications, there are some specific articles within the Spanish electrical law that focus on this topic. These articles deal with topics like residual energy connections, energy surplus exportable to grid, self-consumption, easing of small-sized distributed generation, low voltage generation facilities, protection of systems, etc.

5.1.1 Residual energy connections, energy surplus exportable to grid, self-consumption

RD 900/2015 deals with residual energy connections, which is rather interesting considering the aim of re-injecting electrical energy that comes from the regenerative braking of the train into the grid. This RD is almost completely revoked by RD 244/2019. Nevertheless, it keeps some clauses that are still valid. Checking the second additional clause (*disposición adicional segunda*), it deals with the residual energy connection, which refers to the injection of electrical energy into the grid considering efficiency and energy-saving systems used by consumers. This clause considers that high voltage systems are included in this classification, if they fulfil the following requirements.

- Certification of the grid manager that are in charge of the network where the system is connected.
- A project that supports the energy saving and efficiency measures to adopt. No systems that contain generators or energy storage systems are considered within this classification.

Consequently, if it is required to inject the energy surplus into the grid, there must be a high voltage connection/rate, a positive net energy usage on an hourly basis, and the absence of energy storage. This is conceivably doable through a MITECO (ministry of ecology transition)/DGPEM (general direction of politics of energy and mines) exception

Furthermore, RD 244/2019, which revokes most of 900/2015, deals with self-consumption concept in the Spanish electrical grid. In order to summarise this RD, the following points are developed:

- Development of RD 15/2018 in relation to energy efficiency.
- Allowing hourly net balance and surplus compensation.
- Simplifies metering.

RD 18/2018 modifies the definition and the taxes related to self-consumption. This concept defines the consumption of electrical energy, which comes from generation facilities that are located close to consumption ones and related with them. This new definition also reduces the modalities of self-consumption to only two: with surplus and without surplus.

This RD also allows those facilities up to 100 kW to develop strategies to compensate deficits and surpluses.

The regulation in terms of metering is summarised in the following table.

Modalities				Connection to the net	Subjects	Solicitude	Metering
		Individual/collective					
1.- Without surplus		✓	◇	To inner net	1 consumer	Exempt	1 meter at the connection point to Distribution Network
2.- With surplus	a) Within compensation rate b) Out of compensation rate	✓	◇	To inner net	1 producer 1 consumer	Exempt < 15kW in urban land	1 meter at the connection point to Distribution Network
		◇	✓	To linking common facilities			Multiple configurations[18]
		✓	✓	To close Distribution Network			

✓ Common Case

◇ Uncommon but feasible

5.1.2 Low voltage generation facilities and exceptions

The Parliament of the Region of Madrid has jurisdiction over all facilities within its territory to decide and create its own norms. Therefore, the regulation to consult would be the *Instrucción sobre instalaciones generadoras y autoconsumo*[19] ordinance *Decreto 19/2008*, particularly the article 14, even if it is aimed to simplify permissions under certain circumstances, that covers mostly all urgent situations related to keeping energy supply safe. Therefore, this article happens to have the following characteristics regarding the E-LOBSTER project.

- It is uncertain how E-LOBSTER Project would be accepted as a self-consumption facility at first instance by the approving regional organism, because it does not fully engage with the legal self-consumption definition. 15 kW to 100 kW range requires approved project and legalizations for construction supervision, electric installation, inspection, etc.
- It also requires acceptation of the Technical and Economic Conditions Letter issued by the DSO, as well as a certification of compliance by the inverter maker.

[19] Check http://www.madrid.org/es/transparencia/normativa/nota-informativa-regimen-aplicable-puesta-servicio-instalaciones-generacion-energia for further information about this regulation.

To sum up, it is not possible to confirm that there are legal gaps concerning the installation of E-LOBSTER pilot, but it may take some time to test the procedure works fine in practice, just because of its newness, and the difficulty of classifying the scope of this project.

The technical standards and regulation that concern low voltage generation facilities may be found in the document ICT-BT-40-REBT. This document is not particularly focused on a type of low voltage, but on the whole range of facilities within this voltage.

As far as E-LOBSTER is concerned, the most important topics would be those that speak about self-consumption and energy injection into the grid. Nevertheless, it is important to classify the systems that are under the regulation of this document. These are:

- AC voltage up to 1 kV
- DC voltage up to 1, 5 kV
- New facilities
- Facilities whose installation is remodelled and this remodelling is considered to be higher that 50 % of installed power.
- Looking at this voltage values, the voltage classification is as it follows:

	AC	DC
Very low voltage	$U_n \leq 50\ V$	$U_n \leq 75\ V$
Standard voltage	$50 < U_n \leq 500\ V$	$75 < U_n \leq 750\ V$
Special voltage	$500 < U_n \leq 1000\ V$	$750 < U_n \leq 1500\ V$

Regarding the self-consumption references, the classification is the same that the RD 244/2019 sets. Therefore, the crucial point within this norm is to be able to obtain all the references that mention self-consumption and energy injection into the grid. These references set the protection that is mandatory to this kind of system, and are the following:

- All self-consumption facilities with no regards to their power.
- Every facility that is connected to a low-voltage distribution net must possess devices to control the DC injection into the grid and to avoid overvoltage generation.
- Every self-consumption generators with no regards to their power must be connected to the grid through an independent circuit with type A protection.

5.1.3 Energy Efficiency policies

Regarding the European aim of achieving the horizon 20-20-20, besides the 2020 and 2050 goals, Spain, as a member of the European Union, has an energy efficiency policy that follows these objectives. In order not to be repetitive, this section tries to focus on the efforts of Spain to fulfil the requirements ordered by Europe, considering its own features and the specific situation of the energy sector and market. To do so, the references that has been considered come from two sources:

(A) The Spanish Electrical Grid Platform (PERREE), known as FutuRed, which comprehends a group of administration agents, electrical and service companies, technological centres, and universities.

(B) The national energy efficiency plan 2017-2020 (Ministry of Energy, tourism and digital agenda).

(A) The global aim of these policies is to turn electrical grids into a tool that works allowing the management of sale and demand uncertainties and the alignment of the goals related to feasibility, sustainability and competiveness. These goals arise because of the arrival of elements as smart meters, EV's, the proliferation of renewable energies, distributed micro generation, technologies of information and communication, and the increasing importance of energy efficiency.

Considering this new situation of the electrical and energy sector, in line with this new vision, the objectives set to be fulfilled in 2030 are the following.

- To develop more efficient and robust transport and distribution infrastructures that allow the flow of higher volumes of energy. This will allow achieving energy savings, losses reduction and lower costs.
- To guarantee safe, feasible and flexible operation taking into consideration all the available resources of the electrical system, empowering the active role of all of the agents included into the system.
- To ensure the electrical supply with a proper level of feasibility, quality and cost.
- To ease an effective integration of renewable energies and the distributed generation, so that they would be compatible with centralised generation centres.
- To allow the interactive integration of new consumer and supply and service agents of energy, so that the higher flexibility in the electrical consumption may originate profits and new opportunities considering the grid management.
- To accomplish a more environmentally friendly distribution and transport of energy, integrating the environmental impact reduction criteria and the sustainable growth in the new infrastructure plans.
- Technological deployment of the strategic –considered technologies, power electronics ICT's, storage, and new sensors and materials.
- To develop a transport and distribution grid that may be able to form a platform that provides advanced and ground breaking services to the users.
- To foster a new regulation frame that allows the development of the new goals of the electrical sector.

These are the main objectives, regarding a national perspective. Nevertheless, it is also important the current situation of the electrical sector in Spain in order to be able to plot a path through which would be possible to reach the goals previously introduced.

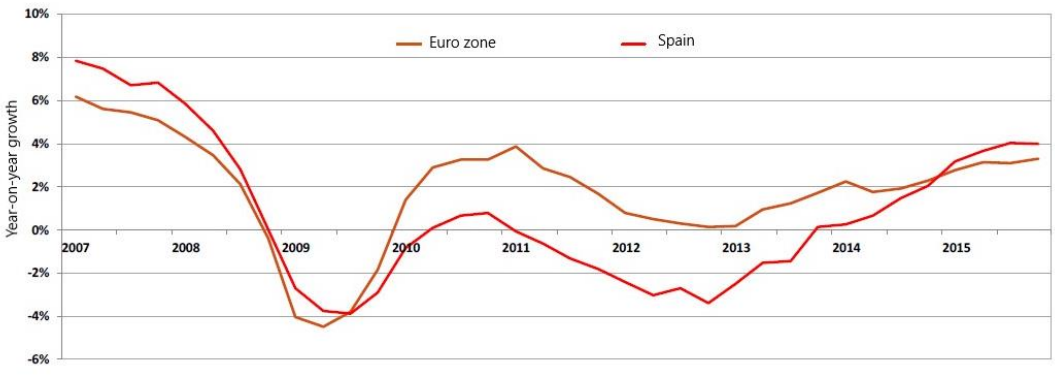
- Electrical sector liberalisation that, as it was introduced in the previous paragraphs, took place in 2003, however until 2009 was not completely implemented. Besides, a new figure has arisen in the sector, which is the EV's charging manager.
- Increase of competition and globalisation caused by the liberalisation.
- Renewable energy integration that is included within the 20-20-20 goals and that is rather important in Spain in order to decrease the energetic dependency. Matching the sale and demand in terms of energy is also a rather difficult and important issue that is even more problematic with the inclusion of renewables into the equation.
- Increase of the electrical demand.
- Grid saturation.
- Environmental impact that is increasingly considered as crucial issue due to the awareness of the society with ecology and environmental topics.

