PANTERA

Pan European Technology Energy Research Approach

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Report on current status and progress in R&I activities: Technology

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Table of Contents

Abbreviations

Acronym	Meaning
CSA	Coordination and Support Action
DER	Distributed Energy Resources
DSO	Distribution System Operator
DN	Distribution Network
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute
ETIP-SNET	European Technology and Innovation Platform Smart Networks for Energy Transition
EV	Electric Vehicle
ES	Energy Storage
HV	High Voltage
ICT	Information and Communication Technology
IEA	International Energy Agency
IoT	Internet of Things
IRP	Integrated Research Program
LV	Low Voltage
LEN	Local Energy Network
MV	Medium Voltage
NRA	National Regulating Authority
PV	Photovoltaics
R&D	Research and Development
RD	Regional Desk
R&I	Research and Innovation
RES	Renewable Energy Sources
RCS	Regulations, Codes and Standards
TSO	Transmission System Operator
TN	Transmission Network
WT	Working Team

1 Introduction

The work in this report is carried out under the activity " The state of R&I, standardisation and regulation" of the PAN European Technology Energy Research Approach (PANTERA) project. PANTERA is an EU H2020 project aimed at setting up a European forum composed of Research & Innovation stakeholders active in the fields of smart grids, storage and local energy systems, including policy makers, standardisation bodies and experts in both research and academia, representing the EU energy system. The special attention has been given on the 15 EU member states (MS) who have been identified as countries with low R&I activities in the area of smart grid, storage and local energy systems. PANTERA is achieving its target through the activities done mainly by its two strong wings: “6+1 Regional Desks (RD)” and “5 Working Teams (WT)”, as shown in Figure1.1 and Table1.1. Six RDs are taking care of these 15 countries with special support from “Best Practice Desk” to identify the best practice examples in the relevant field of studies. More details will be discussed in the following sections. The outcomes will be delivered through the “all-in-one” PANTERA Platform, as shown in Figure1.2.

Figure 1.1 Regional Desk (RD) formed by PANTERA

Table 1.1 PANTERA working teams

Working Domain			
System	Technology	Market	Society
WT1: Research Infrastructure			
WT2: Regulation & Standardisation			
	WT3: Gap Analysis		
	WT4: Innovation Support to the Market Uptake		
WT5: Global & European Research & Innovation Community			

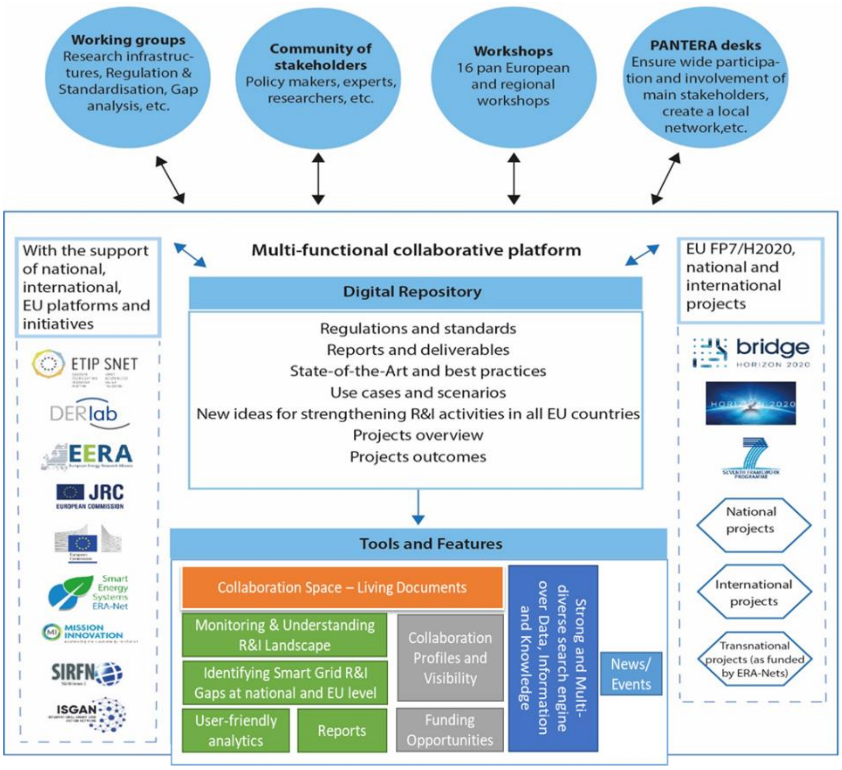

Figure 1.2 PANTERA Platform

1.1 Activity " Report on current status and progress in R&I activities: Technology "

One of the key outcomes of PANTERA is to identify the current status of the EU member states (MS) with the low R&I activities in the field of smart grid, storage and local energy systems. Along with this, PANTERA is analysing the needs for future R&I priorities to achieve the decarbonised European smart grid network in a harmonised way (to meet the EU 2050 energy target by all countries towards the decarbonising whole energy sector). In that sense, the whole smart grid electricity network is considered as Integrated Energy System (IES) and the R&I roadmap to achieve this IES at EU level is initiated in ETIP SNET vision 2050 [1]. This identification and needs analysis at national level are being done through a systematic process under the PANTERA project, called **RICAP** (R&I status and Continuous gAP analysis).

It is also important to learn about the other approaches at national, EU and global level who are analysing the R&I activities in relevant areas according to their objectives. As a part of the RICAP process, PANTERA team is reviewing these initiatives and their activities in relation to smart grid R&I projects.

Based on the review outcomes, PANTERA proposed a technology/systems classification where all the required technologies are identified and classified. This classification is then mapped against the two most important initiatives (EPRI – as International initiative, BRIDGE – as EU initiative) to highlight how the projects already classified in the past can be transferred to the new proposed classification seamlessly.

In the review process, PANTERA also identifies that ETIP SNET is one of the most important initiatives at EU level, who has developed the detailed roadmap for smart grid R&I activities at EU level. Two roadmaps that have been developed so far (2017-2026 and 2020-2030) are classifying the R&I activities in two different structures (cluster and functional objectives in 2017-2026 roadmap, research area and FUNCTIONALITIES in 2020-2030 roadmap). The project evaluation method will then be different for these two roadmaps. Hence, it is important to find out a common path to evaluate the R&I projects that will also allow an easy way to move forward from roadmap 2017-2026 to 2020-2030. PANTERA classified technologies are mapped against the FUNCIONALITIES whereas the seamless transition for the past projects should be secures.

PANTERA review also finds that National Energy and Climate Plan (NECP) for each country defines the R&I priorities at national level to achieve the EU target. Hence, the R&I status based on the NECP are analysed here for all the countries with low R&I activities. At this stage, it is also interesting to learn how the progress is happening along with the ETIP SNET roadmap but analysing it at national level. Hence, PANTERA team is collecting most of the national and EU collaborative projects where these selected countries are participating. A brief study on R&I activities based on the 2020-2030 roadmap is then done for 6 representative counties chosen from the 6 regional desks of the PANTERA process. The 6 countries selection for this study is based on their low performance in R&I activities and thus the representation of the wider region they belong to. It is expected that through the regional desks activities, all countries profiles will be formulated accordingly

It is also important to find out the way how to map NECP R&I priorities to align with ETIP SNET roadmap. An exercise has been presented for the selected countries.

All these studies and analysis finally help PANTERA to develop the RICAP technical process, where an attempt has been made to develop a universal methodology by linking the past to the present and future plan to achieve the target based on the ETIP SNET vision 2050. PANTERA recommends how the proposed technology classification can be linked to the FUNCTIONALITIES of the ETIP SNET 2020-2030 roadmap. A case study for Ireland is given as an example to demonstrate the R&I status based on the technology classification, mapping with FUNCTIONALITIES under the RICAP process. Final recommendation is made to implement the proposed RICAP process in future R&I status analysis towards the achievement of decarbonised EU smart grid network.

1.2 Limitations of the document

Under this task, extensive review has been done on the national, EU and International initiatives and some of the important methodologies to evaluate the smart grid projects and to understand the current R&I status and progress at national level towards the harmonised energy transition as targeted by the European Commission.

PANTERA attempts here to develop a generalised methodology for evaluation process of the R&I projects to achieve the integrated energy system at national and EU level. The proposed RICAP process is not fully verified yet. Over the time period of the PANTERA project, PANTERA teams will collect project information and evaluate the whole process in a coordinated effort with ETIP SNET. The outcome of this work will populate through its all-in-one stop platform.

2 Review on R&I project evaluation methodologies for mapping of R&I needs

There is nowadays a general and widespread consensus about the importance, urgency and acceleration needed to the process of decarbonizing the energy system which is responsible for a significant share of climate-change gas emissions. Hence, the sustainable solutions of low emission technologies and their implementation are a must. This requires substantial public and private investments and regulatory and development schemes to accompany self-sustained market uptake without the need of special measures or incentives. No individual industry, region, country or continent can alone solve this immense challenge of making clean technologies competitive and seamlessly integrated into the energy system. Hence, the national, EU and international communities are working in parallel and also in collaborative manner so as to shorten the time taken to decarbonise their energy systems and reduce emissions and to allow all countries to act in sync along the sustainable development path [1].

On this aspect, it is important to briefly review the R&I initiatives at international, EU and national level and also the project evaluation methods considering by some of the initiatives that encourage PANTERA to develop a general process on identifying the progress on R&I activities both a national and EU level.

The review of existing methodologies is needed for PANTERA specific purposes and objectives as to creating a unique approach to accessing projects and supporting target countries through this process. The universal approach that PANTERA aims to develop is of critical importance not only to identify but also to quantify the needs of the R&I community at both EU and national level.

Under this approach, PANTERA will develop and integrate in the platform a needs identification process that will recommend the necessary R&I action to be taken at national and EU level to achieve the target on decarbonising integrated energy system by 2050. This outcome will also serve as a valuable feedback to both BRIDGE and ETIPSNET.

Following sub-sections thus briefly discuss the considered R&I initiatives and project evaluation methods under the PANTERA CSA.

2.1 Review on R&I Initiatives towards Energy Transition

Each country is obliged to develop its own national energy strategy and delivers it through the National Energy and Climate Plan (NECP) and Nationally Determined Contribution (NDC) at European and International levels respectively. The energy strategy includes an energy research strategy, composed of research programmes. In addition, decisions are taken with regards to the frameworks of international collaboration. The national strategies of the EU28 countries and the European collaboration framework give rise to the strategy of the European Energy Union, where the research and innovation arm is constituted by the SET-Plan [2]. The operation of the SET-Plan is explicated through the different initiatives: ETIPs (focusing on stakeholders under the main driver of the industrial operators and technology providers), EERA (focusing on public research centres and universities) and IWGs (where the main actors are governments representatives highlighting and aligning the national policy priorities). EERA and IWGs, are mostly financed by national research funds and aim at aligning the national research priorities with the SET-Plan. ETIPs address mainly the European research priorities and give indication and feedback to the SET-Plan and the related funding schemes (for example Horizon 2020). National and European research frameworks are amongst the actors of the Technology Collaboration Platforms (TCPs) of the IEA, the main global research framework. Some of the European governments, in the light of their national energy strategies, participate to the CEM initiatives and campaigns and through their national research strategies and resources to some (or all) the Innovation Challenges of Mission Innovation. The mutual relations among the main initiatives are presented in a simplified flow diagram as shown in Figure1. Details of these initiatives are obtained in [1].

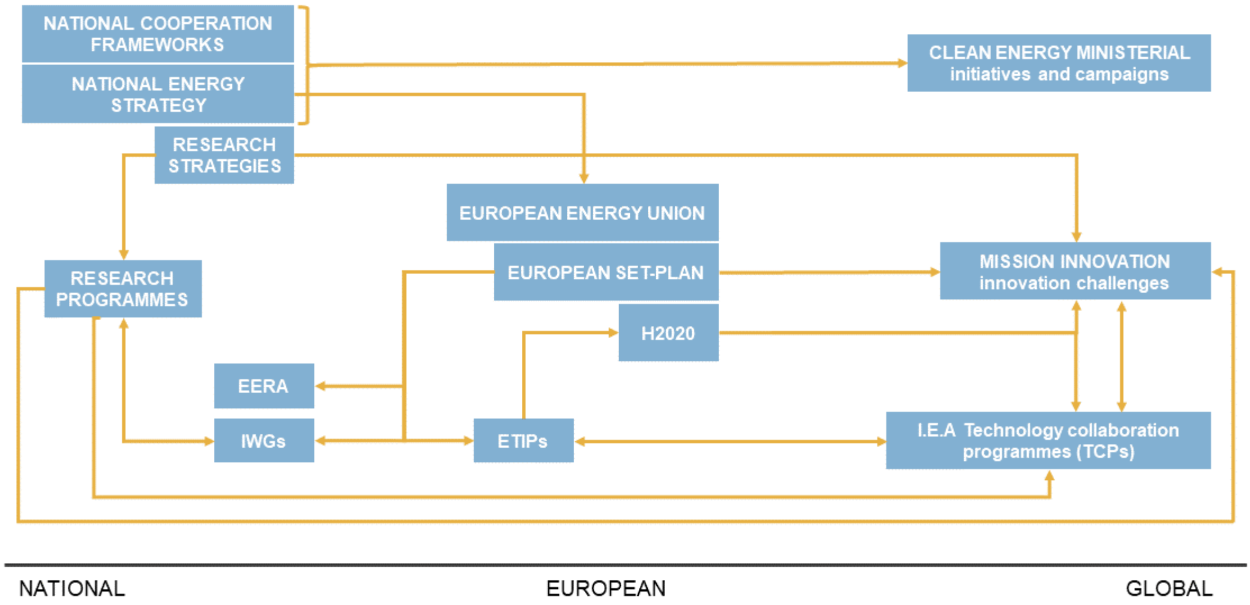

Figure 2.1 Simplified flow and relations among national, European and global initiatives in the field of clean energy technologies and solutions [1]

In the context of PANTERA, to identify the R&I status and activities on smart grid towards the development of integrated energy systems at national and EU level, some of the important initiatives are briefly discussed as follow;

2.1.1 International Initiatives

The ***International Energy Agency (IEA)*** is a key global player in the study, survey and scenario setting of clean technologies. Under the guidance of the IEA Governing Board, the Committee on Energy Research and Technology (CERT) oversees the technology forecasting, analyses and the research, development, demonstration and deployment (RDD&D) strategies of the IEA Secretariat, notably through its flagship technology tracking project, Tracking Clean Energy Progress (TCEP), and the series of Technology Roadmaps. The CERT also provides strategic guidance to its Working Parties, Experts' Groups and the Technology Collaboration Programmes (TCPs) [3]. The TCPs are a complex network with 38 collaborative partnerships exchanging knowledge and conducting various levels of research and technology analysis. One of the most important TCPs is **International Smart Grids Action Network (ISGAN)** which is the only global, government-to-government forum on Smart Grids [4].

Mission Innovation (MI) is a global initiative of 23 countries and the European Union (representing more than 80% of global GHG emissions and of global clean energy R&D budgets) [5]. As part of the initiative, participating countries have committed to seek to double their governments' clean energy research and development (R&D) investments over 5 years (starting from the benchmark of 15 b$/year to reach after 5 years the total investment of 30 b$/year), while encouraging greater levels of private sector investment in transformative clean energy technologies. MI has identified 8 Innovation Challenges (ICs) that are global calls to action aimed at accelerating research, development and demonstration (RD&D) in technology areas that could provide significant benefits in reducing greenhouse gas emissions, increasing energy security and creating new opportunities for clean economic growth. IC1: Smart grids is one of these IC under the MI.

The ***Clean Energy Ministerial (CEM)*** is a high-level global forum to promote policies and programmes that advance clean energy technology, to share lessons learned and best practices and to encourage the transition to a global clean energy economy [6]. Initiatives are based on areas of common interest amongst participating governments and other stakeholders. Together, the 25 countries and the European Commission that are members of the CEM account for about 90% of global clean energy investments and 75% of global greenhouse gas emissions. They also fund the vast majority of public research and development in clean energy technologies. CEM initiatives focus on empowering energy decision makers around the world with the up-to-date information and tools they need to improve the policy environment for clean energy. This low-cost, high-impact technical work also facilitates international coordination that amplifies each government's clean energy deployment efforts.

ISGAN TCP under the IEA is also an initiative of CEM. One of the **objective of ISGAN** is to develop a global framework and related analyses that can identify, define, and quantify in a standardized way the benefits which can be realized from the demonstration and deployment of smart grids technologies and related practices in electricity systems. ISGAN is developing smart grid toolkits analysing the other smart grid technologies and tools adopted by some of the well-known organisations in this area of smart grid.

The ***Electric Power Research Institute (EPRI)*** [7] is one of these organisations closely working with ISGAN where EPRI's methodology to BCA (Benefit-Cost Analysis) is considered as base case [8]. Other departments such as DOE (Department of Energy, USA) and European Commission (EC)'s Joint Research Centre (JRC) also developed its own BCA framework as an improvement of the EPRI methodology [9]. It is to be noted that EPRI is an independent, non-profit organisation for public interest energy and environmental research. They focus on making electric power safe, reliable, affordable, and environmentally responsible. EPRI is also highly involved with different stakeholders in relation to develop the Smart Grid Roadmap Methodology with a particular emphasis on stakeholder's benefit [10].

2.1.2 European Initiatives

European Technology and Innovation Platforms (ETIPs) are recognised as key industry-led communities to develop and implement the SET-Plan R&I priorities, with the aim to foster innovation in low-carbon energy technologies and bring such new technologies to the market. In order to adequately cover all the technologies required for the energy transition, ETIPs are divided into 8 industrial collaboration frameworks and of them ***ETIP SNET (ETIP Smart Networks For Energy Transition)*** is the European technology platform on energy networks [12]. It gathers stakeholders in the energy networks sector under the coordination of industrial operators (network operators and technology providers), for the indication to the European Commission research and innovation priorities. This initiative also monitors the achievement of technological, regulatory and regulatory goals that enable the dissemination of intelligent network solutions.