(B) This document deals with the National Action Plan of Energy Efficiency 2017-2020 that is part of the article 24.2 of the 2012/27/UE Directive, which comes from the European Parliament (25/10/2012). The structure of the document follows the recommendation that appears in the Annex XIV of the Directive 2012/27/UE. In this document, the following points are considered: energy consumption and intensity in Spain, energy efficiency goals and their degree of progress (goals of Spain, estimation of 2020 goal, and saving fulfilment), and the review of measurements (horizontal measures, measure of transport, cogeneration, and transport efficiency).

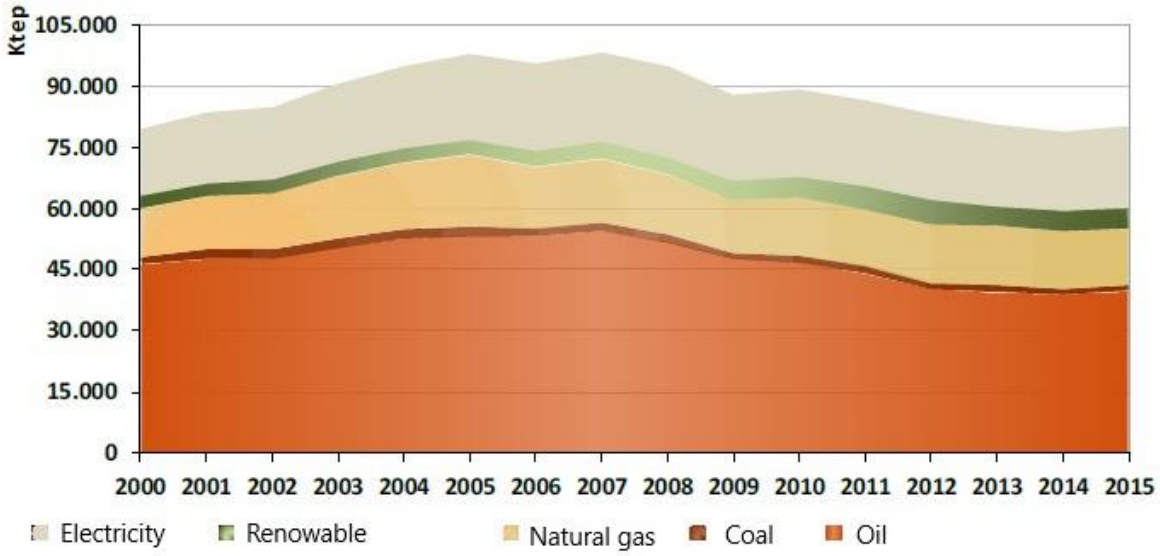
1. Energy consumption and intensity in Spain

Before starting with the analysis of the energy-saving politics of Spain, it is important to understand the macroeconomic situation of the country in terms of energy and economy.

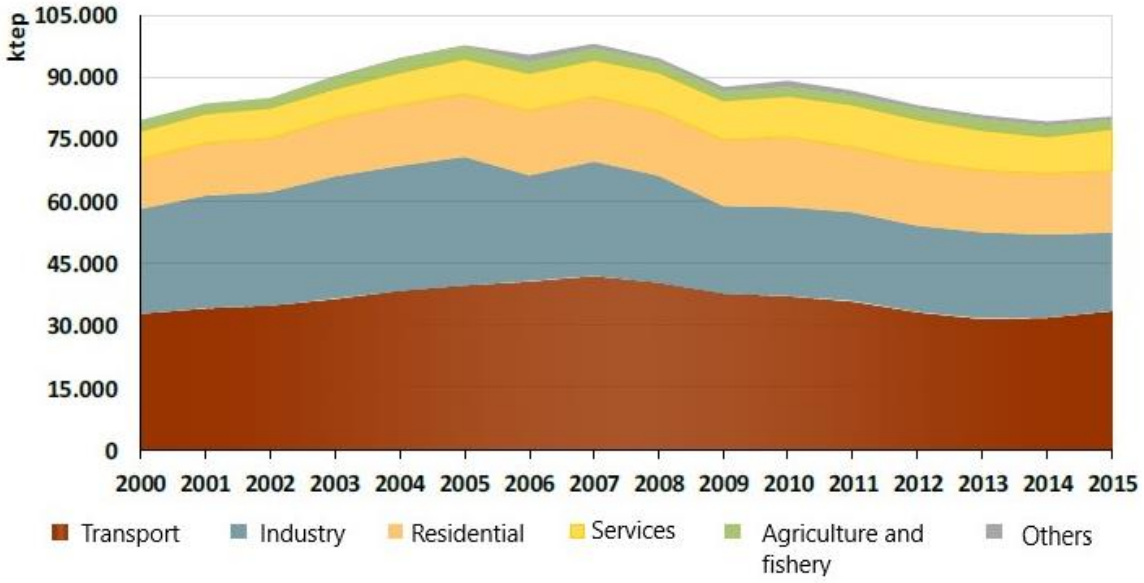
As the economy o f a country is strongly affected by the energy sector and vice versa, it would be interesting to take a look at the economic evolution of Spain until 2015 (this study is performed in 2017 but the range that was studied goes until this year). Here it is possible to notice the economic movements of the country, comparing data like domestic demand, public expenditure, external demand, and supply (where the sector of services, within which transport is included, plays a relevant role).



As far as energy is the topic that concerns this section, it is classified in two types, which are final and primary energy. These data give a brief summary of the situation in the country in relation with the rest of the European Union members. Considering final energy data, it is possible to conclude that within the different types of energy that form the energy map of Spain, renewable energies prove to be 6.3 % over the total.



The classification according to the sector in which the energy is consumed, shows that 41.8% over the total belong to the transport sector.



2. Energy efficiency goals and their degree of progress

The European Directive 2012/27/UE says, “Energy consumption in the EU in 2020 shall not be higher than 1.474 Mtep of primary energy or than 1.078 Mtep of final energy”. This means a decrease in the total amount of energy consumption of 20% of primary energy, 20% of CO_2 emissions, and the 20% of renewable energy consumption. According to this Directive, Spain has proposed s energy consumption reducion through the last years (135.3 Mtep (2011), 121.6 Mtep (2013), 125.28 Mtep (2014), 122.6 Mtep (2017)), which are below the reference value.

Apart from European Directives, Spain set a tax reform in order to achieve a better energy efficiency that consisted in:

- Wasted nuclear fuel tax (10%)
- Hydroelectric generation tax (22%)
- Fossil fuels tax
  - Natural gas (2.79 cent€/m3)
  - Coal used for power generation (14.97 €/Tm)
  - Oil used for power generation (12.00 €/Tm)
  - Diesel use for power generation (29.15 €/1000l)
- Electrical generation tax considering all power generation sources (6%)

Spain also run several funding programs that had the goal of promoting the use of renewable energies and alternative means of transport, among others.

MOVELE program and PIVE program that promote the use of electrical and more efficient vehicles. There are also programs that give help to change transport means, facilitating the development of those that are more environmentally friendly.

3. Review of measurements

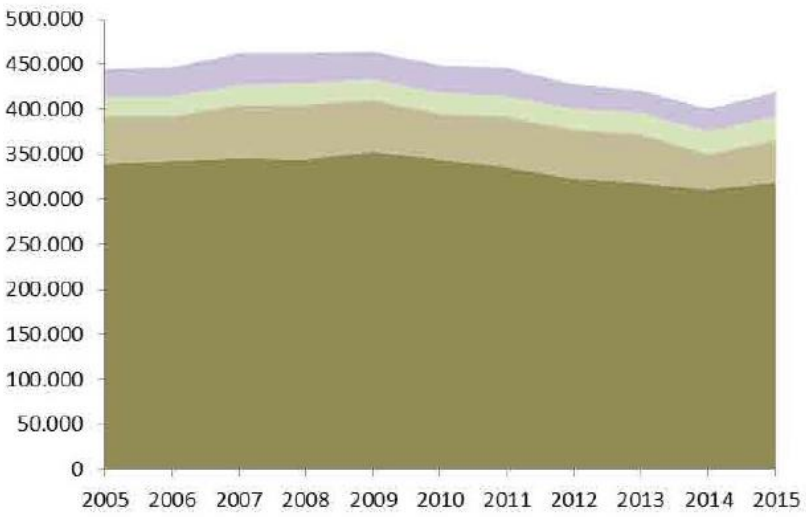
Among the measurements that the Government of Spain took in order to fulfil the requirements from EU, it is reasonable to highlight the RD 8/2014, which contains urgent measures for the growth, competitiveness, and efficiency. The articles within this ordinance that refer to energy efficiency are the following:

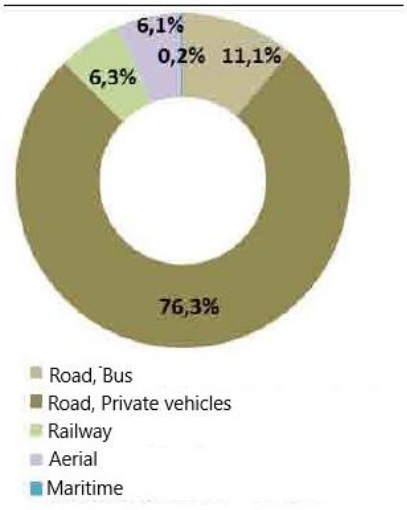
- **Article 69**. Creation of a national system of principles. Due to this article, the national system of energy efficiency principles is created, taxing a yearly energy fee that affects to gas, oil and electricity operators.
- **Article 72**. Energy Efficiency National Funds. The goal of this fund is to finance energy efficiency plans.
- **Article 73**. Organisation, management, and control of the fund.
- **Article 71**. Fulfilment of duties and energy saving certificate.

This fund released an amount of 8 M€ for a program whose goal was to help to increase the efficiency of means of transport, and 13M€ for helping programs for the improvement of energy efficiency in railway systems.

Regarding the transport efficiency, there is a chapter dedicated to this topic, in which railway field is named as the most efficient and environmentally friendly mean of transport. In the case of Spain, the data are the following.

- Demand increased 4.3% in 2015 regarding 2014 data.
- High-speed travellers increase 15%
- Freight train use increase 5.6%





Consequently, considering that railway fulfils the energy efficiency requirements, there are measures included in this help that deal with the following points:

- Measure 1: improvement of energy efficiency regarding the regenerative braking.
- Measure 2: energy saving strategies in railway traffic operation.
- Measure 3: improvement of energy efficiency in railway building facilities.
- Measure 4: improvement of energy efficiency of lighting and signalling.
- Measure 5: improvement of energy efficiency in railway facilities.

5.2 Italian market and regulation

The electricity market was set-up in Italy through the Legislative Decree No. 79 of 16 March 1999 (Decree 79/99, "Bersani Decree"), as part of the implementation of the EU Directive 96/92/EC repealed by Directive 2003/54/EC regarding common rules for the internal market in electricity into national legislation[20] [21].

The electricity market is divided in: 1) Day-Ahead Market (MGP) 2) Intra-Day Market (MI); 3) Dispatching Services Market (MSD).

More in detail, in the framework of MGP and MI (named also Energy Markets) producers, wholesalers, customers, Acquirente Unico (AU) and Gestore dei Servizi Energetici (Energy Services Manager - GSE) buy and sell wholesale quantities of electricity for the next day.

These markets, which are managed by Gestore dei Mercati Energetici (GME), define system marginal prices at which the energy is traded[20].

Regarding the main actors, Acquirente Unico S.p.A. (AU) is a company controlled by "Gestore dei Servizi Energetici", incorporated by the State to guarantee energy supply to families and SMEs, by means of economy, continuity, safety and supply efficiency. AU purchases electricity to the best market conditions and transfers to distribution companies and entitled operators, to supply energy to small consumers out of the free market[22].

Gestore dei Mercati Energetici (Electricity Market Operator - GME) was set up by Gestore dei Servizi Energetici (Energy Services Manager - GSE) a company owned by the Ministry of Economy and Finance. GSE fosters sustainable development by providing support for renewable electricity (RES-E) generation and by taking actions to build awareness of environmentally efficient energy uses. Moreover, GSE manages of the existing RES support schemes.

On the other side, GME carries out its activities in accordance with the guidelines given by the Ministry of Economic Development and the regulatory provisions issued by Autorità di Regolazione per Energia Rete e Ambiente (ARERA, the electricity, gas and water regulator). GME operates power, gas and environmental markets. As part of the process of liberalisation of the electricity sector, GME was initially vested with the organisation and economic management of the wholesale Power Market under principles of neutrality, transparency, objectivity and competition. On the power market platform managed by GME (also known as Italian Power Exchange, IPEX), producers and purchasers sell and buy wholesale electricity.

More in details, with reference to power, GME operates a forward physical market (MTE), a market for the trading of daily products (MPEG) with continuous trading mode, and as mentioned before a day ahead auction market (MGP), an intraday auction market (MI) as well as (on behalf of the Italian TSO Terna) a platform for ancillary services (MSD), through which collects the bids and communicates the results, and a platform for the registration of OTC transactions (PCE). On this platform, parties that have concluded contracts outside IPEX, record their commercial obligations and nominate the related electricity injection and withdrawal schedules that they undertake to execute under the same contracts.[23]

[20] https://www.terna.it/en/electric-system/electricity-market

[21] Electricity regulation in Italy: overview by Carlo Montella, Cristina Martorana and Alberto Tedeschi, Orrick, Herrington & Sutcliffe (Europe) LLP

[22] http://www.acquirenteunico.it/sites/default/files/documenti/Role_activitiesAU_Albania_def.pdf

[23] https://www.mercatoelettrico.org/en/GME/Info/ProfiloAziendale.aspx

Concerning the main generation companies in Italy, the data are reported in the figure below[24] with a comparison between 2017 and 2018.

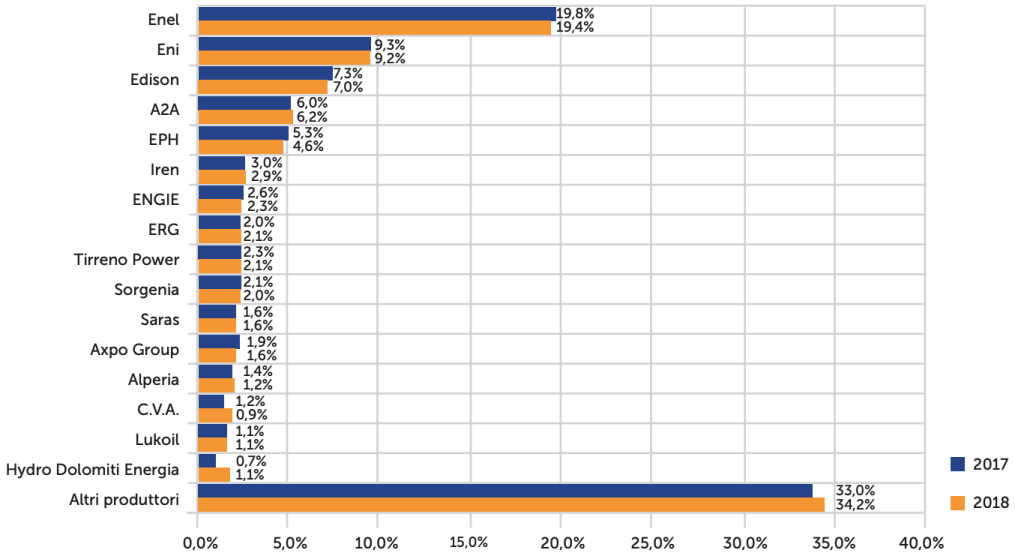


Figure 5.1: contribution to the national production (Source: ARERA)

Regarding the Electric transmission, it is carried out by the following companies:

- Terna S.p.A.;
- Terna Rete Italia;
- Rete9;
- Agsm Trasmissione;
- Mincio Trasmissione;
- Edyna Transmission;
- Arvedi Trasmissione;
- Seasm;
- El.It.E;
- Nord Energia;
- Eneco Valcanale 10.

It is important to underline that the transmission system operator (TSO) role is separate from the transmission asset owner. In this framework, Terna S.p.A. plays the role of TSO role whereas Terna Rete Italia owns and handles the transmission assets[25].

Concerning the Electric Distribution companies, the actors and the data according to the volume of energy distributed are[25]:

- E-distribuzione (Enel group) (85%);
- Unareti (A2A group) (4.2%);
- Areti (Acea group) (3.7%);

[24] Relazione annuale stato dei servizi, ARERA (Autorità di regolazione per Energia Reti e Ambiente) 31 marzo 2019

[25] https://practiceguides.chambers.com/practice-guides/alternative-energy-power-2019/italy/12-principal-state-owned-or-investor-owned-entities (Contributed By DLA Piper Studio Legale Tributario Associato)

- Ireti (Iren group) (1.3%).
- others (1%).

As mentioned before, the Bersani Decree 79/99 supported the liberalisation of the electricity market by introducing the unbundling and selling obligations on the former state monopolist ENEL, by stimulating the competition through new players and by assigning generation, distribution and sale of energy to different companies. Following the Decree 79/99, the wholesale markets opened up in 2004, the retail markets was liberalised in 2007 and the access to the grid network was open to anyone on request (third party connection obligation)[21].