An overall view of the range of activities of the European initiatives across the components of the integrated energy system selected is reported in Figure 2.2 [1]. The figure reports, on the right-hand side the initiatives, in ascending order of number of relations (proceeding clockwise from 00h00h to

06h00) and on the left part of the quadrant the components of the energy system, in ascending order of interest (proceeding clockwise from 06h00 to 12h00).

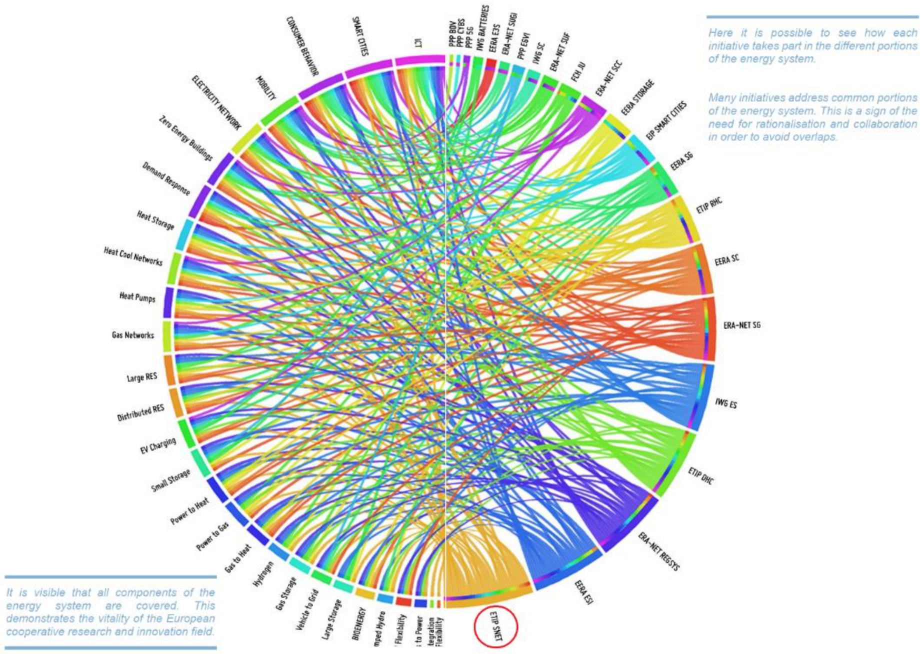

Figure 2.2 Qualitative relations diagram between European initiatives and the portions of the integrated energy system [1]

The overall image that emerges shows at first that all portions of the integrated energy system are covered: this is a sign of vitality of the European cooperative research and innovation field. The second message from the figure is the absolute and urgent need of rationalisation and collaboration. In fact, most of the targets are hit by several lines showing that different initiatives address in parallel the same subjects (at least partially) with a potential risk of overlap. Of these initiatives, it is also illustrated that ETIP SNET covers all the components of integrated energy system. This is also reflected in their vision 2050 [13] for the decarbonised integrated energy system and roadmap [14] towards the achievement.

ETIP SNET Vision 2050 for the Energy system realises that the maximisation of the use of all type of renewables will be possible, allowing to meet environmental challenges, bringing affordable energy to societies while ensuring security of supply. But, such a vision cannot come alone, one of the key recommendations of the vision is to: “achieve fully- coordinated participation of all ETIP SNET stakeholders in all energy systems areas, avoiding silo visions, missions, roadmaps and implementation plans.”

The ***BRIDGE initiative*** - supported by Horizon 2020, the biggest Research and Innovation funding programme ever supported by the European Commission - unites R&I projects in the areas of Smart Grid, Energy Storage, Islands, and Digitalisation to create a structured view of cross-cutting issues encountered in the demonstration projects. Its aim is to foster knowledge sharing among projects as well as a dialogue between innovation and market regulation, through different Working Groups (Data Management, Business Models, Regulation, and Customer Engagement) and task forces of interest. All with the goal to increase the impact that projects make in the ‘real world’ to speed up the energy transition and to possibly help repair the economic and social damage brought by the coronavirus pandemic [15].

2.1.3 National Approaches

National energy and climate plan (NECP) is obligatory to be developed by each EU Member State as an integrated national plan to meet the EU's energy and climate targets. The national plans outline how the EU Member States intend to address (i) energy efficiency; (ii) renewables; (iii) greenhouse gas; (iv) emissions reductions; (v) interconnections and (vi) **R&I (research and innovation)** strategy.

This approach requires a coordination of purpose across all government departments. It also provides a level of planning that will ease public and private investment. The fact that all EU Member States are using a similar template means that they can work together to make efficiency gains across borders [16].

2.2 Review on project evaluation methods

Some of the initiatives have developed processes/methods to evaluate the completed/on-going projects based on their individual plan/strategy. An analysis of completed and ongoing R&I projects allows a more complete picture to be created of the R&I questions that have been answered, and to identify \ needs and so define the future R&I agenda. In this section we highlight three different approaches to smart grid R&I project evaluation.

2.2.1 ETIP SNET methodology

ETIPSNET is the European Technology & Innovation Platforms (ETIP) The ETIPS are European Commission support initiatives to bring together industry and academic stakeholders and experts from the energy sector. The ETIP Smart Networks for Energy Transition (SNET) aims to guide Research, Development & Innovation (RD&I) to support Europe's energy transition. It regularly updates a Strategic Research and Innovation Roadmap, and reports on the implementation of RD&I activities at European, national/regional and industrial levels.

To meet these needs it has developed a roadmap from 2017-2026 which has been updated for 2020-2030 with new structure to reflect the R&I needs for Integrated Energy System (IES) as it is targeted in vision 2050. The project evaluation methods that have been adopted in this study to analyse the projects to align with both roadmaps are discussed below.

<u>Methodology based on ETIP SNET roadmap 2017-2026</u>

A ***10-year RD&I roadmap covering 2017-26*** was adopted in 2016 [17]. This roadmap addressed smart electricity grids, interactions with gas and heat networks and the integration of all flexibility solutions into energy systems, including energy storage and power conversion technologies. The roadmap set out a list of high-level topics ***clustered*** in a tree like structure by a Transmission/Distribution focus, with sub lists of ***functional objectives*** for each topic, as shown in Tables 2.1 and 2.2. The Roadmap set out each functional objective as a R&I theme specifying the associated challenge, objectives, scope and specific tasks.

Table 2.1 Functional objectives (topics) for the Distribution System Operators

Cluster (main activity)	FO ID	Functional Objectives
C1 – Integration of smart customers and buildings	D1	Active demand response
	D2	Energy efficiency from integration with smart homes and buildings
C2 – Integration of decentralised generation, demand,	D3	System integration of small DER
	D4	System integration of medium DER
	D5	Integration of storage in network management

storage and networks	D6	Infrastructure to host EV/PHEV – Electrification of transport
	D7	Integration with other energy networks
	D14	Integration of flexible decentralised thermal power generation
C3 – Network operations	D8	Monitoring and control of LV network
	D9	Automation and control of MV network
	D10	Smart metering data processing and other big data applications
	D11	Cyber security (system approach)
C4 – Planning and asset management	D12	New planning approaches and tools
	D13	Asset management

Table 2.2 Functional objectives (topics) for the Transmission System Operators

Cluster (main activity)	FO ID	Functional Objectives
C1 – Modernization of the network	T1	Optimal grid planning
	T2	Smart asset management
	T3	New materials and technologies
	T4	Environmental challenges and stakeholders
C2 – Security and system stability	T5	Grid observability
	T6	Grid controllability
	T7	Expert systems and tools
	T8	Reliability and resilience
	T9	Enhanced ancillary services
C3 - Power system flexibility from generation, storage, demand and network	T10	Storage integration
	T11	Demand response
	T12	RES forecast
	T13	Flexible grid use
	T14	Interaction with non-electrical energy networks
	T22	Flexible thermal power generation
C4 - Economic	T15	Market-grid integration
	T16	Business models
	T17	Flexible market design
C5 – Digitalization of power system	T18	Big data management
	T19	Standardization and data exchange
	T20	Internet of Things
	T21	Cybersecurity

ETIP SNET adopts a collaborative process and a rolling plan approach. A three-year implementation plan was agreed in consultation with ETIP SNET members identifying what R&I should be conducted in the near term to deliver the smart grid FUNCTIONALITIES set out in the roadmap over the longer term [18]. This report gives more detailed descriptions of each of the topics, setting out what kind of R&I funding scheme and budget is necessary to address the topic fully. It also describes the technology readiness level and which type of partners should participate.

ETIP SNET had developed a project evaluation methodology based on this roadmap to understand the overall R&I progress at EU level. At this purpose, ETIP SNET analysed 121 completed and ongoing SG RD&I projects up to 2019. The Projects were firstly asked to which cluster(s) they contributed, then to which FO(s). For the selected FOs, the Projects screened the different tasks and answered targeted questions. This methodology aimed to analyse and to disseminate results from relevant smart grid RD&I projects. The report consolidates the views of the ETIP SNET experts and project questionnaires on the level to which the FOs in the roadmap had been achieved. It measures the coverage of each RD&I FO in the roadmap and with inputs from the ETIP SNET experts decided which RD&I activities to maintain, and which activities were sufficiently well covered so that the R&I activity could be considered fully addressed to be removed from the list of R&I needs [19]. The topics and FOs that were assessed as Not addressed, Partially addressed, or Totally addressed. Experts also made proposals for the evolution, removal, reformulation, or merging of existing FOs, or the addition of new tasks. This methodology has been adopted here in this work, as shown in Figure 2.3, to study the progress at national level for that selected countries. We are defining this as "Transmission/Distribution Network Approach". Figure2.4 shows the ETIP SNET coverage assessment of the roadmap topics in early 2020.

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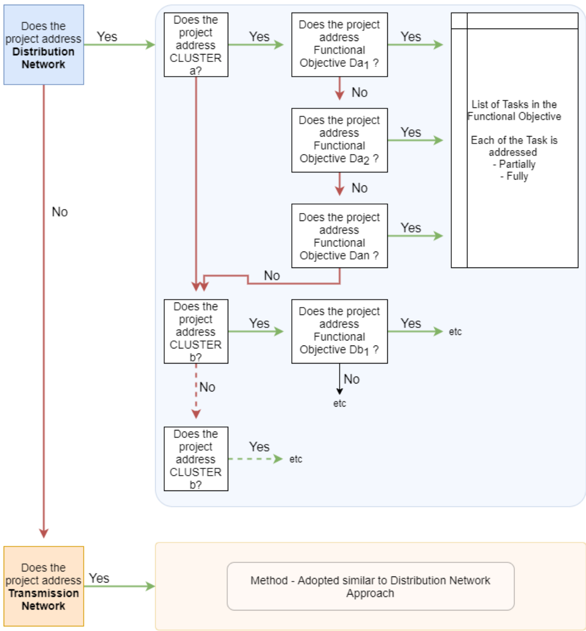


Figure 2.3 ETIP SNET method/process to identify R&I cluster and FUNCTIONALITIES of a project

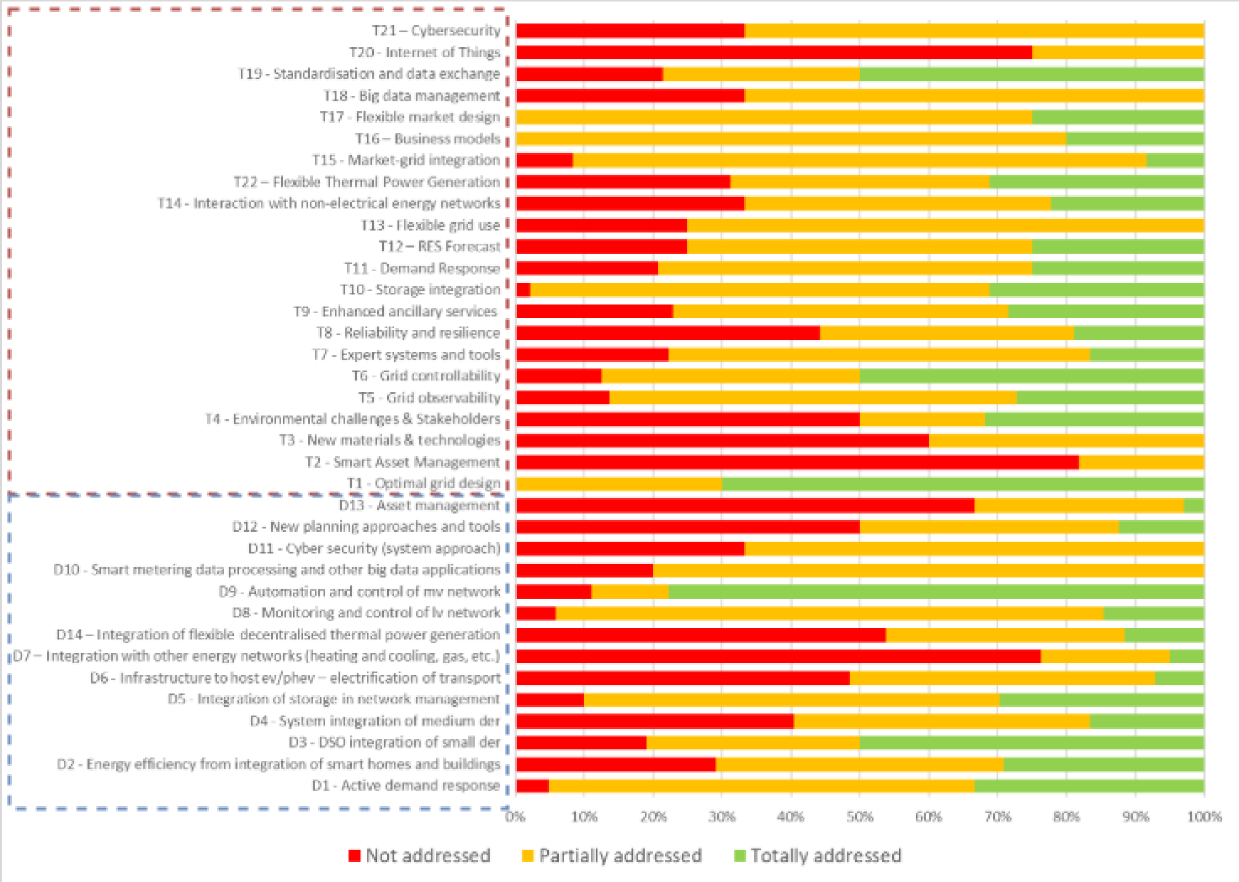


Figure 2.4 ETIP SNET R&I topic coverage assessment

Further assessment of the partially or not addressed existing topics, and proposed new topics allowed the original topics to be updated to a new set of research areas (topics) and FO in the revised roadmap 2030. This assessment was conducted through a consultation process with the ETIP SNET working group members.

<u>Methodology based on ETIP SNET roadmap 2020-2030</u>

The updated ***R&I roadmap 2030*** is more focused on integrated energy system approach where instead of cluster and functional objectives (as defined in the previous roadmap), translates these requirements into 12 high-level functional specifications for the European energy system of 2030, called hereafter FUNCTIONALITIES, and defines dedicated maturity levels for each of them (expressed in Technology Readiness Level -TRL). To turn this FUNCTIONALITIES into reality by 2030, 6 Research Areas (shown in Table2.3) are identified and described, complemented by 120 research and demonstration activities, referred to as tasks in this ETIP SNET R&I Implementation Plan 2021-2024 [20]. Each task is then associated to a Research Area/Topic, and to an expected level of impact towards achieving one or more of the 12 FUNCTIONALITIES specified for the energy system of 2030. This FUNCTIONALITIES is then linked to the building blocks as defined in the vision 2050 and also shown in Table 2.4. This will demonstrate the R&I path in future (2030+..) to achieve the decarbonisation of the integrated energy system in 2050. A basic diagram of this relation is shown in Figure2.5.