Following the Decree 79/99, the Italian government introduced different decrees and support initiatives for renewable energy, including incentives for self-consumption, feed-in tariff schemes, preferential access to the grid, subsidies for equipment, tax relief etc.
In this framework, it is worth to mention the following:

- Conto Energia feed-in tariffs
- Green certificates
- Tariffa onnicomprensiva
- Net metering ("Scambio sul Posto")
- Guaranteed power purchase "Ritiro dedicato"
- etc

The "Conto Energia" was the main support scheme for solar power generation since November 2005 andprovided 20 year incentive tariffs from the date of entry into operation of the relevant plant. Tariffs were defined to cover investment and operating costs and decreased starting from the installation of the relevant plant. The "Conto Energia" does not exit anymore for new plant because the maximum aggregate costs threshold was reached in July 2013. In 2015, more than 500.000 plants representing 17 GW of capacity were supported by "Conto Energia"[21].

An accurate description of Net metering ("Scambio sul Posto") and Guaranteed power purchase ("Ritiro Dedicato") schemes is carried out in paragraph 5.2.1.

The Ministerial Decree of 23rd of June 2016 defined some incentives for renewable energy plants commissioned after 1 January 2013 (other than solar photovoltaic plants). The scheme allow 20 years of incentives including all-inclusive feed-in tariffs composed of the incentive and price for the electricity produced if the facility has a capacity under 500 kW or a standard feed-in tariff for all other plants.

In 2019 the Ministry for Economic Development approved a draft of the Renewable Energy Ministerial Decree ("Decreto FER 2018-2020") regulating support schemes for renewable energies.

5.2.1 Self-consumption and surplus

Regarding Renewables, as mentioned before, GSE manages support schemes for electricity generated from renewable energy sources that is promoted through VAT and real estate tax deductions. The electricity from renewable energy sources injected into the grid can be sold on the free market or to the GSE on a guaranteed minimum price ("Ritiro Dedicato"). Alternatively, renewable energy

producers can opt for Net-metering ("Scambio sul Posto") which provides economical compensation to PV-producers for the electricity injected into the grid[26].

The Net metering ("Scambio sul Posto") is based on the balance of the energy injected into the grid and the one consumed (570/2012/R/efr[27] , art 1,2). The RES producers can use the "Scambio sul Posto" if their plant's capacity does not exceed 500 kW (Art. 2bis,2 612/2014/R/eel[28]). Basically, it is a form of auto-consumption that allows prosumers to offset the electricity produced and injected into the network at a certain moment with the energy taken from the grid and used. Therefore, the electricity system is used as a sort of virtual storage of electricity produced but not self-consumed in the moment in which it is produced. The "Scambio sul posto" can be combined with tax deductions. However, it cannot be combined with the "Ritiro Dedicato" scheme.
The balance is calculated once a year (570/2012/R/efr[27] , art.8). More in details, the owner of the plant receives a compensation equal to the difference between the value of electricity exported to the grid and the value of the electricity consumed in a different period. If more energy is injected into the grid with respect to the one consumed, the plant owner receive an economic compensation, (Art. 6 of 570/2012/R/efr). If plant owner injects less than they consume, the difference is subject to a payment.
Concerning the eligibility criteria, all plants generating up to 500 kW are eligible independently of the technology used. Plants commissioned before the 31st of December 2007 were only eligible if they generation capacity was up to 20 kW whereas plants commissioned before the 31st of December 2014 could be eligible if they generation capacity did not exceed 200 kW. Since the 1st January 2009, "Scambio Sul Posto" also applies to CHP stations with an output of up to 200 KW. Furthermore, according to art.2, paragraph 2 of 570/2012/R/efr, Hybrid plants are also eligible in case their non-renewable generation is below 5%. It is worth to specify that to apply "Scambio sul Posto" scheme, electricity must be supplied to and received from the grid at one and the same connection point.
Concerning Guaranteed minimum price (Ritiro Dedicato) scheme, it is a simplified purchase/resale arrangement rather than a "classical" feed-in tariff[29] and as specified before, it cannot be combined with "Scambio sul Posto" scheme. More in detail, Renewable Energy producers can opt among selling the produced energy on the free market themselves or sell it to the GSE, who then sells the energy on the free market on their behalf ("Ritiro Dedicato"). In this framework, GSE acts as a sort of mediator between producers and the market. Furthermore, producers can opt among receiving a guaranteed minimum price or the market price and in case the market price is higher than the guaranteed minimum price, the producer receives an annual adjustment. Producers up to the following capacities may choose the guaranteed minimum price determined by the energy authority (AEEG 280/07[30])[29]:

- 100 kW for PV, if they make use of other support schemes
- 500 kW for hydro, if they make use of other support schemes
- 1 MW for all sources, if they do or do not make use of other support schemes

Market prices are applied to producers up to the following capacities:

- 1 MW for all sources (excl. cases mentioned above), that already make use of other support schemes,
- More than 1 MW for all sources, if they do not make use of support schemes.

[26] http://www.res-legal.eu/search-by-country/italy/
[27] https://www.autorita.energia.it/allegati/docs/12/570-12.pdf
[28] https://www.arera.it/allegati/docs/14/612-14.pdf
[29] http://www.res-legal.eu/search-by-country/italy/single/s/res-e/t/promotion/aid/feed-in-tariff-ii-ritiro-dedicato/lastp/151/
[30] https://www.arera.it/it/docs/07/280-07.htm

5.2.2 Energy Efficiency policies

The National Energy Strategy 2017 is the ten year plan that the Italian Government defined to anticipate and manage the change of the national energy system. The overall goal is to make the system more competitive, more sustainable and more secure.
The main targets of the plan are[31] [32] [21]:

- Reducing final energy consumption by a total of 10 Mtoe by 2030
- reaching a 28% share of renewables in total energy consumption by 2030, and a 55% share of renewables in electricity consumption by 2030
- continuing to improve the security of energy supply and the flexibility of energy systems and infrastructures
- narrowing the energy price gap
- furthering sustainable public mobility and eco-friendly fuels
- phasing out the use of coal in electricity generation by 2025.
- enhancing Italy's competitiveness, by continuing to bridge the gap between Italian energy prices and costs and European ones, in a global context of rising energy prices
- attaining Europe's environmental and decarbonisation targets by 2030 in sustainable ways, in line with the future targets set by COP21[33]
- changing sectoral energy mixes to promote the achievement of non-ETS[34] CO_2 emission reduction targets, by focusing on the residential and transport sectors
- doubling investments in research and development of clean-energy technologies: from € 222 million in 2013 to € 444 million in 2021.
- Boosting renewables and energy efficiency measures.
- Managing changing natural gas flows and peak demands.
- Diversifying supply sources for geopolitical risk reasons.
- For the renewable energy sector, promoting new investments, by granting incentives for power generation and placing more reliance on competitive auctions;

In particular, concerning the price targets, the key defined objectives are[32]:

- narrowing the gap between Italian natural-gas costs and north-European ones; this gap amounted to about € 2/MWh in 2016;
- narrowing the gap between Italian electricity prices and average EU ones; this gap was equal to roughly € 35/MWh in 2015 for an average household, and to about 25% on average for companies.

Concerning the starting point, in 2016, in a global context of economic recovery and low prices of raw materials, Italy proceeded on its path to strengthen its environmental sustainability by reduce its greenhouse gas (GHG) emissions, and improve the efficiency and security of its energy system.
Here the main results obtained:

- RES covered 17.5% of gross final energy consumption
- energy efficiency continued to grow: the GDP energy intensity dropped by 4.3% as compared to 2012

[31] https://www.mise.gov.it/index.php/en/news/2037432-national-energy-strategy
[32] ITALY'S NATIONAL ENERGY STRATEGY 2017
[33] COP21: 2015 United Nations Climate Change Conference, also known as the Paris Climate Conference (21st Session of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)).
[34] ETS: EU Emissions Trading Scheme.

- Italy's dependence on foreign supply sources continued to fall: energy imports were down by 7 percentage points versus 2010
- there remains an energy cost gap between Italy and the EU, which puts Italy at a is advantage

According to the plan, RES deployment in Italy can decrease emissions as well as the energy dependence. To date, Italy has already achieved its RES targets by 2020, with an RES penetration of 17.5% in total energy consumption in 2015 vs. a 17% target to be reached by 2020. The target of a 28% share of RES in total energy consumption by 2030 is considered by the plan ambitious but feasible. This RES is expected to be broken down as follows[32]:

- 55% of RES-E by 2030 (33.5% in 2015)
- 30% of RES-H&C by 2030 (19.2% in 2015)
- 21% of RES-T by 2030 (6.4% in 2015)

The main actions identified with respect to RES-E are:

- long-term contracts for large-scale power generation; promotion of self-consumption for small-scale power generation
- streamlining the permitting process for repowering wind and hydro plants
- maintaining existing power generation from bioenergy sources, without distortions to the agricultural sector chain
- increasing hydro power generation with innovative projects in existing large-scale plants

With respect to the Energy Efficiency, the main identified actions are the following[32]:

- Residential Sector
    - revising, strengthening and confirming the tax deduction scheme for energy-efficiency investments (so-called "Ecobonus")
    - putting the energy-efficiency fund into operation, and setting aside a reserve for energy-efficiency loan guarantees
    - furthering the evolution of minimum performance standards
- Transport sector
    - Strengthening sustainable local mobility to reduce urban traffic, and supporting the modal switch to smart mobility (car sharing, car pooling, smart parking
    - and bike sharing), cycle and pedestrian mobility, as well as local public transport
    - improving the energy and environmental efficiency of the national stock of cars. Measures to develop eco-friendly mobility rest on a technology-neutral
    - approach, allowing the target to be reached at the least cost to citizens. These measures include local energy, environmental, and pollutant emission
    - requirements, as well as plans for building infrastructures for intermodal transport

5.3 United Kingdom (UK) market and regulation

UK operates its electricity network in accordance with European legislation. The main participants in the operation of the electricity networks are:

Transmission Network Operators : Operators of the high voltage transmission "grid" providing the traditional connection from generation to Distribution Network Operators.