Table 2.3 ETIP SNET R&I Research Areas as defined in roadmap 2030

RA (No)	Research Area (RA)	RA Explanation

1	CONSUMER, PROSUMER and CITIZEN ENERGY COMMUNITY	Citizen and prosumer information, empowerment and engagement
2	SYSTEM ECONOMICS	Business models, market design and market-governance
3	DIGITALISATION	“Communication and data handling for the digitalisation of energy systems functionalities (including Data, Cyber and System security)
4	PLANNING – HOLISTIC ARCHITECTURES and ASSETS	Energy system architectures, design and planning; technology solutions, asset management, maintenance; System Stability and resilience.
5	FLEXIBILITY ENABLERS and SYSTEM FLEXIBILITY	Adapting all energy components to provide flexibility to the system (Flexibility in Demand, Generation, Storage & Energy Conversion, Network, Transport)
6	SYSTEM OPERATION	System supervision, monitoring, control, reliability, resilience and automation (State estimation and supervision, short-term, medium and long-term control), and control room operators’ skills enforcement

Table 2.4 ETIP SNET R&I FUNCTIONALITIES as defined in roadmap 2030

Building blocks (ETIP SNET Vision 2050)	**FUNCTIONALITY (Full name)**	**Short FUNCTIONALITY**[1]
The efficient organisation of energy systems	F1 Cooperation between system operators	F1 Cooperation
	F2 Cross-sector integration	F2 Cross-Sector
	F3 Integrating the subsidiarity principle - The customer at the center, at the heart of the integrated energy system	F3 Subsidiarity
Markets as key enablers of the energy transition	F4 Pan-European wholesale markets	F4 Wholesale
	F5 Integrating local markets (enabling citizen involvement)	F5 Retail
Digitalisation enables new services for Integrated Energy Systems	F6 Integrating digitalisation services (including data privacy, cybersecurity)	F6 Digitalisation
Infrastructure for Integrated Energy Systems as key enablers of the energy transition	F7 Upgraded electricity networks, integrated components and systems	F7 Electricity Systems and Networks
	F8 Energy System Business (incl. models, regulatory)	F8 Business
	F9 Simulation tools for electricity and energy systems (SW)	F9 Simulation
Efficient energy use	F10 Integrating flexibility in generation, demand, conversion and storage technologies	F10 Flexibility
	F11 Efficient heating and cooling for buildings and industries in view of system integration of flexibilities	F11 Heating & Cooling
	F12 Efficient carbon-neutral liquid fuels & electricity for transport in view of system integration of flexibilities	F12 Transport

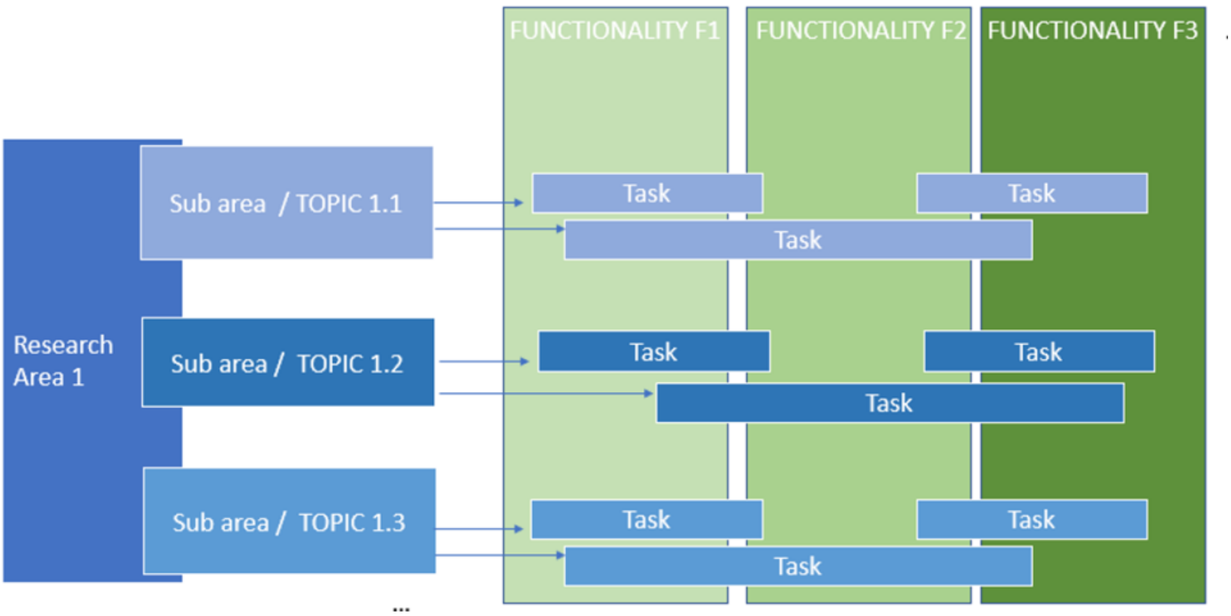


Figure 2.5 Relation among the Research Area/Topic, Task and FUNCTIONALITIES as defined in the ETIP SNET roadmap 2030

It is to be noted that, a project evaluation methodology based on the roadmap 2020-2030 has not yet been developed. For this reason, a similar approach to that adopted in the previous roadmap is used. The proposed methodology to evaluate the projects based on the new roadmap is shown in Figure 2.6. We are defining this as an "Integrated Energy System Approach". However, the consortium of the PANTERA project is to work in designing an evaluation methodology that will be more universal in approach and based on the more robust relationship of: Project to technology to FUNCTIONALITIES. This approach will overcome the complexities of research areas, sub-areas and tasks which are more call related groups than system approach which is more robust, flexible and inherently of universal character.

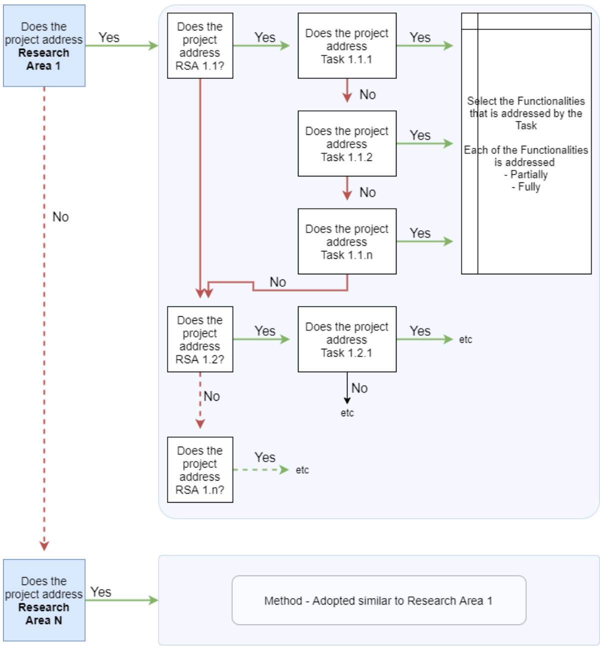


Figure 2.6 PANTERA proposed methodology based on roadmap 2020-2030

2.2.2 **EPRI methodology**

EPRI proposes a global collaborative approach to develop a comprehensive repository of data and information that can be used to move toward the Integrated Grid. They set out an action plan listing technical, operational, environmental, and financial activities to achieve an integrated grid [21]. This was developed in consultation with different stakeholders from the energy sector including utilities, regulatory agencies, equipment suppliers, nongovernmental organizations, and other interested parties. EPRI also proposes the creation of an assessment framework for cost benefit analyses of different technologies to deliver grid integration. The purpose of the framework is to identify demonstration projects for implementation [22].

PANTERA is reviewing EPRI's smart grid roadmap methodology (SGRM) as an international initiative. SGRM adopted five key steps: Vision, Requirements, Assessment, Planning and Roadmap Implementation, as shown in Figure2.7. Within each step there are three or four recommended tasks however, depending on the Roadmap objectives, some tasks are optional. Drilling down further, each task is addressed by one or more possible task methodologies. The optimal methodology is selected depending on the client's needs. For example, within the Assessment step there is a task called "Select Focus Technologies". For some Roadmaps the method used for selection involved scoring and ranking the technology by impact and effort/risk. In other cases, a more detailed scoring method was used. Details can be found in [10].

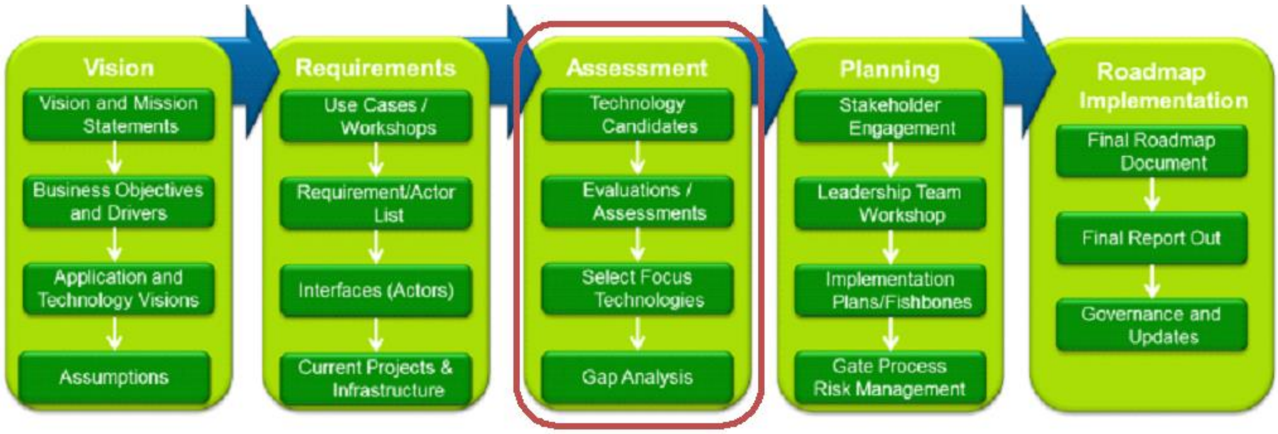


Figure 2.7 EPRI Smart Grid Roadmap Methodology

As a part of assessment and technology selection/mapping, EPRI adopt the first step to identify the candidate technologies, applications and standards, as shown in Figure2.8. Sources for this list include the NIST Standards Framework and Roadmap, the SGIP Catalog of Standards, published industry technology roadmaps and discussion documents such as; the Massachusetts Institute of Technology (MIT) study on the Future of the Electric Grid, the Department of Energy, National Energy Technology Laboratory (NETL) Modern Grid reports and the California Utility Vision and Roadmap prepared by EPRI for the California Energy Commission [10].

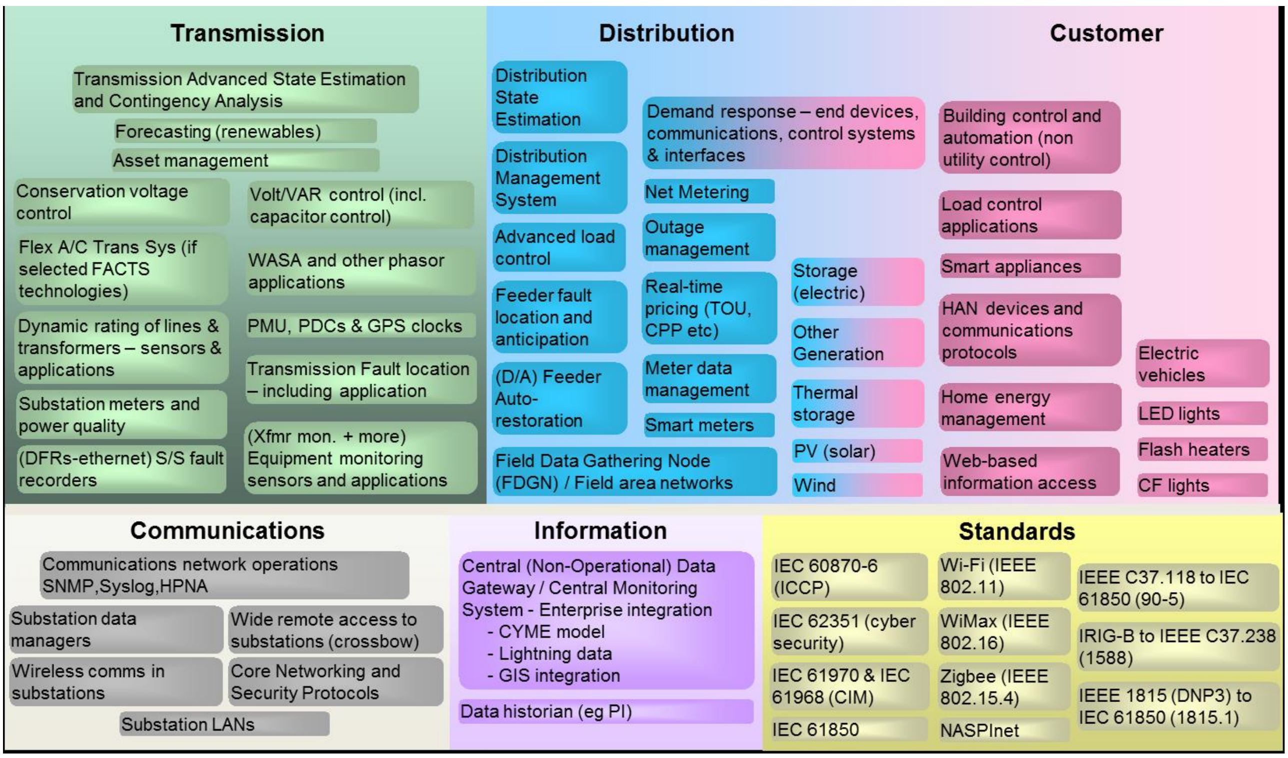


Figure 2.8 EPRI Key Technology Domains and considered list of technologies for the Smart Grid [10]

2.2.3 BRIDGE methodology

BRIDGE considers only the projects funded under the H2020 program. By this time, 64 projects were analyzed in the areas of Smart Grid, Energy Storage, Islands, and Digitalisation over the last 5 years (2014-2019). It aims at fostering the exchange of information, experience, knowledge and best practices among its members. BRIDGE wants to provide field experience, feedback and lessons learned from the participating projects to help overcome the barriers to effective innovation. It aims at gathering coordinated, balanced and coherent recommendations to strengthen the messages and maximize their impacts towards policy makers in view of removing barriers to innovation deployment [23].

As can be seen, BRIDGE is a meeting point of projects which generate very useful information, knowledge and lessons learned that should be made useful in all corners of the EU and mainly effectively used to generate interest and activity in countries with low R&I budget.

Cross cutting issues can sometimes be more important than technology and system solutions for transforming good results into useful contributions to the real economy. They are usually interlinked and highly similar between projects forming a good basis for cooperation and combined effort for improved solutions. This need was the driving force for creating BRIDGE and for this reason it has played an important role in formulating a governance structure for BRIDGE to operate. This has led the BRIDGE cooperation group to activate four different types of activities (Working Groups), addressing cross-cutting issues that are enlisted in the drawing.

BRIDGE has a good coverage in Europe with projects that bring partners from nearly all over the Europe giving a very good basis for working in the direction of R&I activities in the low spending countries. It is of vital importance that the activities that bring projects delivering their knowledge base and best practice case studies to the wider audience of Europe is done with the European perspective with embedded safeguards for covering the unrestricted interests of all Europeans.

Regarding the type of the stakeholders engaged with the projects, BRIDGE has classified them as: Consumers, Regulated Operators (TSOs & DSOs), Regulators, Local Energy Communities (LEC), Technology Providers (Power, Storage and ICT), Electricity Market Players (Energy Suppliers, Aggregators and Market Operators), R&I and Others, existing the possibility of belonging to more than one of these groups.

On the other hand, BRIDGE has also established six different categories with regard to the technologies and services tackled by the projects as shown in Table2.5 to perform the projects classification.

Table 2.5 Smart grid Technologies for project evaluation under the BRIDGE initiative

Technologies and services	
Technologies for Consumers	Demand response
	Smart appliance
	Smart metering
Grid technologies	HVDC
	HVAC
	Multi terminal
	Protections
	HVDC breaker
	Inertia
	Network management tools
	Micro-grid
Large-scale storage technologies	Power to gas
	Compressed Air Energy Storage
	Hydro storage

	Flywheel
Small-scale storage technologies	Batteries
	Electric Vehicles
	Power to heat
Generation technologies	Wind Turbine
	PV
	Solar thermal
	Biogas
	Micro-generation
Market	Electricity market
	Ancillary services

2.2.4 JRC "Smart Electricity Systems and Interoperability"

The Joint Research Centre (JRC) is European Commission’s in-house science service, perform independent scientific research and support EU policy-making on transformations towards smarter and interoperable electricity systems. It provides the scientific advice and technical know-how to support a wide range of EU policies. JRC work revolves around four pillars:

(i) Data Gathering and Processing - constantly develop, update extensive databases of power systems/networks and smart grid projects in Europe. This work further feeds into its modelling, experimental and dissemination activities.

(ii) Smart Grid Interoperability Lab - analyses behaviours and characteristics of evolving power grids incorporating more renewables, electric vehicles, dispersed energy resources.

(iii) Integrated Assessment - to support policy initiative and study smart grids as complex techno-socio-economic systems with multiple physical, cyber, social, policy, and decision-making layers.

(iv) Cooperation and Dissemination - builds upon synergistic cooperation with key stakeholders to reach a critical mass.

JRC holds the biggest and most comprehensive smart grid database which includes a total of 950 smart grid projects, launched from 2002 up until today, amounting to €5 billion investment. JRC has also developed an interactive map, as shown in Figure2.9, to highlight the projects key information. Recent report, based on the survey analysis, finds that strong differences exist between Member States (MS) in the number of projects and the overall level and pace of investment in smart grid R&I activities [24]. It is found that that 15 out of 28 MS spending less than 5% of R&I investment in the area of smart grid. JRC also identifies six domains, as shown in Figure2.10, where smart grid projects are actively demonstrating the activities. The domains with highest investment are smart network management, demand-side management and integration of distributed generation and storage, together accounting for around 80% of the total investment. PANTERA CSA is an H2020 project under the call Pan-European Forum for R&I on Smart Grids, Flexibility and Local Energy Networks [25].

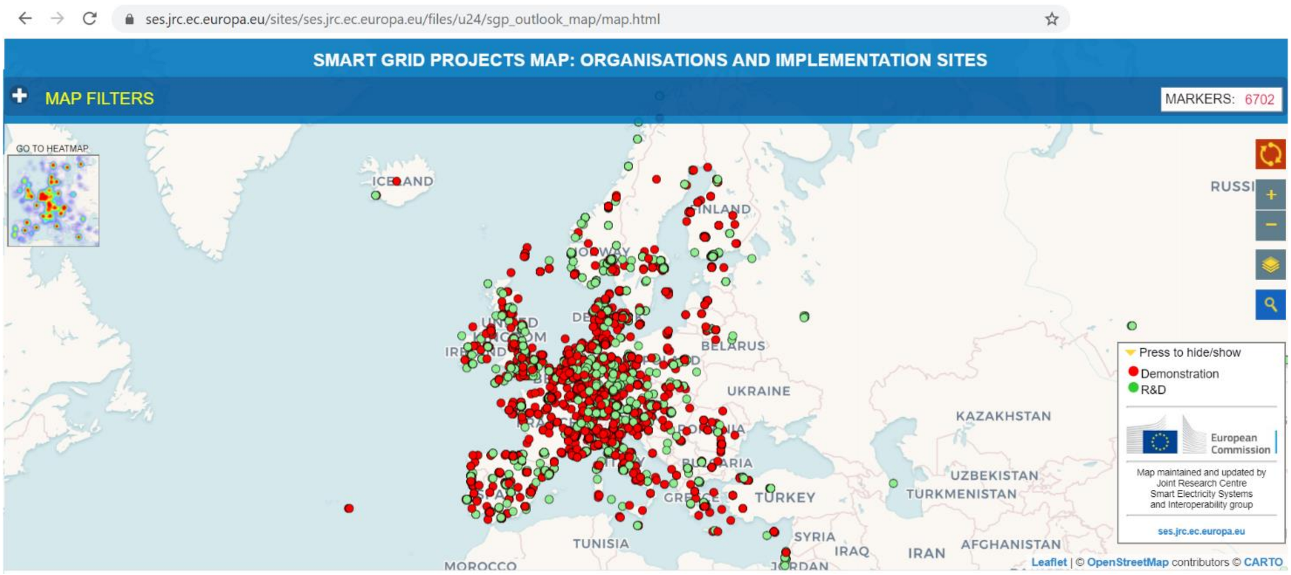


Figure 2.9 JRC interactive map on smart grid projects in EU countries

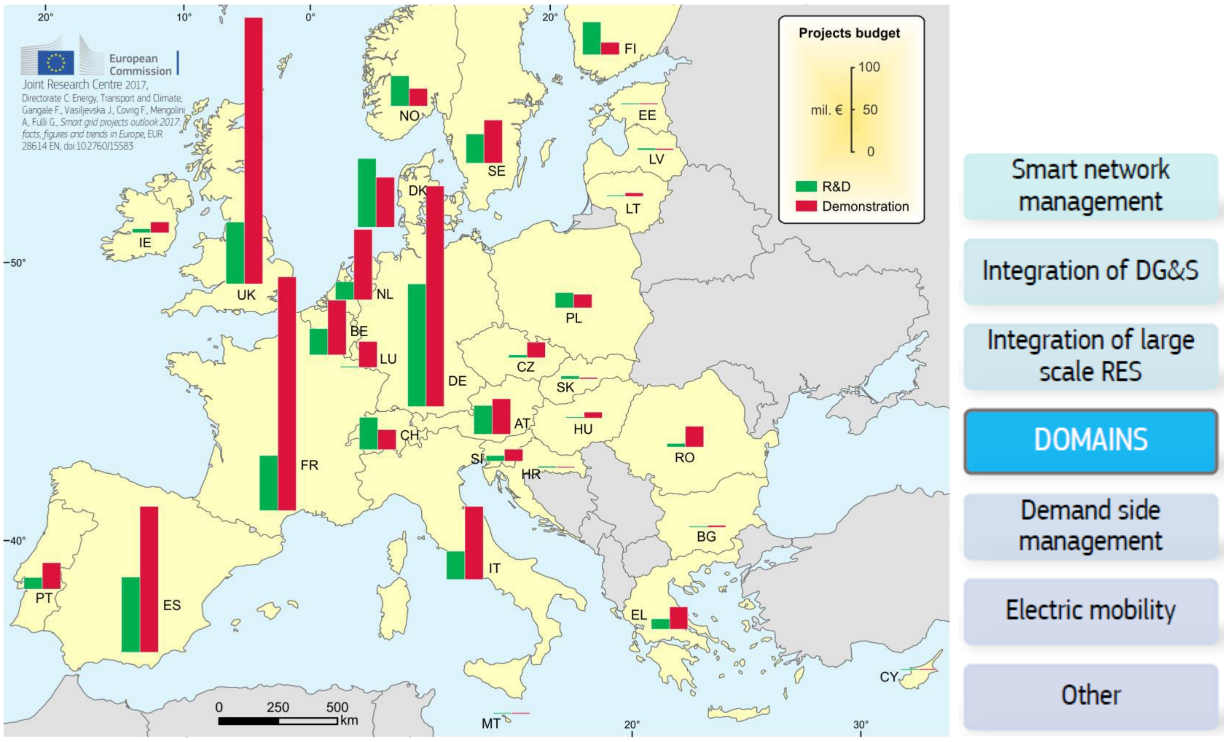


Figure 2.10 R & D and demonstration investment in the EU and research domain [24]

3 PANTERA proposed Technologies/Systems classification for Integrated Energy System

Attempts of building a suitable platform with key exploitable results from projects should be open and wide enough to cover all countries and all levels of the economy. PANTERA platform, among others, will generate quantified benefits that can operate as a driving force for targeted participation in the R&I activities of Europe. To this effect, PANTERA is working with ETIP SNET, BRIDGE andJRC to build a living platform

PANTERA is proposing the RICAP process supporting the ETIP SNET approach for the integrated energy system. Under this prism, PANTERA is proposing a list of technologies/systems for the integrated energy system that the R& I projects should be classified under. This, as already mentioned, is aimed to have a universal approach so that solid quantified feedback from all projects are given through the platform. Towards the above direction, PANTERA consortium is working closely with ETIP SNET and BRIDGE.

Following sub-sections, thus, discuss the PANTERA proposed list of technologies/systems, their mapping with BRIDGE and EPRI smart grid technologies for seamless transition and the how to align with ETIP SNET new roadmap and finally the RICAP process. It is worth mentioning that the ETIPSNET previous roadmap is investigated and the analysis is provided here. This will provide a solid baseline of how the transition between roadmaps would be performed smoothly. This applies not only for the classification but also for WP4 interviews so far(M1-M18) that were based on the previous roadmap

3.1 PANTERA Technologies/Systems Classification

At the highest level, a Smart Grid infuses Information and Communications Technologies with the existing electric power infrastructure (grid) to improve the efficiency and performance of the grid and provide electricity consumers with more information, options and control of their services. A Smart Grid can be thought of as a collection of new technologies that are integrated into the existing electricity infrastructure that enable new or enhanced capabilities. For example, Smart Grid Technologies can include:

- Communications networks
- Sensors
- Data processing and management
- Phasor Measurement Units and other intelligent electronic devices
- Smart meters and related applications
- Software applications such analytics
- Communications protocols

Electricity Infrastructure can include:

- Transmission lines
- Substations
- Transformers
- Distribution lines
- Generation
- Distributed generation
- Loads

New or enhanced Capabilities can include:

- Dynamic line rating
- Situational awareness
- Demand response
- Automated fault location, isolation and recovery
- Automated voltage management

- Smart metering
- Usage information to consumers
- Condition-based maintenance

A synthesis of the available Technologies into the following list can be considered adequately to suit the purpose of the classification of projects through BRIDGE, ETIP SNET and the PANTERA platform. This synthesis has taken all the available data from the reports of EPRI but following the philosophy of the BRIDGE analysis as indicated to us by INTENSYS4EU (INTegrated ENergy SYStem, a pathway for EUrope) [26] and bearing in mind the targeted FUNCTIONALITIES of the 10 year and Implementation Plans of ETIP SNET. Table3.1 shows the PANTERA proposed Technologies/Systems for integrated energy system. The content of Table 3.1 has been agreed already between BRIDGE and WT3 Energy Experts of WG5 of ETIP SNET and passed through many iterations before finalization. Of course this proposal list will be validated through a solid methodology in the next and it will be included in the next deliverable of WP3

Table 3.1 PANTERA proposed Technologies and Systems for Integrated Energy System

Technologiesand Systems in support of the Functionalities			
No.	**Group of technologies**	**Technologies**	**Description**
1	**Integrated Grid**	Flexible ac transmission systems (FACTS)	Controllable power electronic equipment that will support the Transmission smart grid operations
2		Models, Tools, Systems for the operation analysis, control and the development of the integrated grid including cost elements	Advanced models, tools, systems for the operation analysis, control, state estimation and the development of the integrated grid (TYNDP etc) including cost elements
3		HVDC	High Voltage Direct Current overhead and underground grid.
4		Forecasting (RES)	Advanced forecasting tools (RES) that will allow a low estimation error and provide an accurate feedback for the actors that need these type of services. E.g. aggregators, operators, RES owners, ESP, the market operator etc.
5		Asset management	The methodology, procedures, the devices and software that allow the efficient management of assets of the integrated grid.
6		Outage management, fault finding and associated equipment (including protection)	The methodology, procedures, the devices and software that allow the efficient management of outages including fault finding of the integrated grid.
7		Equipment and apparatus of the integrated grid	All the primary equipment (rated at the rated voltage of the system) and apparatus constituting the integrated grid including Power

			guards and limiters.
8		Equipment, sensing, monitoring, measuring for analysis, solutions and control	Equipment, sensing, monitoring, measuring for analysis, solutions and control including procedures and software that make observable the integrated grid. These include the devices and the procedures that allow PMUs, PDCs and GPS to be efficient tools of the smart grid paradigm
9		Advance distributed load control	Software or hardware devices or procedures that allow advanced distributed control of distributed assets of the grids including different type of DERs and load
10		Feeder auto-restoration / self-healing	Advanced procedures and systems that facilitate the feeder auto-restoration thus implementing the self- healing of the interconnected system
11		Smart metering infrastructure	All the procedures and systems that are related to smart meters as devices and complete bi-directional communication link between metering data management systems and end users.
12	**Customers and market**	Distributed flexibility, load management & control and demand response including end devices, communication infrastructure and systems	All procedures, controls and devices that facilitate distributed flexibility, load management including explicit demand response and system
13		Smart appliances	Smart appliances that allow customer market participation and smart load control.
14		Building control, automation and energy management systems	All procedures, controls and devices that secure smart building automation including home energy management, active control, monitoring and market participation
15		Electric vehicles	Electric vehicles are vehicles based on battery or fuel cell resource for transport needs.
16		Energy communities	Its primary purpose is to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates. May engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;
17		Lighting	Any apparatus emitting light and related systems.

18		Electricity market	All elements of the electricity market including platforms that enable wholesale, retail, real time pricing / spot, flexibility, aggregated and peer to peer trading including ancillary services, etc.
19	**Storage**	Storage Electric	In the electricity system, apparatus capable of deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy.;
20		Thermal Storage	The main parts and all auxiliary components that form a ready to integrate device capable of storing thermal energy for use at a later stage.
21		Power to gas	The main parts and all auxiliary components that form a ready to integrate device from technologies that uses electrical power to produce a gaseous fuel for storing or use otherwise.
22		Pumped storage	The main parts and all auxiliary components that form a ready to integrate system to operate as a Pumped storage system which is the process of storing energy by using two vertically separated water reservoirs. Water is pumped from the lower reservoir up into a holding reservoir. Pumped storage facilities store excess energy as gravitational potential energy of water.
23		Other Storage	The main parts and all auxiliary components that form a ready to integrate device capable of storing energy other than the above systems.
24	**Generation**	Flexible generation	The main parts and all auxiliary components that form a ready to integrate device
25		Solar including PV & CSP	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from PV or CSP technologies.
26		Wind	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from wind technologies.
27		Hydropower	The main parts and all auxiliary components that form a ready to integrate system capable of generating electricity from flowing hydro.
28		Hydrogen & sustainable gases	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from hydrogen and other sustainable gases.

29		Other generation	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electrical energy other than the above.
30	**Digitalization, Communication and Data**	Communication networks including devices and systems for signals and data connectivity and solutions	Any combination of equipment and systems forming a communications network as a group of *nodes* interconnected by *links* that are used to exchange messages between the nodes. The links may use a variety of technologies based on the methodologies of *circuit switching*, *message switching*, or *packet switching*, to pass messages and signals including Local Area Networks, Home Area Networks and web-based solutions and cloud services for smart gird operations
31		Digital Twins	Any combination of equipment and systems forming Digital twins that are virtual replicas of physical devices that can used to run simulations before actual devices are built and deployed.
32		Artificial intelligence	Any combination of equipment and systems forming Artificial intelligence that simulates human intelligence in machines that are programmed to think like humans and mimic their actions.
33		Data and cyber security including repositories	Any combination of equipment and systems offering Cyber security for defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks, including generated data from the interconnected system with related repositories other than that related to the MDMS (Meter and Data Management System).

3.2 Mapping of the PANTERA technologies against EPRI & BRIDGE initiatives

It is important to show that PANTERA proposed technologies for integrated energy system are covering all the smart grid technologies that are already have been considered by EPRI and BRIDGE initiative in their project evaluation methodologies. This way, a seamless transition of classification will be secured without jeopardizing of losing critical information of the past and present projects from PANTERA database Table3.2 shows the overall classification areas of technologies that are considered in BRIDGE (Table2.5), EPRI (Figure2.7) and PANTERA (Table3.1).

Table 3.2 Overall Technology classification areas

PANTERA					
Integrated Grid	Customers and Market	Storage		Generation	Digitalization, Communication and Data
BRIDGE					
Grid	Consumers	Large	Small	Generation	-----

Technologies	and Market	Scale Storage	Scale Storage			
EPRI						
Transmission	Distribution		Customer		Communication	Information

Details of the technologies and their mapping under the areas are shown in Figure3.1. It is found that “Grid Technologies” under the BRIDGE and “Transmission and Distribution” technologies under the EPRI are very well mapped with the PANTERA defined technologies under the “Integrated Grid”. Technologies for “consumer and market” under BRIDGE and “Customer” under EPRI are almost aligned with “Customers and Market” under the PANTERA classification. Electric Vehicle is considered as “Small Scale Storage” Technology in BRIDGE, whereas for PANTERA, it is classified under the “Customers and Market” category and similar for EPRI. On the other hand, Microgrids are considered as “Grid technology” under BRIDGE. In PANTERA, it is considered as a Technical solution for enabling Energy Communities under the “Customers and Market” category. It is to be noted that, EPRI did not consider any separate classification for “Storage” or “Generation”. All the storage and generation technologies are mapped within Distribution and Customer categories. Whereas, BRIDGE ponders on small and large scale categories for storage technologies. Another important issue is that BRIDGE initiative did not consider any ICT/digitalisation technologies in their project evaluation process. Whereas, EPRI considers communication and information as separate categories.

PANTERA Proposed Classification																									
Integrated Grid															Customer and Market										
Flexible ac transmission systems (FACTS)	Models, Tools, Systems for the operation analysis, control and the developme	HVDC	Forecasting (RES)	Asset management	Outage management, fault finding and associated equipment (including protection)	Equipment, sensing, monitoring, measuring for analysis, solutions and control			Equipment and apparatus of the integrated grid		Advance distributed load control	Feeder auto-restoration / self-healing		Smart metering infrastructure	Distributed flexibility, load management & control and demand response including	Building control, automation and energy management systems			Smart appliances	Electric vehicles	Energy communities	Lighting	Electricity market		
BRIDGE Classification																									
Grid Technologies															Customer and Market										
		HVDC/ HVDC Breaker/ Multi-terminal			Protections			Network management tools	HVAC/*Multi-terminal				Inertia	Smart metering	Demand response				Smart appliances	Electric Vehicles	Microgrids		Electricity market		Ancillary services
EPRI Classification																									
Transmission & Distribution															Customer										
Flexible ac transmission systems (FACTS)	Advanced state estimation and contingency analysis (TN/DN)		Forecasting (RES)	Asset management	Fault location & application/ fault recorders/ voltage control/ Volt/VAR control (TN/DN)/ Outage management (DN)	PMU, PDCs & GPS clocks / other phasor applications	Equipment (include line rating/transformer) monitoring sensors and applications	Distribution Management System/ Field data gathering node/Field area networks		Substation meters and power quality	Advanced load control	Feeder Auto Restoration		Net metering/ Smart meters/ meter data management	Demand response-end devices, communications, control systems & interface	Building control and automation (non utility control)	Home energy management	Load control applications	Smart appliances/ Flash heaters	Electric vehicles		LED, CL lights		Real-time pricing	

Storage					Generation						Digitalization, Communication and Data							
Storage Electric	Thermal Storage	Power to gas	Pumped storage	Other Storage	Flexible generation	Solar including PV & CSP	Wind	Hydropower	Hydrogen & sustainable gases	Other generation	Communication networks including devices and systems for signals and data	Digital Twins	Artificial intelligence	Data and cyber security including repositories				
Large/Small scale Storage Technologies					Generation Technologies													
Batteries	Thermal storage	Power to gas	Hydro storage	Compressed Air Energy Storage / Flywheel	Micro-generation	PV	Wind turbine			Solar thermal / Biomass								
Storage (Distribution - Customer)					Generation (Distribution - Customer)						Communications & Information							
Storage Electric	Thermal storage					PV (solar)	Wind				Comms network operations/ Wide remote access to substations (crossbow)			Core Networking & Security protocols	Substation data managers/ Wireless comms in substations/ Substation LANs	Web based information access	HAN devices & communications protocols	Central (non-Operational) Data Gatway/Central monitoring System

Figure 3.1 PANTERA proposed technology for integrated grid and its mapping with technologies assessed by EPRI and BRIDE initiatives

3.3 Mapping the 2017-2026 roadmap to 2020-2030 roadmap of ETIP SNET

It is already mentioned that the previous roadmap considered smart grid network with more focus on transmission and distribution network. Thus, the R&I activities were divided into clusters and functional objectives (FO) with special objectives on the integration of storage and section coupling issues for future integrated energy system. Details of these cluster and FO are discussed in a previous section. Moving towards the development of a new roadmap for an integrated energy system approach, the activities are divided into research areas and FUNCTIONALITIES. The roadmap development plan is also shown in Figure3.2. Both the transmission and distribution network are now the part of the integrated grid network and hence it is very normal that the FOs in the previous roadmap now form the FUNCTIONALITIES as defined in the new roadmap, but in an integrated approach. The mapping of FO and FUNCTIONALITIES are shown in Table 3.3. Hence, PANTERA is designing a methodology that will be universal in the analysis of projects by relating to technologies and through technologies to the adapted characterization of the system which for the 2030 system are the approved 12 functionalities Thus the PANTERA strengthens the roadmap mapping process, as shown in Figure3.3, to move for the project evaluation process.