Distribution Network Operators; Operators of the geographic distribution networks and connections to the majority of customers

Office of Gas and Electricity Markets (Ofgem); The regulator of the monopoly suppliers and responsible for the correct functioning of the market.

The Electricity System Operator; Independent of all commercial parties, responsible for managing the operation of the electrical network in "real time", balancing the needs of customers and suppliers.

The arrangements for the operation of the networks are set out in the [UK] Grid Code and Distribution Network Codes which balance the needs of all parties to provide a sustainable, secure and competitive electricity market in the UK and in so far as this is technically possible, across Europe. Whilst the UK operates under the principles set out in European directives, a completely free market is constrained by technical limitations within the current system.

In the UK, there are four licenced high voltage transmission networks that enable the transfer of high voltage electricity from power stations around the country. National Grid is the largest of these organisations and owns the main electricity transmission network in England and Wales. SP Energy Networks owns the network in southern Scotland, and Scottish and Southern Electricity Networks owns the grid network in northern Scotland. Northern Ireland Electricity Networks owns the grid network in the Northern Ireland. There are interconnections under the Irish Sea between Northern Ireland and the remainder of the UK, as well as connections to mainland Europe.

A legally separate company. National Grid ESO is the Electricity System Operator (ESO) in Great Britain (England Wales and Scotland), responsible for balancing electricity supply generation and demand in real time.

Alongside the "national grid" are 14 licensed distribution network operators (DNOs), distributing electrical energy within a local area, and connecting to individual customers. These areas result from the sale and privatisation of the historic publicly owned "electricity boards". Since then there has been some change to the ownership and commercial arrangements resulting in individual companies holding more than one licence.

- North of Scotland: Scottish and Southern Electricity Networks
- Central & Southern Scotland: SP Energy Networks
- North East England & Yorkshire: Northern Powergrid
- North West England: Electricity North West
- Merseyside, Cheshire, North Wales & North Shropshire: SP Energy Networks
- East Midlands & West Midlands: Western Power Distribution

- South Wales & South West England: Western Power Distribution
- London, South East England & Eastern England: UK Power Networks
- Central Southern England: Scottish and Southern Electricity Networks
- Northern Ireland: Northern Ireland Electricity Networks
- Republic of Ireland: ESB Networks

The Electricity distribution networks carry electricity from the high voltage transmission grid to industrial, commercial and domestic users.

In addition to these public networks, there are some private local distribution networks, such as those operated by the railway companies.

Although individual customers are connected to their local distribution network, or in some instances, such as the railway, are connected to the National Grid, the electricity can be purchased from any supplier of electrical energy.

5.3.1 Regulation and peculiarities of electrical market in UK

UK operates its electricity network in accordance with European legislation and has network codes covering grid connections electricity markets, and system operation (the Electricity System Operator). The arrangements for the operation of the networks are set out in the [UK] Grid Code and Distribution Network Codes. The codes balance the needs of all parties to provide a sustainable, secure and competitive electricity market in the UK and across Europe.

Since the transmission grids and distribution networks are natural monopolies, they are regulated to protect consumers from potential abuse of that monopoly power and to protect the interests of existing and future electricity and gas consumers. The regulator as mentioned before is the Office of Gas and Electricity Markets (Ofgem) which is a government department and an independent National Regulatory Authority, in accordance with the EU Directives. Ofgem licences the private owners to operate on the electricity network and sets conditions for operation which, among other things, limit the amount of revenue which these companies can recover from their customers.

On 1st April 2019 the Electricity System Operator (ESO) became a legally separate business within the National Grid Group to provide independence and transparency in decision making to promote competition and benefit of consumers.

Although Great Britain (England Wales and Scotland) and Northern Ireland are separate islands there are electricity interconnectors joining these parts and Mainland Europe, allowing the transfer of electricity across borders. In practice, these interconnectors can behave as a power source (equating generation) or as a load on the network, exporting out of the network and are regulated accordingly. There are currently four interconnectors in service, with others planned.

- 2GW to France (IFA)
- 1GW to the Netherlands (BritNed)
- 500MW to Northern Ireland (Moyle)
- 500MW to the Republic of Ireland (East West).

In the UK, there are very few organisations that undertake any self-generation other than for backup purposes. Although historically most railways in the UK originally had a private power station, the formation of the national grid, and the availability of economic centrally generated power encouraged a move towards procuring electricity from the national grid. London Underground has retained some generation capacity for emergency purposes and does use this capacity on occasions when it is economically advantageous to do so.

The UK Government Department of Energy and Climate Change has announced a vision is for every home in the UK to have a smart meter, with a plan to install 50 million meters in 30 million homes and businesses over a seven year period The expectation is that this will lead to significant changes to energy usage and the electricity system.

The UK Government view is that smart metering will play an important role in Britain's move to a low carbon economy and will help meet the long-term challenge to achieve an affordable, secure and sustainable energy supply. The benefits are expected to be £7.3 billion more than the £11.3 billion costs as the domestic smart metering programme helps support and promote efficient energy usage by consumers.

Smart meters are gas and electricity meters that are capable of two-way communication, having the capability to allow data to be read remotely and displayed on a device within the home, or by the electricity authority. Ultimately, smart metering will create a platform to support smart grids, and smart cities managing the efficient generation and distribution of energy, allowing the increased use of low-carbon generation, like solar and wind power.

5.3.2 Low voltage generation facilities

The UK national grid was designed to transmit electricity from large central power stations out to customers in a radial manner. However, with the advent of policies of decarbonisation, and decentralisation things are changing. The large central coal fired stations are closing and more distributed solar and wind generation is being added to the network. On some days recently, there has been no coal fired generation being used in the UK. The network must be adapted accordingly to allow the insertion of generation capacity lower in the network. The role of Distribution Network Operators is changing from being solely distribution of bulk power to being one of accepting generation across their networks.

5.3.3 Energy Efficiency policies

The Environment (Wales) Act 2016 requires Welsh Government to reduce emissions of greenhouse gases (GHGs) in Wales by at least 80% for the year 2050. Similarly in England, the Climate Change Act 2008 sets a target for the year 2050 for the reduction of targeted greenhouse gas emissions - “It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline”.

The Climate Change Act 2008 sets a framework to achieve the headline requirement including carbon budgeting; trading schemes for reduction of greenhouse gas emissions; adaptation to climate change; requirements on waste and recycling and for making more general provisions about climate change.

As is the norm in the UK, in this “primary legislation” the Act permits the detail to be implemented through more agile “secondary legislation”.

6 Transport policies

Following the Paris Agreement[2] the world has committed to move towards a low-carbon economy. Despite technological improvements, transport is still responsible for around one quarter of Europe's greenhouse gas (GHG) emissions, which are a substantial contributor to climate change. While in other sectors GHG emissions have gradually declined since 1990, those from transport only started to decrease in 2007 and still remain higher than in 1990.

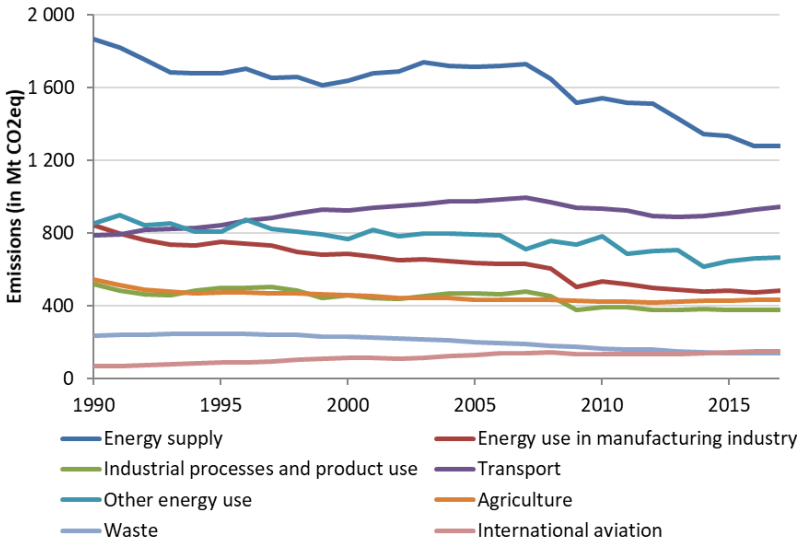


Figure 6.1: EU greenhouse gas emissions by sector 1990-2017 (Source: EEA (2017))

In 2017, transport emissions excluding international aviation and maritime represented close to 22% of the total emissions. Transport emissions including international aviation and maritime transport emissions were close to 26% of total emissions, this means that within the transport sector, road transport is the biggest emitter, accounting for about 80 % of all EU GHG emissions from transport. On road, light and heavy duty vehicles are by far the main emitters of GHG emissions from transport, accounting for 95% of all GHG emissions from transport.
The European policy to promote sustainability, reduced environmental impact and improve energy efficiency in the transport sector follows two main principles:

- shift person and good transport towards low carbon and energy efficient transport modes (modal shift);
- improve energy efficiency and reduction in the carbon intensity of vehicles.