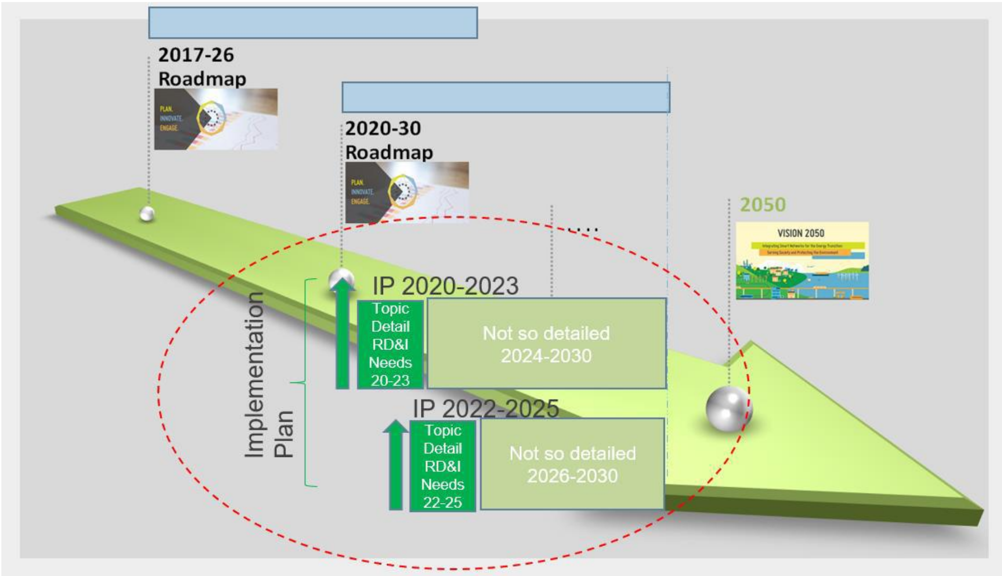


Figure 3.2 ETIP SNET roadmap development process

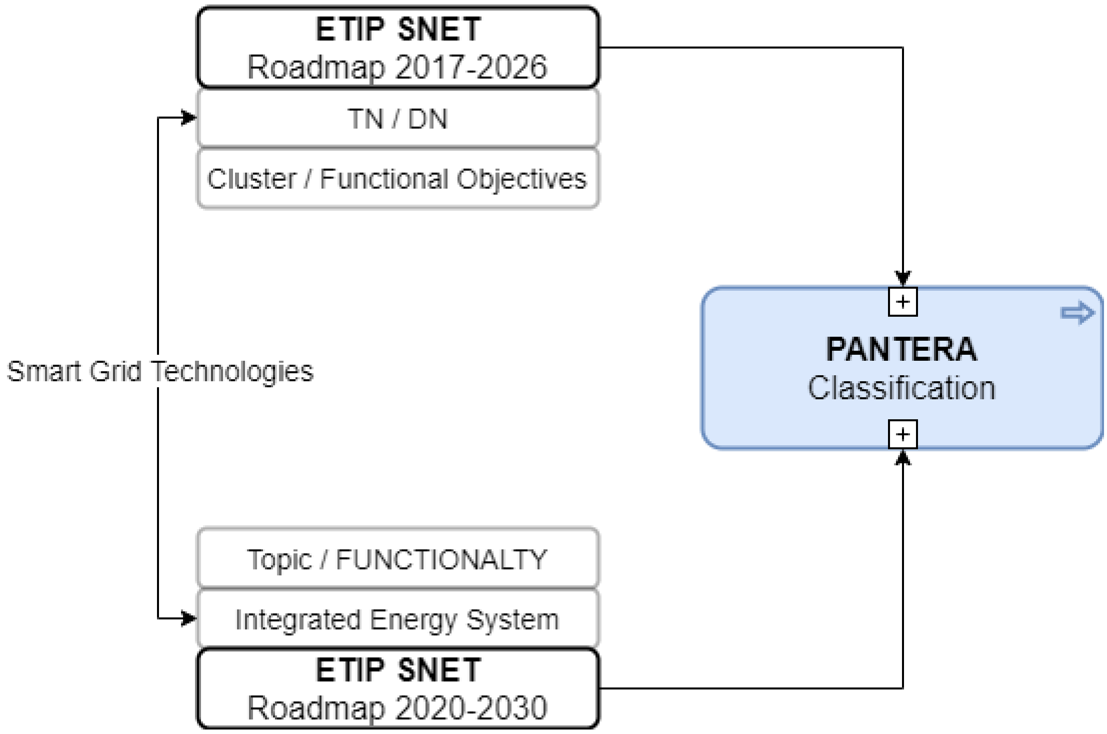


Figure 3.3 PANTERA mapping process between the roadmaps

Table 3.3 Mapping of FO (2017-2026) with FUNCTIONALITIES (2020-2030)

DN	FO	Mapping FUNCTIONALITIES
D1	Active demand response	F4, F5, F10
D2	Energy efficiency from integration with smart homes and buildings	F6, F11
D3	System integration of small DER	F10
D4	System integration of medium DER	F10
D5	Integration of storage in network management	F10
D6	Infrastructure to host EV/PHEV – Electrification of transport	F12
D7	Integration with other energy networks	F2
D14	Integration of flexible decentralised thermal power generation	F2
D8	Monitoring and control of LV network	F7
D9	Automation and control of MV network	F7
D10	Smart metering data processing and other big data applications	F6
D11	Cyber security (system approach)	F7
D12	New planning approaches and tools	F9
D13	Asset management	F1, F2, F3
TN	**FO**	**Mapping FUNCTIONALITIES**
T1	Optimal grid planning	F1, F7
T2	Smart asset management	F1, F2, F3
T3	New materials and technologies	F1, F2, F7
T4	Environmental challenges and stakeholders	F3, F7
T5	Grid observability	F1, F2, F7
T6	Grid controllability	F1, F2, F7
T7	Expert systems and tools	F9

T8	Reliability and resilience	F6, F7
T9	Enhanced ancillary services	F4, F5
T10	Storage integration	F10
T11	Demand response	F4, F5, F10
T12	RES forecast	F9
T13	Flexible grid use	F10
T14	Interaction with non-electrical energy networks	F2
T22	Flexible thermal power generation	F11
T15	Market-grid integration	F4, F5
T16	Business models	F8
T17	Flexible market design	F4, F5
T18	Big data management	F6
T19	Standardization and data exchange	F6
T20	Internet of Things	F6
T21	Cybersecurity	F6

4 R&I Status Analysis for the Member States with Low R&I activities

PANTERA is targeting to develop a universal methodology for evaluating projects and their contribution to technology and FUNCTIONALITIES maturity and thus identify the R&I needs, hence, this section starts with outlining the R&I priorities defined in the NECPs for a selection of all countries from the group that are characterised with low activity in R&I in support of the energy transition. The PANTERA team has studied the R&I activities of these countries by analysing their activities in smart grid projects. The following sub-sections presents these studies.

4.1 R&I Priorities based on NECP

It is already mentioned that the NECP outline how the EU Member States intend to address (i) greenhouse gas; (ii) emissions reductions; (iii) energy efficiency; (iv) renewables; (v) interconnections and (vi) R&I (research and innovation) strategy. PANTERA team has gone through the details of these national plans and strategies for 2030. The summary of the national targets by 2030 as outlined in the NECPs are presented in Appendix 8.1. This section is summarising the key NECP inputs in relation to R&I priorities at national level towards the achievement of 2030 targets.

4.1.1 Bulgaria

In 2018, total research and development (R&D) costs in Bulgaria in all sectors stood at 0.75 % of GDP (against an EU average of 2.11 % according to Eurostat data). In 2017, R&D costs in the private sector stood at 0.53 % (as compared to the EU average of 1.36 %), despite the significant improvement compared to 2007, particularly in the sector of Information and Communication Technologies. The share of large multinational companies in R&D investment account for more than half of total investments in the business sector. Regional concentration is also a prominent feature of the process, with more than 70 % of R&D activity concentrated in the Southwest region, and more specifically Sofia. In 2017, R&D costs in the public sector stood at 0.21 % of GDP as compared to the EU average of 0.69 %. In 2018, Bulgaria doubled its R&D budget with a view to supporting the implementation of the Scientific Research Strategy for the period 2017-2030 and had committed to gradually increase public spending on R&D to 1 % of GDP in 2025.

There is a clear need for the implementation of the latest energy technologies. Bulgaria aims to accelerate this process in order to speed up transition to clean and highly efficient energy technologies. This is one of the mechanisms for achieving a secure, sustainable, environmentally friendly and highly efficient energy sector. The implementation of new technologies will contribute to lowering technological losses in existing networks, expand the energy market, contribute to finding solutions to the challenges of decarburization, lower energy costs for consumers and reduce harmful emissions, thereby improving quality of life for citizens. In connection with this, the goals of the Bulgarian government in the area of research, innovation and competitiveness are summarized as follows:

Table 4.1 R&I priorities in Bulgaria to achieve 2030 target as defined in NECP

Decarbonisation
• Improvement of ambient air quality; • Support for local industries for the introduction of low-carbon technologies and • for the public administration and household sectors for the use of new highly • efficient energy-saving technologies; • Developing smart energy systems, grids and storage capacity outside TEN-E • Development of hydrogen technologies
Energy Efficiency
• Introduction of new energy-saving technologies that improve the quality of life and working conditions of Bulgarians • Reducing technical losses in electricity transmission and distribution • Increasing the reliability of measuring the quantity of electricity that is received in or leaves the electricity distribution grid and limiting the option for its unauthorized use • building Smart Grid networks
Energy Security
• Development of innovative technologies for energy storage, such as capacity of back-up systems for the integration of electricity from renewable sources through battery storage system • Digitalization of energy networks through the development of smart grids and smart metering, smart medium-voltage and low-voltage electricity distribution systems and efficient use of local energy sources. • Consumer protection and addressing energy poverty.
Internal Energy Market
• Development of system services for electricity demand response measures, demand management and distributed generation on organized electricity markets and to improve efficiency in network design and operation • Introduce dynamic pricing for demand response measures by final customers • Transmission network improved observability

4.1.2 Croatia

The Act on State Aid for Research and Development Projects regulates (i) requirements for granting state aid for research and development projects; (ii) the procedure for determining the fulfilment of conditions for exercising rights, (iii) record keeping and reporting as well as other issues related to the exercise of the right to aid for research and development projects. The purpose of the Act is to increase private sector investments in research and development, increase the number of entrepreneurs investing in research and development and foster cooperation between entrepreneurs and organizations for research and dissemination of knowledge in research and development projects, whereby research and development includes creative and systematic work undertaken for the purpose of increasing knowledge - including knowledge of humanity, culture and society - and developing new applications of existing knowledge. Research and development activities must include five basic criteria: new knowledge (as the objective of activity), creative (new concepts, ideas and methods that enhance existing knowledge), uncertain in terms of outcome, systematic (planned with secured funds and by recording outcomes) and transferable (outcomes are transferable as new knowledge) and/or reproducible (outcomes can be reproduced).

Major technological advances are expected in the application of ICT technologies in all sectors, with particularly great impact in energy and transport sectors. The development of energy storage systems, electric vehicle and battery infrastructure, autonomous systems in various sectors and robotics will play a decisive role.

Increasing energy efficiency is strongly present in all sectors of consumption, with the strongest effects expected in the building sector and transport.

The changes that are expected in the energy sector are economically viable and will not ultimately entail higher costs. In doing so, the nature of costs will change - investment costs will increase and operating and energy costs will be reduced. Ultimately, energy markets will be fully integrated, both geographically - at the level of the European Union and neighboring countries, as well as across sectors - there will be an interconnection of the electricity, heat, gas and transport sectors.

Table 4.2 R&I priorities in Croatia to achieve 2030 target as defined in NECP

Decarbonisation
• Energy management systems for planning, investment, real-time management and monitoring energy efficiency and reducing CO 2 emissions • Systems for CO2 capture, transport, use and storage. • Reduce the vulnerability of natural systems and society to the negative impacts of climate change • Increase the ability to recover from the effects of climate change • Exploit the potential positive effects that may also be due to climate change. • Development of the Programme of Green Infrastructure Development in Urban Areas • Development of new and improvement of existing primary and secondary equipment for power system (primary equipment: turbines, generators, motors, transformers, switches, measurement, protection, supervision, management) power lines and cables, secondary energy equipment control.
Energy Efficiency
• Advanced conventional energy solutions • New technologies and improvements related to power plants, substations, components and systems related to renewable energy sources • New research related to increasing the efficiency and production capacity of industrial, agricultural and forestry plants and machinery • Establishment of a certification system and lifelong learning of construction workers on the subject of energy efficiency • Application of advanced grids and complex energy systems • Energy-efficient lighting • Sustainable conversion of biomass into energy, biogas technologies for electricity and heat generation • Development of the Circular Spatial and Building Management Development Programme
Energy Security
• Advanced energy storage systems • Diagnostics and better management of energy equipment
Internal Energy Market

- Systems for energy management and support to functioning of the energy market at the levels of microgrids, advanced grids and smart cities
- Developing/amending the evaluation study of storage capacities available in the territory of the Republic of Croatia

4.1.3 Cyprus

On the Research, innovation and competitiveness dimension, The National Board for Research and Innovation has issued in May 2019 the Cyprus Strategy Framework for Research and Innovation 2019 – 2023, entitled "Innovate Cyprus". The current strategic framework adopts the following vision:

"Cyprus to become a dynamic and competitive economy, driven by research, scientific excellence, innovation, technological development and entrepreneurship, and a regional hub in these fundamental areas".

"Innovate Cyprus" will be put into action through a first set of policy measures and activities. For this purpose, an implementation roadmap is designed for the initial period of 2019-2021. Moreover, the roadmap will be updated and further enhanced according to progress and developments in the national R&I ecosystem, as well as with the support of further case-studies and the elaboration of a detailed R&I strategy.

Energy and water resource efficiency, as well as mitigation of climate change are among the sectors which are considered crucial to be addressed by R&I according to "Innovate Cyprus". Thus, the objective in R&I in energy and climate is the best possible production of research work and innovative products and services that will help increase energy efficiency, energy security, and renewable energy and tackle climate change. At the same time R&I must add value to businesses and provide useful insights for policy makers.

In terms of decarbonization, Cyprus is expected to become an exporting country in electricity generation mainly produced from solar energy. At the same time, gas will be available for backup purposes and for security of energy supply. In addition to photovoltaics, other technologies such as concentrated solar thermal systems will contribute to the dominance of RES in the energy system.

The most important projects relating to power generation from RES concern wind parks and photovoltaic (PV) parks, concentrated solar thermal plants and biomass and biogas utilisation plants. 6 wind parks are currently in operation, while as regards solar energy, 4 PV parks have been connected to the national grid so far.

As for the energy efficiency dimension, a key priority is to step up research into innovative applications of heating and cooling systems. At the same time, the maturation and integration of innovative energy-saving technologies that contribute significantly to improving energy efficiency, will be facilitated.

In particular, research and innovation activities related to improving the energy efficiency of buildings will include:

- Roof insulation
- Heat pumps for heating
- Photovoltaic panels
- High efficiency air conditioning units
- LED lighting
- Solar Water Heaters for hot water
- Biomass boiler

Regarding the energy security and the internal energy market dimensions, the main research and innovation actions are focusing on:

- Advanced Metering Infrastructure (AMI)deployment
- Meter Data Management System (MDMS) installations
- Design, engineering, supply, installation, configuration, testing and commissioning of a Supervisory Control and Data Acquisition/Advanced Distribution Management System (SCADA/ADMS)

The deployment of an Advanced Metering Infrastructure, including the roll-out of 400.000 smart meters by January 2027 will enable the optimization and control of the distribution system, increase the penetration of distributed renewable sources, enable aggregation of RES, demand response and storage and increase direct final customer participation in all market stages (active customers). Furthermore, it will contribute to increased system observability, load and generation forecasting accuracy, accurate system analysis and planning, load management alternative to ripple control, optimization of the operation of the distribution system, supervisory control and data acquisition of photovoltaic systems. The existence of a smart meter is necessary for the provision of consumer FUNCTIONALITIES, such as near real-time feedback on their energy consumption or generation.

The installation of an MDMS system is essential for the central data management of the Advanced Metering Infrastructure (AMI). The MDMS shall provide integration with the Meter Data Collection Systems and other utility information systems (SCADA, GIS) and FUNCTIONALITIES such as Data Warehousing and Management, Meter Operations, Data Validation-Editing-Estimation (VEE).

As for the Supervisory Control and Data Acquisition/Advanced Distribution Management System, SCADA communicates with 175 RTUs installed at MV Level equipment. The ADMS shall provide, among other FUNCTIONALITIES, applications for Power Flow, Switching Order Management, Short Circuit Analysis, Short-Term Load and Generation Forecasting, RES Management and Curtailment, Emergency Load Shedding and Restoration, Cyclic Load Shedding and Restoration, Outage Management System and Power Quality Monitoring.

Table 4.3 R&I priorities in Cyprus to achieve 2030 target as defined in NECP

Decarbonization
• Utilization of wind parks in operation • Utilization of photovoltaic parks in operation • Energy Efficiency • Roof insulation in the building stock • Deployment of photovoltaic panels • Deployment of heat pumps for heating • Utilization of biomass boilers • Promotion and utilization of high efficiency air conditioning units
Energy Security
• Optimization and control of the distribution system • Load and generation forecasting • Supervisory Control and Data Acquisition of PV systems
Internal Energy Market
• Load profile management through demand response • Increased distribution system observability • Direct participation of customers in all market stages, through aggregation

4.1.4 Czech Republic

The fifth dimension of the Energy Union is that of research, innovation and competitiveness. In this regard, the Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. However, research, development and innovation in sustainable energy are one of the priority areas of key strategic documents such as the National R&D Strategy for Smart Specialisation and the National Priorities for Oriented Research, Experimental Development and Innovation. In the development of priorities in this area, the Czech Republic also seeks to take into account the priorities at EU level, especially the priorities of the European Strategic Energy Technology Plan. It is not possible to precisely determine the exact level of public funding of research, development and innovation for low-carbon technologies. However, the National Plan shows the estimate of public finances allocated to the energy sector.

The Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. The difficulty of setting energy and climate targets is due, inter alia, to the structure of public funding for research, development and innovation, which is not sector-focused, but is provided under national and ministerial support programmes. The strategic objectives are then described in more detail in the relevant strategy papers. These documents include in particular the National Research and Innovation Strategy for Smart Specialisation and National Priorities of Oriented Research, Experimental Development and Innovation.

National priorities for oriented research, experimental development and innovation include indicative share of funds by priority area, which should be allocated for implementation within the overall R&D&I budget. On the basis of this strategic document, approximately 18% of the total research, development and innovation budget should be allocated to the priority Sustainable Energy and Material Resources.

The area of research, development and innovation is also addressed specifically in the State Energy Policy of the Czech Republic. The research, development and innovation areas are also partially addressed by other strategic energy documents such as the National Action Plan for the Development of Nuclear Energy in the Czech Republic, the National Action Plan for Smart Grids, or the National Action Plan for Clean Mobility.

The Czech Republic's priority areas of research and innovation, in terms of the **decarbonisation**, **energy efficiency**, **energy security** and **internal energy market** dimensions, are listed in the table below.

Table 4.4 R&I priorities in Czech Republic to achieve 2030 target as defined in NECP

Decarbonization
• Increase in the use of renewable energy sources (solar, geothermal, biomass) • Development of new photovoltaic systems including control elements • Development of advanced biofuels made from non-food biomass and waste • Development of the energy use of hydrogen including fuel cells • Research in 3rd and 4th generation nuclear technologies • Development of intelligent transport systems
Energy Efficiency

• Development in the construction technologies for nuclear power in relation to material engineering • Development of high temperature materials • Research in more efficient use of fossil energy sources • Development of high-efficiency cogeneration (trigeneration) in district heating systems • Research and innovation of gas and steam turbines • Increase in the use of heat pumps with high efficiency • Development of new technologies for the energy recovery of secondary raw materials and wastes
Energy Security
• Increase in the efficiency and reliability of energy systems and distribution networks • Development of production and consumption management • Development of protection against cyber-attacks and the protection of telecommunication systems
Internal Energy Market
• Development of technologies aiming at increasing the flexibility of the energy system • Research in the implementation of the circular economy model • Development of local energy production

4.1.5 Estonia

On the Research, innovation and competitiveness dimension, the current national development documents in Estonia have not set independent research and development targets related to the energy sector.

Research and development and innovation for increasing competitiveness are governed by the following current sectoral development plans:

- Estonian Rural Development Plan 2014-2020
- Competitiveness Plan 'Estonia 2020'
- National Waste Plan 2014-2020
- Estonian Forestry Development Plan 2020
- Transport Development Plan 2014-2020

An agriculture and fishery sector development plan until 2030, a forestry development plan for the period 2021-2030 and an infrastructure and mobility development plan for the period 2021-2030 are being drafted.

The overall objective of the NDPES 2030 (National Development Plan of the Energy Sector) is to ensure, among other things, the growth in the competitiveness of the economy: to ensure that customers have an energy supply with market-based prices and availability that meets the European Union's long-term energy and climate policy targets and at the same time contributes to the improvement of Estonia's economic climate and environmental status.

The long-term vision for Estonian climate policy and sectoral and cross-cutting policies to set a clear path towards alleviating climate change were agreed upon at national level in the development document 'General Principles of Climate Policy until 2050'. Estonia aims to have a competitive low-carbon economy by 2050. This will ensure that the country is ready and able to minimize the negative consequences of climate change and make optimal use of the positive effects. In accordance with the first policy document covering the entire economy, Estonia's main priority is to be transformed into an environment that will primarily be attractive for the development of innovative technologies, products and services that reduce GHG emissions. The export of these technologies, products and services and their global implementation in solving global problems connected with climate change will also be promoted.

The introduction of low-carbon emission technologies and the efficient use of resources in industrial processes will be promoted. Legislation will be used to motivate industry to employ predominantly low-carbon fuels and production inputs. In seeking to limit the GHG emissions of energy and industry, preference will be given to directions in research, development and innovation that promote the development of efficient energy technologies, valorize domestic renewable energy resources, increase primary energy savings and reduce GHG emissions.

Estonia joined the Hydrogen Initiative at the informal meeting of EU energy ministers in Linz, Austria on 17 and 18 September 2018. The public meeting of the ministers of energy in Brussels on 19 December 2018 discussed follow-up measures connected with the Hydrogen Initiative. The use of hydrogen in different sectors of the economy offers the most efficient possibility for moving towards a low-carbon economy.

As related to the dimensions of energy efficiency and energy security, specific activities of the Estonian research and innovation system are focused on the development of the “smart house” concept, with the deployment of IT solutions (controlling the house electronically, incl. with mobile devices), using more efficient materials and use of more efficient energy solutions. This trend is also gaining more attention in Europe, i.e. the Smart City initiative of the European Commission is likely to push this area further into the spotlight.

These activities aim at the creation of an innovation environment for the development of smart services, leading eventually to the optimization of network usage and improved transmission network observability.

Towards the dimension of internal energy market, there are no specific research and innovation activities mentioned in the Estonian NECP.

Table 4.5 R&I priorities in Estonia to achieve 2030 target as defined in NECP

Decarbonization
• Introduction of low-carbon emission technologies and the efficient use of resources in industrial processes • Motivation of industry to employ predominantly low-carbon fuels and production inputs • Increase in hydrogen production
Energy Efficiency
• Development of “Smart House” concept • Deployment of IT solutions towards energy efficiency
Energy Security
• Optimization of network usage • Transmission network improved observability

4.1.6 Greece

Concerning the **Research, innovation and competitiveness dimension**, the Greek Research and Innovation System is considered as one of the strengths of the Greek economy. Promoting research and innovation will continue to be a priority in the period 2020-2030, by strengthening important technologies which will contribute to the attainment of all energy objectives.

In terms of **decarbonization**, achieving the goal of reducing greenhouse gas emissions in all sectors of economic activity is the main priority of Research and Innovation System in Greece. The development and utilisation of innovative RES technologies, which can contribute to the further exploitation of the domestic potential, is expected to play an important role. In this regard, new applications and technologies for renewable electricity generation, as well as other applications enabling them to expand their use and utilize existing energy infrastructure, are already being evaluated and promoted.

In the coming period, priority will be given to utilizing the geothermal potential for electricity generation, to developing a viable market for small wind turbines contributing to both scattered production and increased domestic value added as well as marine wind parks with corresponding multiple combining benefits for the energy system, the grids and the national economy. Similarly, initially mainly through pilot applications, the development of projects for the energy utilization of wave energy and of RES hydrogen production will be promoted.

As for the **energy efficiency dimension**, a key priority is to step up research into new materials and innovative applications of heating and cooling systems, with an emphasis on improving their reliability and automated operation. At the same time, the maturation and integration of innovative energy-saving technologies that contribute significantly to improving energy efficiency, will be facilitated.

In particular, research and innovation activities related to improving the energy efficiency of buildings will include:

- New building materials: Innovative materials and building technologies that will support a recycling process, innovative thermal insulation building systems with improved thermal performance, innovative thermal insulation system without materials derived from mineral sources.
- Prefabricated active roof and facade elements: Standard panels for ventilated facades or roofs combining photovoltaic and thermal solar systems, thermal insulation, phase change materials, batteries.
- Cost-effective, intelligent, flexible heat pumps and high-temperature heat pumps: Intelligent heat pump adjustable to provide additional services to the grid, versatile heat pump to provide a wider operating range and operation control equipment, further development & deployment of absorption technologies and heat pump absorption systems.
- Digital programming and operational optimization: Automated fault detection and diagnosis, combining statistics and technical data to improve energy demand forecasts and updating-upgrading building assessment methods

Regarding the **energy security and the internal energy market dimensions**, the main research and innovation actions to be strengthened are: i) the creation of an innovation environment for the development of smart services and ii) the development of an optimized energy network.

These actions will facilitate the increased observability and controllability of medium and low voltage networks with high penetration of distributed energy resources, smart-flexible design, programming and operation of the network based on improved transmission network observability; the development and implementation of solutions and tools for load profile management through demand response and control in order to optimize network usage.

Table 4.6 R&I Priorities in Greece NECP

Decarbonisation
• Utilization of geothermal potential for electricity generation • Development and deployment of marine wind parks (use of small wind turbines) • Wave energy utilization • Increase in RES hydrogen production
Energy Efficiency

• Thermal insulation building systems with increased thermal performance • Ventilated facades or roofs with PV and solar systems, thermal insulation, batteries • Deployment of flexible and high-temperature heat pumps • Improve on energy demand forecasts, via the combination of statistics and technical data, as a result from the digital programming and operational optimization of the energy system
Energy Security
• Load profile management through demand response • Observability and controllability of medium and low voltage networks with high penetration of DER • Transmission network improved observability
Internal Energy Market
• Load profile management through demand response • Observability and controllability of medium and low voltage networks with high penetration of DER • Transmission network improved observability

4.1.7 **Ireland**

The Energy Research Strategy published by DCCAE recognises Ireland's reputation as a world class location for research across a several sectors, including Life Sciences and ICT, with many global companies actively engaged in research activities in Ireland. The strategy states that the Irish energy research system should:

1) Develop new technologies for the harnessing and integration of indigenous renewable resources (e.g. wind energy, ocean energy and bioenergy).

2) Identify and develop products and services that will radically transform the efficient utilisation of energy across all sectors of the economy, with consequent benefits for economic growth, development of new Irish businesses and job creation.

3) Undertake basic research in such areas as material sciences and bio-sciences, to expand the knowledge base on which breakthrough innovations in energy supply and utilisation can be made.

4) Take innovative ideas and concepts developed elsewhere, and examine how they might usefully be adapted, further developed, demonstrated and deployed by Irish companies both in Ireland and abroad.

5) Help Irish companies in the energy sector to develop and grow at national and international level.

6) Seek to collaborate and attract investment from indigenous and foreign businesses in order

to enhance the benefits of energy research.

7) Contribute to effective policy making, through the development and maintenance of an energy system modelling capability.

8) Investigate and address the various technological and behavioural barriers to the uptake of new energy efficient and low carbon technologies.

Table 4.7 R&I priorities in Ireland to achieve 2030 target as defined in NECP

Decarbonisation

• Research on the integration of renewable electricity systems on the grid, on carbon sequestration, on bioenergy emissions and on the environmental impacts of renewable technologies. • Suggestion of a collaborative approach to research between Government, academia, research bodies and industry, including the development of a costed model setting out the least coast pathway to decarbonisation
Energy Efficiency
• Increased energy efficiency and competitiveness utilising existing infrastructure
Energy Security
• Increased security of supply (including LNG) • Research on demand side management, energy storage, floating wind, hybrid technologies and on making biofuels economically viable
Internal Energy Market
• Focus on areas specific to Ireland such as agriculture and non-synchronous generation • Focus on integration of renewable electricity onto a power system • High energy volume storage and power-to-gas technologies research

4.1.8 Italy

On the **Research, innovation and competitiveness dimension**, during the COP 21 in Paris, Italy signed up to the multilateral initiative which aims to promote an acceleration of technological innovation to support the energy transition by means of a significant increase in public funding dedicated to cleantech research. The initiative comprises a series of 'Innovation Challenges'.

Italy views the Strategic Energy Technology (SET) Plan as a fundamental instrument for meeting the new challenges posed by decarbonization and agrees with the role the Commission has assigned to it in setting the objectives of the present Plan. Since the SET Plan was first introduced, Italy has progressively aligned its objectives and priorities for public investment in research and innovation in the energy sector with those of the SET Plan. As confirmation of this commitment, Italy follows all of the key actions of the SET Plan with its own experts, who have set up standing consultation groups with businesses and national research bodies, and engages in collaboration with other Member States that has often translated into joint participation in Horizon projects.

In addition, the conception and construction of the Innovation Challenges envisaged by Mission Innovation to a large extent reflect the SET Plan methodology and there are significant synergies between the two. Italy therefore considers the systematic and integrated management of research in the energy sector to be necessary, both for the SET Plan and for Mission Innovation, in order to improve efficiency and the effectiveness of the allocated resources.

The objective is to create the conditions for a system where the participation of industry and public and private Italian research centres in future research programmes provided either by the SET Plan/Horizon Europe or Mission Innovation is broader and less fragmented, effectively offers the opportunity to play a more decisive role and which has better success than has been achieved in the past. The principal objectives aim to:

- monitor and develop product and process technologies vital to the energy transition;
- promote the introduction of technologies, organisational and operational models and systems used for the energy transition and for safety.

Following the intense work carried out by the Italian Delegation as part of the working groups set up by the SET Plan for the implementation of the Key Actions, it is considered that renewable sources

– among them solar PV and CSP in particular, and, in the longer term, sea energy (wave, tidal and current energy), storage systems (including hydrogen and power-to-gas and, more generally, the integration between the electricity system and other systems), system devices for safety of the electricity system, electric mobility, biorefineries, materials, processes and systems for **energy efficiency of the industry and of buildings** represent the subjects that have, concurrently, sufficient focus among research bodies, a considerable industrial basis and are of significant interest to the system, not only for the 2030 objectives but also and especially in the longer term view, looking ahead to 2050.

Moreover, **the development of smart grids** will also be a dominant theme over the coming decades in Italy. It will benefit not only small producers but also large companies, insofar as the availability of a network in which all devices communicate among themselves will channel a quantity of information able to appropriately **predict energy demand to software equipped with artificial intelligence**.

Also, the modernization of electricity networks, poses as a priority for the R&I community, with a view to smart grids. The **increase in generation of distributed energy resources** in fact requires real transformation of the **distribution networks and of the related operational modes**, with modernisation both of the hardware component (e.g. to also make distribution networks also bi-directional) and of the software component (e.g. to enable demand response management initiatives).

The field of cybersecurity is one where large spaces and opportunities, therefore, the cyber research plan in the electricity sector in Italy will also have to address, in the next few years, the issue of innovation of energy infrastructure from a long-term perspective, by means of **modelling and simulation activities, experimental activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector**.

In this same context, it must be considered that **the evolution of the energy mix and of the set-up of the markets** will increasingly involve, in an active role, new parties and new resources, at several voltage levels. This creates requirements for research and innovation in technologies to **make the system more 'readable' and the networks smarter**, and to maintain development of the necessary instruments for **safely managing the networks and the energy system**.

Lastly it is considered to be of interest to encourage research into the potential benefits **of integration of the electricity and gas systems through the development of pilot power-to-gas, power-to-hydrogen and gas-to-power projects;** an integration that sees the gas network as a useful tool for development of an ever greater quantity of intermittent renewables, itself a carrier of renewable gases, and – through conversions of electrical energy carriers into gas and vice versa – a pillar of an integrated energy infrastructure, which enables the full potential of renewable sources to be exploited, also guaranteeing the storage of energy in the medium to long-term.

The evolution and development of the technologies previously cited would allow the **storage of excess energy produced by non-programmable renewable energy sources (RES) into renewable energy carriers (biomethane, hydrogen, heat)** increasing the overall efficiency of the energy system and initiating a synergic course between the two systems towards a possible fusion of the gas and electricity sectors into a single energy sector.

Table 4.8 R&I priorities in Italy to achieve 2030 target as defined in NECP

Decarbonization
• Further exploitation of solar PV and CSP renewable sources • Utilization of wave / tidal energy • Development of power-to-gas storage systems

Energy Efficiency
• Development of Smart Grids • Energy demand forecasting via software equipped with artificial intelligence • Storage of excess energy produced by non-programmable renewable energy sources (RES) into renewable energy carriers (biomethane, hydrogen, heat) • Make the system more 'readable' and the networks smarter
Energy Security
• Evolution of the energy mix • Modelling and simulation activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector • Experimental activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector • Management of the distribution network and the energy system
Internal Energy Market
• Increase in generation of distributed energy resources • Load profile management through demand response

4.1.9 Latvia

Concerning the Research, innovation and competitiveness dimension, the Sustainable Development Strategy of Latvia 2030 has a vision of innovation in the creation of low-carbon goods and in the development of RES technologies. The Strategy also identifies the need to increase the cooperation between research institutions and companies.

Research and innovation is developed in Latvia in accordance with the Smart Specialization Strategy (RIS3). There are five main specialization areas: smart energy; knowledge intensive bio economy; biomedicine, medical appliances, bio-pharmacy and bio-technology; advanced materials, technologies and engineering systems; information and communication technologies.

The RIS3 specialization area "Smart energy" is focused on the following domains: development of clean technologies and new materials; research and development of digital solutions for acquisition, storage and integration of renewable energy into the energy system; improvement of energy efficiency in construction and automation; optimization of production processes; development of alternative fuels for transport.

As for the targets for 2030, investments in research and innovation have to be at least 2% of the GDP and at least 25% of the total investments have to be invested in research and innovation to achieve climate neutrality. However, in the past five years, investments in R&I have not even reached 0.7% of the GDP. This represents a significant obstacle for the development of R&I in any economic sector. One of the main challenges for Latvia for the 2021-2030 period will be to increase investments in R&I.

In terms of decarbonisation, research and innovation are focused on the development of RES technologies, including the production and use of biomethane, hydrogen and modern biofuels, the smart use of biomass before combustion and the use of solar energy in transport. The creation and the implementation of more resource-efficient and zero-emission technologies are also priorities of the R&I sector. Another areas that worth mentioning concerning the research and innovation in the decarbonisation dimension are: materials and engineering technologies for the acquisition and storage of renewable energy (solar and hydrogen energy), acquisition technologies for bioenergy (biomass, biogas), wave energy acquisition technologies, smart mobility and intelligent transport systems.

The implementation of the railway electrification project is expected to reduce the use of fossil energy sources and make rail transport more environmentally friendly. This will significantly reduce greenhouse gas emissions from transport sector.

Demonstrating projects, such as the "Reduction of Greenhouse Gas Emissions – Low Energy Consumption Buildings" attract public attention and raise awareness. The goal of the project is to encourage people to implement energy efficiency measures that will result in reduction of GHG emissions in the building sector.

As for the energy efficiency dimension, the priority areas of research and innovation are the following:

- Modernization of existing energy production technologies
- Development of heat insulation materials and technologies
- Creation of materials with high resource efficiency and energy efficiency
- Development of production technologies
- Improvement of the physical construction parameters of buildings
- Modernization of boiler houses
- Development and introduction of high-efficiency cogeneration in district heating
- Development and application of digital energy innovation
- Improvement of energy system management technologies
- Modernization of the electricity metering

Regarding the energy security dimension, research and innovation are focused on the development of solutions for energy storage, integration and smart transmission. Promoting the self-generation of energy will also be a priority. The development of RES technologies will ensure the increase of energy security. It is important to mention that the use of innovative solutions improving the energy efficiency in all sectors of the economy is a sustainable and cost-efficient way of bolstering Latvia's energy security.

In terms of the internal energy market dimension, main priority of research and innovation is the development of market models of a new type – peer-to-peer trading, aggregation services, energy as a service, local community energy systems. Another priority area is the improvement of electrical system management. It is important to establish an effective link between research and innovation of technologies and their commercialization.

Table 4.9 R&I priorities in Latvia to achieve 2030 target as defined in NECP

Decarbonization
• Development of RES technologies (production and use of biomethane, hydrogen and modern biofuels; smart use of biomass before combustion; use of solar energy in transport) • Creation and implementation of more resource-efficient and zero-emission technologies • Materials and engineering technologies for the acquisition and storage of renewable energy (solar and hydrogen energy) • Acquisition technologies for bioenergy (biomass, biogas) • Wave energy acquisition technologies • Intelligent transport systems
Energy Efficiency
• Modernization of existing energy production technologies • Development of heat insulation materials and technologies • Creation of materials with high resource efficiency and energy efficiency • Development and introduction of high-efficiency cogeneration in district heating • Development and application of digital energy innovation • Modernization of the electricity metering
Energy Security

• Development of solutions for energy storage, integration and smart transmission • Promotion of self-generation of energy • Development of RES technologies (which will ensure the increase of energy security)
Internal Energy Market
• Development of market models of a new type – peer-to-peer trading, aggregation services, energy as a service, local community energy systems • Improvement of electrical system management • Establishment of an effective link between research and innovation of technologies and their commercialization

4.1.10 **Lithuania**

Concerning the **Research, innovation and competitiveness** dimension, the main objective for Lithuania is to evolve from a country importing energy technologies to a country creating and exporting energy technologies. Lithuania aims at becoming a center of information technology and cybersecurity solutions for energy, solar and wind energy technologies, biomass and biofuel technologies, geothermal technologies, energy market development and creation of new electricity system management approaches. Synergies between scientific and academic institutions, energy companies and engineering industry companies will be enhanced by promoting different forms of cooperation.

In terms of **decarbonization**, research and innovation are focused on the development and network integration of new technologies for low greenhouse gas and ambient air emissions. The development of power generation technologies from renewable energy sources will also be a priority. In this context, the possibilities for offshore wind energy production will be explored, production of solar technologies will be encouraged by establishing Lithuania as the largest exporter of solar technologies in the Baltic region. The use of biomass and the recycling of waste for energy recovery will be increased. The modernization of 9 biomass power plants will take place. Lithuania will also focus on research on the use of hydrogen in energy, industry and transport.

The introduction of clean environmentally friendly transport technologies is expected to reduce the negative impact of the transport sector on climate and nature (air pollution, noise). Thus, research and development of intelligent transport systems will be encouraged. Developing the market for advanced biofuels, electrifying the transport and integrating the use of biomethane gas in the transport sector are all part of the R&I objectives for the decarbonization of transport.

As for the **energy efficiency** dimension, the priority areas of research and innovation are the following:

Modernization of existing energy production technologies

Development of technologies for distributed energy production, smart grids, and production and use of new viable forms of energy

Development and application of digital energy innovation

Development of alternative fuels and energy-savings technologies (it will increase energy efficiency in end-use and will boost Lithuania's competitiveness in clean energy technologies)

Development of new production processes, materials and technologies: energy efficiency, safety, durability and other requirements for materials are constantly increasing the R&I activities, resulting in important international competitiveness

Renovation of inefficient residential and public buildings

Increase in the energy performance of buildings and businesses

Conversion of all public and private residential and non-residential buildings to near zero-energy buildings by 2050

Development of new technologies for the heating and cooling sector (heat pumps, modern biofuel boilers, high-efficiency cogeneration plants)

Regarding the **energy security** dimension, research and innovation are focused on ensuring security and quality of electricity supply, vulnerability of electricity systems and optimization of operating modes. Other important aims are energy and cyber security, reliability of energy equipment and systems, and resistance to cyber-attacks. The development of electricity storage technologies will be encouraged by attracting investment for their production in Lithuania. A capacity mechanism is currently being developed in order to ensure the adequacy of the Lithuanian electricity system and to reduce the likelihood of loss of load. This capacity mechanism will ensure reliable operation and high level of security of electricity supply after 2025. As for gas supply security, the development of liquefied natural gas technologies will be encouraged.

In terms of the **internal energy market** dimension, main priorities of research and innovation are the functioning of electricity markets and power mechanisms, and the involvement of consumers in the electricity system and markets. Another priority area is the improvement of electrical system management. Lithuania has to ensure optimal energy pricing and promote liquidity in the energy trade market.

Table 4.10 R&I priorities in Lithuania to achieve 2030 target as defined in NECP

Decarbonization
• Development and network integration of new technologies for low GHG emissions • Offshore wind energy production • Development of solar technologies production • Increase in biomass use • Development of the use of hydrogen in energy, industry and transport • Intelligent transport systems • Increase in RES in transport (advanced biofuels, biomethane)
Energy Efficiency
• Modernization of existing energy production technologies • Development of smart grids, production and use of new viable forms of energy • Development of new production processes, materials and technologies • Renovation of residential and public buildings • Increase in energy performance of buildings and businesses • Development of new technologies for the heating and cooling sector
Energy Security
• Security and quality of the electricity supply, optimization of operating modes • Energy and cyber security, reliability of energy equipment, and resistance to cyber-attacks • Development of electricity storage technologies • Development of a capacity mechanism ensuring the adequacy of the electricity system • Development of liquefied natural gas technologies
Internal Energy Market

- Functioning of electricity markets and power mechanisms
- Involvement of consumers in the electricity system and markets
- Improvement of electrical system management
- Optimal energy pricing and promotion of liquidity in the energy trade market

4.1.11 **Malta**

On the **Research, innovation and competitiveness dimension**, Malta will seek to support and bolster R&I initiatives relating to the dimensions of Energy Union, specifically those which address national policy priorities and challenges, and those which contribute to national competitiveness and economic growth. The Draft National Strategy for R&I in Energy and Water 2021-2030 aims to strengthen and increase coordination and cooperation on R&I projects between the public sector, research institutions and business enterprises.

The high-level objectives under the dimension of Research, innovation and competitiveness dimension, are presented as follows:

- renewable solutions for islands
- integration of RES electricity
- energy efficient solutions for industry and services

In support of **decarbonisation** through cleaner power generation, the main priority of the Research and Innovation System in Malta is to focus on RES innovative technologies and energy efficiency projects mainly by further exploiting solar energy (photovoltaic and solar water heaters), heat pumps, biofuels, and energy recovery from waste.

During the past years Malta has embarked upon a wholesome reform of the energy sector. This has resulted in improved policy making, more focused economic and environmental regulation as well as a reformed operational landscape. Substantial progress has been made in recent years in **diversifying the energy mix**. Significant efforts have been targeted at upgrading the energy infrastructure, including switching **electricity production from oil to natural gas**. Important measures in this area include the **gasification of the Maltese power plants** and the **completion of the electricity interconnector with Italy**. The Maltese Government also introduced several programmes to incentivise **energy performance improvements in buildings, through grant schemes or soft loans for energy saving solutions**. These solutions include **energy efficient appliances**, **energy-saving lighting systems**, **thermal insulation**, **double-glazing**, **solar heating**, **photovoltaic panels**, **solar water heaters** and **wind energy resources**.

In terms of **Energy Security**, the development of the **energy storage market** is considered essential for further deployment of photovoltaic capacity and for optimization of the power system by providing for demand management and peak demand shaving. Cost-effective, technically viable options to increase the flexibility of Malta's power system are being assessed, whilst ensuring the desired level of security of supply and further integration of low carbon technologies.

The **deployment of new smart meters** and replacement of old inefficient smart meters will continue post-2020 in line with the requirements of Articles 19 and 20 of Directive (EU) 2019/944 on common rules for the **internal market** for electricity. Smart metering systems will have to comply with the minimum functional and technical requirements and provide final customers with information on actual time of use and real-time consumption data in order to support energy efficiency programmes as well as demand response.

Table 4.11 R&I priorities in Malta to achieve 2030 target as defined in NECP

Decarbonization
• Wind energy resources utilization • Solar Energy exploitation (PV panels, solar water heaters)
Energy Efficiency
• Thermal insulation building systems • Deployment of energy-saving lighting systems • Deployment of energy efficient appliances • Double-glazing utilization (Double Glazed Windows) • Deployment of heat pumps
Energy Security
• Development of energy storage market, leading to increased photovoltaic capacity and optimization of the power system
Internal Energy Market
• Load profile management through demand response

4.1.12 **Poland**

National objectives and budgetary funding targets for research and innovation, including with regard to the Energy Union, are carried out within the framework of the state science, technology and innovation policy.

The main criteria applied in the NRP to choose strategic directions for research and development include the long-term needs of the economy, the high level of research in national centers – the competitiveness at the global level, the micro-, small- and medium-sized-scale development of business sectors based on new Polish technologies or the priority directions in research development defined in European research programs and strategies (e.g. the SET-Plan and Horizon 2020 which constitutes the main source of funding for the measures defined in the SET-Plan and the EU energy and climate policy).

Strategic directions for research and development work defined in the NRP are as follows:

1. New energy technologies,
2. Diseases of affluence, new medicines and regenerative medicine,
3. Advanced information, telecommunications and mechatronic technologies,
4. Modern materials technologies,
5. Natural environment, agriculture and forestry,
6. Social and economic development of Poland in the conditions of increasingly global markets,
7. State security and defense.

In the scope of **decarbornization,** the activities are in supporting the scientific research to decarbonize the energy sector with co-financing and providing incentives for private investment in new technologies and research and development in the field of high-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems; smart and energy-efficient building technologies and environment-friendly transport solutions

In the terms of **energy efficiency,** the key priority steps are in the fields of developing of environment-friendly and efficient district heating systems and development of heat production in cogeneration processes.

Regarding the **energy security and the internal energy market dimensions** R&D activities will be concentrated on developing of resources for integrated and interconnected energy system assigning a central role to energy user, efficient and flexible energy generation and the use of raw materials combining the reduction of impact on the environment with energy security, diversification of energy generation and use technologies, implementation of competitive organizational and business models, green and energy-efficient city.

Table 4.12 R&I priorities in Poland to achieve 2030 target as defined in NECP

Decarbonisation
• Determination of the potential of forest areas for carbon dioxide sinking and the launching of research aimed at developing better methods of carbon dioxide balance calculation • Developing better methods of carbon dioxide balance calculation • Environment-friendly transport solutions • Minimization of waste generation, including waste unfit for processing, and the use of waste for materials production and energy generation purposes(recycling and other forms of recovery)
Energy Efficiency
• Smart and energy-efficient building technologies; • High-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems
Energy Security
• Efficient and flexible energy generation and the use of raw materials combining the • reduction of impact on the environment with energy security • Diversification of energy generation and use technologies,
Internal Energy Market
• Continuous enhancement of technological advancement and the quality of operation; • Implementation of competitive organizational and business models; • Optimization of capital use. • Support for building close relations between business entities and public institutions and the science sector.

4.1.13 **Romania**

Concerning the **Research, innovation and competitiveness dimension**, programs for stimulating the research / innovation activities developed at Cabinet level have a general scope, with fundamental research being prioritized across all domains, including Energy. Per existing constraints, the progress of the research sector would continue upon priorities, in order to optimize the capacity of the existing research infrastructure in Romania.

In the scope of **decarbonisation** the activities are in supporting the scientific research to decarbonize the energy sector with co-financing and providing incentives for private investment in new technologies and research and development in the field of low GHG technologies**,** Introduce strong economic incentives for an environmentally friendly transport system through price instruments, Promote more compact, cross-functional, transit-oriented development measures as a way to reduce distances travelled by vehicles, develop infrastructure and reduce maintenance costs, etc.

In the terms of **energy efficiency** the key priority steps are in the fields of developing smart meters and smart grids, Smart medium and low voltage power distribution systems (including smart grids and IT systems) and efficient use of local energy sources including assigned storage, Creation of an energy efficiency investment fund (FIEE), financed by private funds, European funds, state budget.

Regarding the **energy security and the internal energy market dimensions** R&D activities will be concentrated on developing of resources for integration of smart metering, IoT technologies, storage facilities and distributed production systems.

Table 4.13 R&I priorities in Romania to achieve 2030 target as defined in NECP

Decarbonisation
• Support scientific research to decarbonize the energy sector • Adopt advanced technologies in the energy sector by attracting private investments, supporting scientific research and developing strategic partnerships • Integration of distributed production systems and prosumers into the power grid system
Energy Efficiency
• Implementation of smart city concept, integrating developed infrastructure; implementation of IoT at residential level • Creation of an energy efficiency investment fund (FIEE), financed by private funds, European funds, state budget, complying with the provisions of Law no. 500/2002 and no.69/2010
Energy Security
• Smart medium and low voltage power distribution systems (including smart grids and IT systems) and efficient use of local energy sources including assigned storage • Digitization of the national energy system in the transmission, distribution and consumption segments and introduction of the IoT and AI in the transport and distribution systems" management.
Internal Energy Market
• Develop capacities and mechanisms to integrate the intermittent RESs in the national energy system and in the electrical accumulators systems, including the small storage capacities at the prosumer premises • Encourage domestic, industrial and agricultural prosumers build-up, along with the development of electrical grids and smart meters • Integration of distributed production systems and prosumers into the power grid system • Develop smart metering and smart grids

4.1.14 **Slovakia**

Concerning the **Research, innovation and competitiveness** dimension, Slovakia's main priority is to ensure sustainable energy. Key areas for R&I funding are: improving the transmission capabilities and security of the Slovak electricity network; developing smart grids and renewable energy sources; developing nuclear energy. The estimated total investments for these areas for the 2020-2024 period amount for EUR 112.8 million. Extra-budgetary resources coming from private sector R&D investments amount for approximately EUR 28.8 million.

In 2018, the Slovak Research and Development Agency (SRDA) launched a public call for applicants to address R&D projects in the science and technology fields. The SRDA's main objective is to improve the quality of R&D through competition. The total funding for the entire period of projects supported under this call is EUR 33 million. These funds were distributed according to the requirements of the individual groups. The total amount of funds provided by the SRDA to address any of the projects is limited to EUR 250 000.

Research and development incentives have for objective to support the growth of R&D in the business sector in Slovakia, as well as to increase its cooperation with the academic sector (universities, Slovak Academy of Science) and cooperation between business sectors in Slovakia and in the EU. R&D incentives increase the leading-edge nature and excellence of the R&D. In the upcoming years, the Ministry of Education, Science, Research and Sport of Slovakia will focus, through R&D incentives, on: research and development into highly efficient energy sources and technologies for transport systems; research and development into biodegradable plastics, including composite materials; the use of RES for the automotive industry.

Slovakia is involved in international activities in research and innovation through bilateral agreements on scientific cooperation with EU countries and outside the EU. Slovakia is a member of the IEA and participates in scientific cooperation within the EU through the 7th EU Framework Programme and EURATOM (European Atomic Energy Community). Slovakia is also involved in the Allegro project, which is a cooperation project in nuclear energy between Slovakia, Hungary, the Czech Republic and France.

In terms of **decarbonisation**, research and innovation are focused on the development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy). In the field of RES innovation there is the National Centre for Research and Applications of RES at the Slovak Technical University (STU). Four STU faculties are engaged in RES research and innovation: the Faculty of Chemical and Food Technology, the Faculty of Electrical Engineering and Informatics, the Faculty of Mechanical Engineering and the Faculty of Civil Engineering. Their main areas of research are biomass, solar energy and hydropower.

Slovakia participates in the EURATOM programme which is focused on nuclear research and its role is to contribute to the long-term plan for decarbonising the energy system. Priorities of the programme are: scientific excellence, industrial leadership and changes in society. There are two main areas of research and innovation in the EURATOM programme: nuclear fission and radiation protection, and the development of magnetic nuclear fusion as an energy source.

As for the **energy efficiency** dimension, the priority areas of research and innovation are the following:

- Development of new network, consumption, production and interoperability technologies
- Development of technologies to increase energy efficiency and decrease energy intensity
- Development of new energy transmission systems (power cables without dispersive electrical and magnetic fields)
- Development of energy conversion technologies
- Development of the efficient use of domestic deposits of energy raw materials and geothermal energy
- Development of high-efficiency cogeneration in district heating systems
- Construction, reconstruction and modernisation of heat distribution systems

Regarding the **energy security** dimension, research and innovation are mainly focused on the development of energy storage technologies. The possibilities of energy storage in the form of mixture of natural gas and hydrogen are being explored. This type of storage can accelerate the use of RES because it eliminates the disadvantages of these energy sources (volatility of the amount of energy obtained). The development of RES and nuclear technologies will contribute to the increase of energy security. The creation of new energy transmission systems is also a priority.