Central elements of such approach include action on overall vehicle efficiency, promoting low- and zero emission vehicles and infrastructure, and the long-term switch to alternative and net-zero carbon fuels for transport, taking advantage of smart pricing and further encouraging multi-modal integration and shifts towards more sustainable transport modes.

6.1 2011 Roadmaps relevant with respect to Transport sector

In 2011 the Commission came forward with three strategic roadmaps relevant with respect to transport sector:

1. the Roadmap for moving to a competitive low carbon economy in 2050;

2. the Energy Roadmap 2050 (already illustrated in chapter 2)
3. the 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. These roadmaps cover 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 Union launched in 2015 and already described in chapter 2 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"[35], followed by "A European Strategy for Low-Emission Mobility" in June 2016[36], adopted in July 2016. The Strategy confirmed the 2011 White Paper[37] 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 outlined concrete actions and set clear and fair guiding principles to Member States to achieve European Goals.
To this end, the Strategy for Low-Emission Mobility proposed an Action Plan based on:

1. higher efficiency of the transport system;
2. low-emission alternative energy for transport;
3. 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 in chapter 3 and 4 (which included the European strategy on Cooperative Intelligent Transport Systems), approved in June 2019;
- 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. This latter will be illustrated in the next paragraph.

6.1.1 European Mobility packages (Europe on the Move)

'Europe on the Move' is a set of initiatives that will make traffic safer; encourage fairer road charging; reduce CO_2 emissions, air pollution and congestion.
The first Mobility Package put forward a first set of eight legislative initiatives with a special focus on road transport[38].

[35] Communication on the implementation of the Paris Agreement commitments, Brussels, 2.3.2016 COM(2016) 110 final
[36] A European Strategy for Low-Emission Mobility, Brussels, 20.7.2016
[37] COM (2011) 144 White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system.
[38] First Mobility Package - https://ec.europa.eu/commission/news/europe-move-2018-may-17_en

These proposals aimed at improving the functioning of the road haulage market, enhancing the conditions of workers, and promoting smart road-charging in Europe. The Commission also made a proposal, by now adopted, for a monitoring and reporting system of CO_2 emissions and fuel consumption for HDV (lorries and buses) to promote the use of the most fuel-efficient vehicles (Regulation (EU) 2018/956). In addition, a number of non-legislative accompanying documents, presented a wide range of EU policy support measures designed to accelerate the shift to a sustainable, digital and integrated mobility system (investment financing for infrastructure, research and innovation, collaborative platforms, etc.).

The second Mobility Package (Clean Mobility Package)[39] included legislative initiatives on road transport vehicles, infrastructure and combined transport of goods.
The Second Mobility Package, focused on clean mobility among others includes:

- the "Communication Towards the Broadest Use of Alternative Fuels", an Action Plan on Alternative Fuel Infrastructures, under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU. It established a common framework of measures for the deployment of alternative fuel infrastructures in the Union in order to minimize dependence on oil and to mitigate the environmental impact of transport. It sets out minimum requirements for the building-up of alternative fuel infrastructures, including recharging points for electric vehicles and refuelling points for natural gas (Liquid and Compressed Natural Gas) and hydrogen, to be implemented by means of Member States' national policy frameworks.

A set of 4 legislative initiatives, targeting road and combined transport, which aims at strengthening CO_2 emission standards for new cars and vans from 2020, promoting clean mobility through public procurement, stimulating combined use of trucks and trains, barges and ships for the transport of goods and promoting the development of bus connections over long distances.

1. To maintain market shares and to accelerate the transition towards low and zero emission vehicles, the Commission proposed new targets for the EU fleet wide average CO_2 emissions of new passenger cars and vans that will apply from 2025 and 2030 respectively. Both for new cars and vans, the average CO_2 emissions will have to be 30% lower in 2030, compared to 2021.
2. To promote clean mobility through public procurement the Clean Mobility Package sets out minimum public procurement targets for clean light-duty vehicles, trucks and buses for 2025 and 2030. The targets are expressed as minimum percentages of clean vehicles in the total number of road transport vehicles covered by the aggregate of all procurement contracts and public service contracts. Under the new rules, by 2030 up to 65% of new buses will have to be 'clean', as defined under the Directive on Alternative Fuels Infrastructure (DAFI). For light-duty vehicles, the proposal provides a definition of clean vehicles based on a combined CO_2 and air pollutant emissions thresholds, while it uses a definition based on alternative fuels (electricity, hydrogen, natural gas including biomethane) for heavy-duty vehicles. It also makes it possible to adopt a delegated act to use emission thresholds for heavy-duty vehicles after a future adoption of CO_2 emission standards for such vehicles. CO_2 Emission thresholds for light-duty vehicles range between 25 and 40 grams CO_2/km for 2025 and drops to zero in 2030. Emissions of air pollutants must be at least 20 % below the emission limits set in Annex I of Regulation (EC) 715/2007 or its successors. The proposal sets minimum procurement targets for each category of vehicle and each Member State. For light-

[39] Clean Mobility Package - https://europa.eu/rapid/press-release_IP-17-4242_en.htm

duty vehicles, Member States must reach a share between 16 % and 35 %. For buses, Member States' targets range from 29 % to 50 % (2025) and from 43 % to 75 % (2030), and for trucks from 6 % to 10 % (2025) and from 7 % to 15 % (2030).

3. An action plan and investment solutions for the trans-European deployment of alternative fuels infrastructure. The aim is to support national policy frameworks, by supporting investments in the transport network (the trans-European transport network or "TEN-T") and in urban areas. This will ensure availability of alternative fuels for road users. (https://ec.europa.eu/transport/themes/sustainable/news/2017-11-21-eu-funding-alternative-fuel-deployment_en).
4. Strategic Action Plan for Batteries in Europe (adopted in May 2018) foresees concrete measures to develop an innovative, sustainable and competitive battery production system in Europe. It furthermore aims to ensure (for instance, through free trade agreements) that mining in third countries is done responsibly and that production from European sources is boosted. It also supports collection and recovery of batteries as well as increased has strategic importance to the EU's integrated industrial policy so that the vehicles and other mobility solutions of tomorrow and their components will be invented and produced in the EU.

With the third Mobility Package entitled 'Sustainable Mobility for Europe' the EU Commission seeks to promote safe, connected and clean mobility across the EU. This third Mobility Package contains various legislative and non-legislative proposals that will affect the EU automobile industry[40].
Besides a proposal on "Connected and Automated mobility" and a 'Strategic Action Plan on Road Safety', the package includes a proposal on the first-ever EU CO_2 emissions standards for Heavy Duty Vehicles (HDV), In 2025, average CO2 emissions from new trucks will have to be 15% lower than in 2019. For 2030, an indicative target of at least 30% is proposed.
The Commission also proposed a regulation on the labelling of tires regarding fuel efficiency and other essential parameters and repealing Regulation (EC) No 1222/2009 and a proposal for amending Council Directive 96/53/EC on the time limit for the implementation of the special rules regarding maximum length in case of cabs delivering improved aerodynamic performance, energy efficiency and safety performance.
Regarding UK[41] [42], whilst rail is already less carbon intensive than road transport, the use of heavy diesel on rail does contribute to the overall pollution levels. Although rail may be less carbon intensive than road transport, the increase in use of Rail in the UK has meant that rail emissions have increased in absolute terms - up 33% since 1990. Improving rail emissions and moving freight and passenger vehicles off the roads onto greener forms of transport becomes an important strategy.

The UK Rail Industry has taken on the challenge to remove all diesel-only trains from the network by 2040 and to provide a vision for how it will decarbonise. A "Rail industry decarbonisation taskforce" lead by senior members of the UK rail industry, and supported by RSSB, was set up to answer the challenge.

The final report of the taskforce notes that the challenge will be to find the lowest carbon system at the most reasonable cost and to consider a whole system balance of the available technologies. It observes that what is clear is that a significant rail decarbonisation by 2050 can only be achieved with

[40] Sustainable Mobility for Europe' - https://ec.europa.eu/commission/news/europe-move-2018-may-17_en
[41] Final report to the minister for rail – [UK] Rail industry decarbonisation taskforce - July 2019
[42] Royal College of Physicians. Every breath we take: the lifelong impact of air pollution. Report of a working party. London: RCP, 2016.

a balanced and judicious mix of cost-effective electrification, coupled with the deployment of targeted battery and hydrogen technology where these are the best solution.

To give a perspective on the volume of emissions for UK rail, in 2016-17, passenger electric rolling stock consumed 3,524 million kWh of electricity and 501m litres of diesel, which generated 2,961 ktonnes of CO2e emissions whilst freight services consumed 58 million kWh of electricity and 204 million litres of diesel which generated 629 ktonnes of CO2e emissions. The traction energy represents about 63% (2008-09 data) of the overall rail greenhouse gas emissions.

The UK government has devolved some powers to the Welsh Government which is adopting policies that propose a low carbon public transport system in Wales, accessible to all and whichcontributes to life in Wales. The plan has an ambition for a zero-emission bus, taxi and private hire vehicle fleet by 2028. The Welsh Government is making investment in rail and increasing services to make public transport more attractive and connected and to discourage the use of private vehicles. A zero-emission bus fleet is also planned.

The Welsh Government view the most effective way of reducing CO2 emissions in the near-term is to encourage modal shift from car journeys to the existing and improved public transport system and to "active travel".

In the South Wales Metro project, to be delivered by 2023, the Core Valley Lines rail network (around Cardiff) will be speeded up and increased to "metro" frequency. There will be four trains per hour to each of the "heads of the valleys" (Treherbert, Aberdare, Merthyr Tydfil and Rhymney) and direct connectivity into Cardiff Bay. The newly electrified lines will be powered with 100% renewable energy. The concept will then be extended to North Wales and Swansea Bay Metro and North East Wales Metro.

Progress is being made in the UK as emissions fell by 3% in 2017 and emissions have now fallen by 43%, from 1990, Yet at the same time, the economy grew by over 70%. Emissions from electricity generation, the most significant factor in the UK, fell by 59% between 2008 and 2017 without compromising the service to consumers.

6.2 Electrical vehicles

All levels of governance within the EU have recognised that Electric mobility provides an important potential to reducing pollution in urban areas. Electric mobility could significantly reduce air pollution caused by transport, due to less fossil fuel use, especially if the electricity is produced from renewable sources. EVs do not emit tailpipe CO_2 and have significantly lower NOX emissions than conventional vehicles. The largest potential reduction in GHG emissions in an EV compared to a conventional vehicle occurs in the use phase of the vehicle. EVs typically have higher GHG emissions in the manufacturing phase but this can be more than offset in the use phase, if the vehicle is mostly charged with renewable energy. To promote the electric mobility take-up effective public policies need to tax negative environmental practices and favour low-emission technologies.
Countries such as those involved in the Electric Vehicles Initiative [43]are already making progress from their initial phases of EV policy implementation (e.g. establishment of standards, public procurement

[43] https://www.iea.org/topics/transport/evi/ Electric Vehicles Initiative (EVI)

and early charging roll out, economic incentives). Many of these countries have regulatory instruments in place and, to date, some advanced markets like Norway have started phasing out some aspects of their EV support policies (Figure below).

		Canada	China	European Union	India	Japan	United States
Regulations (vehicles)	ZEV mandate	✓*	✓				✓*
	Fuel economy standards	✓	✓	✓	✓	✓	✓
Incentives (vehicles)	Fiscal incentives	✓	✓	✓	✓		✓
Targets (vehicles)		✓	✓	✓	✓	✓	✓*
Industrial policies	Subsidy	✓	✓			✓	
Regulations (chargers)	Hardware standards**	✓	✓	✓	✓	✓	✓
	Building regulations	✓*	✓*	✓	✓		✓*
Incentives (chargers)	Fiscal incentives	✓	✓	✓		✓	✓*
Targets (chargers)		✓	✓	✓	✓	✓	✓*

Notes: * Indicates that the policy is only implemented at a state/province/local level. ** Standards for chargers are a fundamental prerequisite for the development of EV supply equipment. All regions listed here have developed standards for chargers. Some (China, European Union, India) are mandating specific standards as a minimum requirement; others (Canada, Japan, United States) are not. ZEV = zero-emissions vehicle. Check mark indicates that the policy is set at national level. Building regulations refer to an obligation to install chargers (or conduits to facilitate their future installation) in new and renovated buildings. Incentives for chargers include direct investment and purchase incentives for both public and private charging.

Figure 6.2: EV-related policies in selected regions [IEA (2019), "Global EV Outlook 2019"[44], IEA, Paris,

In the European Union, key policy developments in 2018/19 included fuel economy standards for cars and trucks and the Clean Vehicles Directive which provides for public procurement of electric buses. The Energy Performance Buildings Directive sets minimum requirements for charging infrastructure in new and renovated buildings. Incentives supporting the roll-out of EVs and chargers are common in many European countries.

6.2.1 Incentive mechanisms to support the development of the EV in EU countries[45]

Local, regional and national authorities in EU Member States offer various incentives to encourage the purchase and use of EVs. Some of these incentives are not limited to passenger cars but also include other road vehicles such as vans, buses, bicycles and motorcycles. EV owners are often either fully exempted from paying the vehicle registration tax (for instance, in Flanders in Belgium) or pay a discounted rate (for instance, in Wallonia in Belgium). Other tax reductions are also offered. For instance, Germany exempts EVs from the annual circulation tax for a period of 10 years, starting from the date of their first registration. Austria exempts EVs from the consumption/pollution tax, ownership tax and company car tax. In Ireland, EV owners pay the minimum rate of the road tax.
Some governments also offer purchase grants. The amounts under these grants, the method of calculating them and the types of eligible vehicles vary greatly from one government to another. Among the incentive mechanism, two macro-categories of incentive dedicated to the electric cars have been identified:

[44] www.iea.org/publications/reports/globalevoutlook2019/
[45] Sustainable Mobility for Europe' - https://ec.europa.eu/commission/news/europe-move-2018-may-17_en

- EV purchase incentives, which provide for the user a reduction on the EV's purchase price;
- EV use and circulation incentives, which provide for the user some bonus for the whole lifecycle of the electric car;

Furthermore, amid EV purchase incentives, it is possible to take into account:

- Rebates at purchase: discount at the moment of purchasing an EV;
- VAT exemptions: at the moment of the purchasing;
- Tax deductions.

For what concerns the EV use and circulation incentives, the following types of incentives may be included in this category:

- Circulation tax exemption: the EV's user enjoys a discount on the circulation tax that can be partial or total;
- Deduction on tariffs: in this case, the user enjoys a discount, partial or total, on the price for the highway toll, on the price of parking charges, etc...;
- Electricity cost reductions: the user enjoys a reduction of the price of the electricity used in order to charge the vehicle.

For instance, swapping a diesel car (older than 2001) for a new electric car in France entitles the owner to up to €11 000 in grants from the state. Many countries also offer purchase grants or discounts to buyers of two-wheelers. One example is Sweden, which subsidises 25 % of the cost of buying an electric two-wheeler (such as a bicycle or a moped).

There are other kinds of support for EVs as well. Several governments have, for instance, ensured that EVs are part of their public procurement contracts, or have given them access to bus lanes or to free parking. The Estonian government, for instance, has purchased about 500 EVs for the employees of the Ministry of Social Affairs and allows municipalities to permit EVs to use bus lanes.

Regarding UK, the Government has already committed to ending sales of petrol and diesel cars by 2040, as poor air quality is seem as the biggest environmental risk to public health in the UK and in a report by the Royal College of Physicians – potentially linked to as many as 40,000 premature deaths a year.

While in general, air pollution has been mostly falling as industry becomes cleaner, in many cities, nitrogen oxides, from the discharge of car exhausts, regularly exceed safe levels. The Royal College of Physicians link air pollution to cancer, asthma, stroke and heart disease, diabetes, obesity, and changes linked to dementia. The report indicates that in the UK, the cost to the country can be greater than £20 billion every year through the health problems resulting from exposure to air pollution.

Diesel vehicles produce the majority of nitrogen oxide gases coming from the roadside. The UK Government has set out a plan to address levels of harmful pollutant nitrogen dioxide, a form of the nitrogen oxide pollutants emitted by vehicles. In an "Air quality plan for nitrogen dioxide (NO2) in UK (2017)", the UK's plan is set out for reducing roadside nitrogen dioxide concentrations.

The UK Government had already taken action to improve air quality, when in 2011, the Government announced the proposal that conventional car and van sales would end by 2040, so that almost every car and van on the road to be a zero-emission vehicle by 2050. However, the Committee on Climate Change observes that polluting vehicles will still be on UK roads after 2050 when the UK should be on zero emissions, and the committee suggests that petrol and diesel vehicles may need to be phased out by 2030-35. To achieve zero emission cars, implies the use of batteries that require elements that are in short supply and a considerable increase in the car charging network. The Scottish government plans to ban polluting vehicles by 2032. A

The Mayor of London has introduced some measures to clean up London's air pollution. An ultra-low emission zone (ULEZ) charges a £12.50 fee to older, more polluting cars in the centre of London. The plan is to reduce emissions in London by 45%.

6.3 Charging infrastructure

As illustrated in the introduction, one of the main objective of E-LOBSTER is to establish mutual synergies between power distribution networks, electrified urban transport networks and charging stations for electric vehicles. With respect to this point, it is worth to mention that one major issue holding back the wider uptake of EVs is the perception that they cannot cover the desired distance without needing a recharge (range anxiety). This could either be due to the actual lack of charging infrastructure or to a lack of awareness that it exists. Although the charging infrastructure for EVs has been increasing at various speeds across the EU, similarly to the use of EVs, it is still insufficient in some Member States and there is lack of centralised information on all existing recharging points[46].

The EU has taken measures to incentivise Member States to increase the number of recharging points, raise awareness of their existence and make them more standardised and interoperable.

Building on the 2013 "Clean fuels strategy"[47] aimed at ensuring that electric recharging points have a standardised design and use, the EU adopted the "Alternative Fuels Infrastructure Directive" in 2014 [9].

The directive recommends introducing a minimum level of infrastructure for charging EVs across the EU (around one public recharging point for every 10 EVs), and also giving consideration to wireless charging and battery-swapping.

However, as the number of EVs is expected to increase, more recharging points will be needed: the Commission estimates that around 440.000 publicly accessible recharging points will be needed by 2020, and some 2 million by 2025.

Furthermore, the directive aims to make information about the location of recharging points more easily available and to help standardise their technical specifications. It also recommends that recharging points use intelligent metering systems that recharge batteries from the electrical network at times of low general electricity demand, and that in the long term, recharging points would also allow EVs to feed power from the batteries back into the network.

The EU has also taken measures to improve the charging infrastructure at home and at the workplace. The 2018 Energy Performance of Buildings Directive requires that:

- For non-residential buildings, at least one electric recharging point be fitted into all new non-residential buildings (such as shopping malls), and in existing buildings that are undergoing substantial renovation and have over 10 parking spaces. In addition, the directive requires that at least one in five parking spaces in these non-residential buildings is to be equipped with conduits for electric cables that enable the installation of recharging points for EVs.
- In new and renovated residential buildings with more than 10 parking spaces, the directive requires only that every parking space have conduits for electric cables that enable the installation of recharging points for EVs. So far, these provisions have had limited impact, as only a marginal part of the EU building stock is new or is being renovated. The development of charging infrastructure in existing buildings is left to the Member States. They are called on to simplify permitting and approval procedures for the installation of recharging points in buildings.

A number of governments support the installation of EV charging infrastructure. For instance, Estonia has helped to install a nationwide fast-charging EV network within its national electric car mobility

[46] EPRS_BRI(2019)637895_EN

[47] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Clean Power for Transport: A European alternative fuels strategy

system, ELMO, ensuring the presence of quick recharging points, 40-60 km apart, on all roads with dense traffic. All population centres with over 5 000 inhabitants are served. In Sweden, individuals who install a recharging point for an EV in their homes may get a tax reduction for the associated labour cost.

To help to connect EV recharging points to the distribution network while increasing the share of renewable energy in the electricity grid, in 2016 the Commission proposed as illustrated in chapter 3 and analysed in chapter 4 the new electricity directive. In this directive as explained in the analysis of chapter 4, the Commission called on Member States to create a framework that facilitates the connection of EV recharging points to the distribution network. It furthermore proposed that customers have access to electricity price comparison tools, smart charging, and dynamic electricity price contracts. The potential role of E-LOBSTER in this context, was already explained.

To further increase the share of renewables in the electricity grid, the 2018 "Directive on the promotion of renewable energy sources"[48] (to see also chapter 3) set a 32 % binding EU target for the share of renewable energy in final energy consumption by 2030. It also called for giving further incentives on electric mobility (such as giving consumers comprehensive information on the lower running costs of EVs).

Concerning UK, it has been set up an Office for Low Emission Vehicles across government to support the introduction for ultra-low emission vehicles (ULEV). The office has funding of £900 million to position the UK at the global forefront of ULEV development, manufacture and use with the aim of contributing to economic growth and reduction of greenhouse gas emissions and air pollution on UK roads. The funding is being used to install additional charging points; investigating if electric car charge points should be installed in all future new homes; and supporting many other projects which encourage the use of electric vehicles.

[48] DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)

7 Policies for Smart Cities

With respect to the key objectives of E-LOBSTER, it is worth to focus also on Smart cities.
A Smart city can be defined as a place where thanks to the use of Information and Communication Technologies (ICT), the traditional networks and services are made more efficient for the benefit of citizen as well as business. However, to limit the concept of Smart City to the use of ICT for the reduction of the emission and better use of resources could be restrictive. Actually, currently Smart City includes also smarter urban transport, upgraded water supply and waste disposal facilities, efficient ways for heating and lighting buildings as well as more interactive and responsive city administration and safer public spaces[49].
The European innovation partnership on smart cities and communities (EIP-SCC) is an initiative supported by the EC bringing together cities, industry, SMEs, banks, research and stakeholders.
The scope of the initiative is to rely on more sustainable integrated solutions and to make better urban life and at the same time to target specific city challenges from different policy areas such as energy, mobility, ICT etc
In this context, the priority of the partnership are the following[49]:

- sustainable urban mobility
- sustainable districts and built environment
- integrated infrastructures and processes in energy, information and communication technologies and transport
- citizen focus
- policy and regulation
- integrated planning and management
- knowledge sharing
- baselines, performance indicators and metrics
- open data governance
- standards
- business models, procurement and funding

According to the report "The making of a smart city: policy recommendations", city authorities, planners and developers have to cope with a relevant number of barriers in the preparation and implementations phases of smart city projects. Actually, shifting cities to a low carbon future presents different technological, economic as well as social challenges and there is the need to reform policies at all levels. As a matter of fact, the framework conditions need to be conceived to facilitate the adoption of new solutions and promote innovation. This requires a sound positive policy environment.
At the local level, key barriers that have to be addressed by policy actions are[50]:

- Inappropriate level of local competences and administrative capacity
- High administrative burdens
- Inappropriate procurement rules
- Inappropriate Stakeholder involvement;
- Access to capital;
- Public Private Partnerships;
- Inappropriate Regulatory environment at national level.

[49] https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en
[50] https://smartcities-infosystem.eu/sites/default/files/document/the_making_of_a_smart_city_-_policy_recommendations.pdf

At EU level, the following main areas have to be addressed:

- Need for policy coherence across sectors;
- Reinforcing EU funding programme.

The European Commission identified the importance of the Smart Cities topic in its Communication "Europe 2020: A European Strategy for Smart, Sustainable and Inclusive Growth"[51]. Through this communication, the EC provided the political background for implementing Smart City solutions. For smart cities, policy documents from the three sectors (energy, transport and information technology) are of relevance.[52]

It is important to highlight that at EU level several policies, proposals and initiatives are in place to achieve the objective of more attractive and competitive urban areas, healthier and more sustainable places to live in[53]:

- The energy union strategy sets out the targets and actions to transform the European energy system in the most sustainable in the world.
- The Urban Agenda for the EU promotes better laws, easier access to funding and more knowledge sharing on issues relevant for cities, bringing together the relevant stakeholders: European Commission, national ministries, city etc.
- The smart cities policy context aims to support the energy union and the Urban Agenda for the EU.
- The energy performance of buildings directive (EPBD) promotes smart technologies in buildings to increase their energy efficiency.
- The EU Covenant of Mayors for Climate & Energy brings together thousands of local governments voluntarily committed to implementing EU climate and energy objectives in cities.
- The Strategic Energy Technology Plane (SET-Plan) promotes research and innovation efforts across Europe by supporting the most impactful technologies in the EU's transformation to a low-carbon energy system.
- The Smart Cities Information System (SCIS) providing a lasting repository of information on smart city projects and serves as a knowledge platform to exchange data, experience and know-how.

[51] https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

[52] D2.2 Energy policies and regulatory framework analysis – Nobel Grid Project

[53] https://ec.europa.eu/energy/en/topics/technology-and-innovation/energy-and-smart-cities

8 Conclusions

The scope of this report was to describe the existing policies and regulatory framework of the energy market at European level with a special focus then at National level on the countries where the members of the consortium are located (potential sites for replication activities) and where the demonstration activities will be implemented (Spain).

Actually, 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. E-LOBSTER is demonstrating tools and technologies, software and hardware to assess the source of losses and to the maximise local consumption of Renewable Energy Sources (RES) production thanks to the use of Electrical Energy Storage (EES) and advanced power electronics devices.

In this framework, to identify the existing policies and regulatory frameworks is crucial for the project activities and for the future development of business models for the E-LOBSTER solutions. By taking into account the interdisciplinary approach of E-LOBSTER, the main policy areas investigated included electricity, energy market, energy efficiency, transport and Smart Cities.

In particular, at the beginning of the study an accurate analysis of the existing Roadmaps at EU level was carried out by focusing in particular on the EU Energy Roadmap 2050 and on the Energy Union Strategy.

A complete overview of the “Clean energy for all Europeans package” was provided by paying special attention and analysing all the articles relevant with respect to E-LOBSTER.

Then, the analysis of the electricity market and regulatory framework in Spain (where the demonstration activities will be implemented) and Italy and UK (where most of the partners are located and potential countries for future replications activities) was carried out.

The last part of the report was related to transport and Smart Cities policies.

This report will be used as reference for the discussion in the envisaged workshops with stakeholders (DSOs and Transport Managers) during the second project year.