In terms of the **internal energy market** dimension, main priority of research and innovation is the development of circular economy model. Local power consumption management concepts are also being developed so that electricity is not transformed to a higher voltage at the generation site and then back to a lower voltage at a remote location. Research on the involvement of consumers in the electricity system and markets is of significant importance for the internal energy market dimension.

Table 4.14 R&I priorities in Slovakia to achieve 2030 target as defined in NECP

Decarbonisation
• Development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy) • Development of nuclear technologies (participation in the EURATOM programme)
Energy Efficiency
• Development of new network, consumption, production and interoperability technologies • Development of technologies to increase energy efficiency and decrease energy intensity • Development of new energy transmission systems (power cables without dispersive electrical and magnetic fields) • Development of energy conversion technologies • Development of the efficient use of domestic deposits of energy raw materials and geothermal energy • Development of high-efficiency cogeneration in district heating systems • Construction, reconstruction and modernisation of heat distribution systems
Energy Security
• Development of energy storage technologies (possibilities of energy storage in the form of mixture of natural gas and hydrogen) • Development of RES and nuclear technologies (will increase energy security) • Creation of new energy transmission systems
Internal Energy Market
• Development of circular economy model • Development of local power consumption management concepts • Research on the involvement of consumers in the electricity system and markets

4.2 Mapping of NECP R&I priorities to align with ETIP SNET roadmap 2030

In the previous sub-chapter, an analysis of the R&I status and priorities for the countries with low R&I activities was performed, based on the findings from the individual NECPs. The identification of the standing of the R&I activity in the aforementioned countries, was directed towards building a methodology, in order to map the R&I needs and how they can be tackled with the integration and deployment of different technologies in each country, as an initial step. The second step aims at connecting those technologies with the FUNCTIONALIT of the 10-year roadmap of ETIP SNET, that were previously described in section 2.2.1 and are available in table 2.3.

In the following sections, an initial mapping between NECP activities and ETIP SNET roadmap FUNCTIONALITIES is performed. This will facilitate the definition of technologies that needs to be accelerated through each country's NECP implementation, based on the respective mapping between FUNCTIONALITIES and technologies that will take place in chapter 5.

4.2.1 Bulgaria

Table 4.15 R&I priority and FUNCTIONALTY mapping: Bulgaria

Decarbonisation	Functionalities
Improvement of ambient air quality;	F3, F11,F12
Support for local industries for the introduction of low-carbon technologies and for the public administration and household sectors for the use of new highly efficient energy-saving technologies;	F3, F11, F12
Developing smart energy systems, grids and storage capacity outside TEN-E	F1,F2, F4, F8, F10
Development of hydrogen technologies	F2, F4, F8, F10
Energy Efficiency	
Introduction of new energy-saving technologies that improve the quality of life and working conditions of Bulgarians	F11,F12
Reducing technical losses in electricity transmission and distribution	F7,F11
Increasing the reliability of measuring the quantity of electricity that is received in or leaves the electricity distribution grid and limiting the option for its unauthorized use	F6,F7
Building SMART GRID networks	F6,F7,F11
Energy Security	
Development of innovative technologies for energy storage, such as capacity of back-up systems for the integration of electricity from renewable sources through battery storage system	F1,F6,F7,F8
Digitalization of energy networks through the development of smart grids and smart metering, smart medium-voltage and low-voltage electricity distribution systems and efficient use of local energy sources.	F6,F7,F8,F9
Consumer protection and addressing energy poverty.	F3, F12
Internal Energy Market	
Development of system services for electricity demand response measures, demand management and distributed generation on organized electricity markets and to improve efficiency in network design and operation	F1,F2,F4,F5, F8,F10
Introduce dynamic pricing for demand response measures by final customers	F3,F4, F5, F8
Transmission network improved observability	F4, F6, F5, F7

4.2.2 Croatia

Table 4.16 R&I priority and FUNCTIONALTY mapping: Croatia

Decarbonization	Functionalities
Energy management systems for planning, investment, real-time management and monitoring energy efficiency and reducing CO 2 emissions	F2,F10
Systems for CO2 capture, transport, use and storage.	F2,F3
Reduce the vulnerability of natural systems and society to the negative impacts of climate change	F11, F12
Increase the ability to recover from the effects of climate change	F2, F11, F12
Exploit the potential positive effects that may also be due to climate change.	F7, F11, F12
Development of the Programme of Green Infrastructure Development in Urban Areas	F1,F2,F3, F8,F11,F12
Development of new and improvement of existing primary and secondary equipment for power system (primary equipment: turbines, generators, motors, transformers, switches, measurement, protection, supervision, management) power lines and cables, secondary energy equipment: control	F4,F5
Energy Efficiency	
Advanced conventional energy solutions	F11,F7,F6

New technologies and improvements related to power plants, substations, components and systems related to renewable energy sources	F8,F10
New research related to increasing the efficiency and production capacity of industrial, agricultural and forestry plants and machinery	F12
Establishment of a certification system and lifelong learning of construction workers on the subject of energy efficiency	F7, F3
Application of advanced grids and complex energy systems	F6,F7,F8,
Energy-efficient lighting	F3, F7
Sustainable conversion of biomass into energy, biogas technologies for electricity and heat generation	F2, F12
Development of the Circular Spatial and Building Management Development Programme	F10,F11
Energy Security	
Advanced energy storage systems	F8, F10
Diagnostics and better management of energy equipment	F7,F10
Internal Energy Market	
Systems for energy management and support to functioning of the energy market at the levels of microgrids, advanced grids and smart cities	F1, F4, F5
Developing/amending the evaluation study of storage capacities available in the territory of the Republic of Croatia	F1, F4, F5

4.2.3 Cyprus

Table 4.17 R&I priority and FUNCTIONALTY mapping: Cyprus

Decarbonization	Functionalities
Utilization of wind parks in operation	F1, F2, F7
Utilization of photovoltaic parks in operation	F1, F2, F7
Energy Efficiency	
Roof insulation in the building stock	F11
Deployment of photovoltaic panels	F7, F10, F11
Deployment of heat pumps for heating	F7, F10, F11
Utilization of biomass boilers	F7, F10, F11
Promotion and utilization of high efficiency air conditioning units	F7, F10, F11
Energy Security	
Optimization and control of the distribution system	F1, F2, F4, F6, F7
Load and generation forecasting	F6 , F7, F9
Supervisory Control and Data Acquisition of PV systems	F6, F7, F8
Internal Energy Market	
Load profile management through demand response	F3, F4, F5, F6, F8, F9, F10
Increased distribution system observability	F1, F2, F6, F7
Direct participation of customers in all market stages, through aggregation	F1, F2, F3, F4, F5, F6, F7, F8, F10

4.2.4 Czech Republic

Table 4.18 R&I priority and FUNCTIONALTY mapping: Czech Republic

Decarbonization	Functionalities
Increase in the use of renewable energy sources (solar, geothermal, biomass)	F5, F7, F10
Development of new photovoltaic systems including control elements	F7, F10
Development of advanced biofuels made from non-food biomass and waste	F10, F12
Development of the energy use of hydrogen including fuel cells	F7, F10, F12
Research in 3rd and 4th generation nuclear technologies	F7, F10

Development of intelligent transport systems	F7, F10, F12
Energy Efficiency	
Development in the construction technologies for nuclear power in relation to material engineering	F10, F11
Development of high temperature materials	F10, F11
Research in more efficient use of fossil energy sources	F1, F2, F10
Development of high-efficiency cogeneration (trigeneration) in district heating systems	F11
Research and innovation of gas and steam turbines	F11
Increase in the use of heat pumps with high efficiency	F11
Development of new technologies for the energy recovery of secondary raw materials and wastes	F10
Energy Security	
Increase in the efficiency and reliability of energy systems and distribution networks	F1, F3, F5, F6, F7, F9, F10
Development of production and consumption management	F6, F7, F9, F10
Development of protection against cyber-attacks and the protection of telecommunication systems	F6
Internal Energy Market	
Development of technologies aiming at increasing the flexibility of the energy system	F1, F2, F5, F6, F7, F8, F9, F10
Research in the implementation of the circular economy model	F1, F2, F4, F8
Development of local energy production	F3, F5, F10

4.2.5 **Estonia**

Table 4.19 R&I priority and FUNCTIONALTY mapping: Estonia

Decarbonization	Functionalities
Introduction of low-carbon emission technologies and the efficient use of resources in industrial processes	F1, F2, F7, F11
Motivation of industry to employ predominantly low-carbon fuels and production inputs	F1, F2, F7, F11, F12
Increase in hydrogen production	F7, F8, F10
Energy Efficiency	
Development of “Smart House” concept	F1, F2, F3, F5, F6, F7, F8, F10, F11
Deployment of IT solutions towards energy efficiency	F1, F2, F6, F7, F8, F9, F10, F11, F12
Energy Security	
Optimization of network usage	F1, F2, F6, F7
Transmission network improved observability	F1, F2, F6, F7
Internal Energy Market	
-	-

4.2.6 **Greece**

Table 4.20 R&I priority and FUNCTIONALTY mapping: Greece

Decarbonization	Functionalities
Utilization of geothermal potential for electricity generation	F7
Development and deployment of marine wind parks (use of small wind turbines)	F1, F7, F10
Wave energy utilization	F1, F7, F10
Increase in RES hydrogen production	F7, F8, F10
Energy Efficiency	
Thermal insulation building systems with increased thermal performance	F11

Ventilated facades or roofs with PV and solar systems, thermal insulation, batteries	F10, F11
Deployment of flexible and high-temperature heat pumps	F10, F11
Improve on energy demand forecasts, via the combination of statistics and technical data, as a result from the digital programming and operational optimization of the energy system	F6, F9, F10, F11
Energy Security	
Load profile management through demand response	F3, F4, F5, F6, F8, F9, F10
Observability and controllability of medium and low voltage networks with high penetration of DER	F1, F2, F4, F7
Transmission network improved observability	F1, F2, F6, F7
Internal Energy Market	
Load profile management through demand response	F3, F4, F5, F6, F8, F9, F10
Observability and controllability of medium and low voltage networks with high penetration of DER	F1, F2, F4, F7
Transmission network improved observability	F1, F2, F6, F7

4.2.7 **Italy**

Table 4.21 R&I priority and FUNCTIONALTY mapping: Italy

Decarbonization	Functionalities
Further exploitation of solar PV and CSP renewable sources	F1, F7, F10
Utilization of wave / tidal energy	F1, F7, F10
Development of power-to-gas storage systems	F7, F8, F10
Energy Efficiency	
Development of Smart Grids	F1, F2, F3, F4, F5, F6, F7, F8, F10
Energy demand forecasting via software equipped with artificial intelligence	F6, F9, F10, F11
Storage of excess energy produced by non-programmable renewable energy sources (RES) into renewable energy carriers (biomethane, hydrogen, heat)	F7, F10
Make the system more ‘readable’ and the networks smarter	F1, F2, F6, F7, F9
Energy Security	
Evolution of the energy mix	F1, F2, F4, F10
Modelling and simulation activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector	F1, F2, F8, F9
Experimental activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector	F1, F2, F8, F9
Management of the distribution network and the energy system	F1, F2, F6, F7, F9
Internal Energy Market	
Increase in generation of distributed energy resources	F1, F2, F4, F5, F7, F10
Load profile management through demand response	F3, F4, F5, F6, F8, F9, F10

4.2.8 **Latvia**

Table 4.22 R&I priority and FUNCTIONALTY mapping: Latvia

Decarbonization	Functionalities
Development of RES technologies (production and use of biomethane, hydrogen and modern biofuels; smart use of biomass before combustion; use of solar energy in transport)	F1, F7, F10, F12
Creation and implementation of more resource-efficient and zero-emission technologies	F7, F10
Materials and engineering technologies for the acquisition and storage of	F7, F10

renewable energy (solar and hydrogen energy)	
Acquisition technologies for bioenergy (biomass, biogas)	F7, F10
Wave energy acquisition technologies	F7, F10
Intelligent transport systems	F7, F10, F12
Energy Efficiency	
Modernization of existing energy production technologies	F5, F6, F7, F9, F10
Development of heat insulation materials and technologies	F11
Creation of materials with high resource efficiency and energy efficiency	F10, F11
Development and introduction of high-efficiency cogeneration in district heating	F11
Development and application of digital energy innovation	F6
Modernization of the electricity metering	F5, F6, F7, F9, F10
Energy Security	
Development of solutions for energy storage, integration and smart transmission	F7, F10
Promotion of self-generation of energy	F3, F5
Development of RES technologies (which will ensure the increase of energy security)	F1, F7, F10, F12
Internal Energy Market	
Development of market models of a new type – peer-to-peer trading, aggregation services, energy as a service, local community energy systems	F1, F2, F8
Improvement of electrical system management	F6, F7, F8, F9, F10
Establishment of an effective link between research and innovation of technologies and their commercialization	F2

4.2.9 **Lithuania**

Table 4.23 R&I priority and FUNCTIONALTY mapping: Lithuania

Decarbonization	Functionalities
Development and network integration of new technologies for low GHG emissions	F7, F10
Offshore wind energy production	F7, F10
Development of solar technologies production	F7, F10
Increase in biomass use	F7, F10
Development of the use of hydrogen in energy, industry and transport	F7, F10
Intelligent transport systems	F7, F10, F12
Increase in RES in transport (advanced biofuels, biomethane)	F7, F10, F12
Energy Efficiency	
Modernization of existing energy production technologies	F5, F6, F7, F9, F10
Development of smart grids, production and use of new viable forms of energy	F5, F6, F7, F9, F10
Development of new production processes, materials and technologies	F2
Renovation of residential and public buildings	F11
Increase in energy performance of buildings and businesses	F11
Development of new technologies for the heating and cooling sector	F11
Energy Security	
Security and quality of the electricity supply, optimization of operating modes	F1, F5, F6, F7, F8, F9, F10
Energy and cyber security, reliability of energy equipment, and resistance to cyber-attacks	F6, F7, F9
Development of electricity storage technologies	F7, F10
Development of a capacity mechanism ensuring the adequacy of the electricity system	F7, F9

Development of liquefied natural gas technologies	F10
Internal Energy Market	
Functioning of electricity markets and power mechanisms	F1, F2, F7, F8, F10
Involvement of consumers in the electricity system and markets	F3, F5
Improvement of electrical system management	F6, F7, F8, F9, F10
Optimal energy pricing and promotion of liquidity in the energy trade market	F1, F2, F7, F10

4.2.10 **Malta**

Table 4.24 R&I priority and FUNCTIONALTY mapping: Malta

Decarbonization	Functionalities
Wind energy resources utilization	F1, F7,F10
Solar Energy exploitation (PV panels, solar water heaters)	F1, F7, F10
Energy Efficiency	
Thermal insulation building systems	F11
Deployment of energy-saving lighting systems	F7, F10
Deployment of energy efficient appliances	F7, F10, F11
Double-glazing utilization (Double Glazed Windows)	F7, F10, F11
Deployment of heat pumps	F7, F10, F11
Energy Security	
Development of energy storage market, leading to increased photovoltaic capacity and optimization of the power system	F1, F2, F4, F5, F6, F7, F8, F10
Internal Energy Market	
Load profile management through demand response	F3, F4, F5, F6, F8, F9, F10

4.2.11 **Poland**

Table 4.25 R&I priority and FUNCTIONALTY mapping: Poland

Decarbonization	Functionalities
Determination of the potential of forest areas for carbon dioxide sinking and the launching of research aimed at developing better methods of carbon dioxide balance calculation	F3, F12
Developing better methods of carbon dioxide balance calculation	F3,F12
Environment-friendly transport solutions	F12
Minimization of waste generation, including waste unfit for processing, and the use of waste for materials production and energy generation purposes(recycling and other forms of recovery)	F11,F12
Energy Efficiency	
Smart and energy-efficient building technologies;	F11
High-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems	F6,F7,F10
Energy Security	
Efficient and flexible energy generation and the use of raw materials combining the reduction of impact on the environment with energy security	F4, F6, F7, F9, F10
Diversification of energy generation and use technologies,	F1, F2, F4, F7
Internal Energy Market	
Continuous enhancement of technological advancement and the quality of operation;	F2, F4, F5
Implementation of competitive organizational and business models;	F5, F6, F8,
Optimization of capital use.	F3, F4, F8
Support for building close relations between business entities and public institutions	F2, F3,F5,F6

and the science sector.	

4.2.12 **Romania**

Table 4.26 R&I priority and FUNCTIONALTY mapping: Romania

Decarbonization	Functionalities
Support scientific research to decarbonize the energy sector	F3,F11,F12
Adopt advanced technologies in the energy sector by attracting private investments, supporting scientific research and developing strategic partnerships	F3,F11,F12
Integration of distributed production systems and prosumers into the power grid system	F7, F10
Energy Efficiency	
Implementation of smart city concept, integrating developed infrastructure; implementation of IoT at residential level	F6, F10,F11,F12
Creation of an energy efficiency investment fund (FIEE), financed by private funds, European funds, state budget, complying with the provisions of Law no. 500/2002 and no.69/2010	F3, F11,F12
Energy Security	
Smart medium and low voltage power distribution systems (including smart grids and IT systems) and efficient use of local energy sources including assigned storage	F6, F7,F10
Digitization of the national energy system in the transmission, distribution and consumption segments and introduction of the IoT and AI in the transport and distribution systems management.	F6,F7,F9,F10
Internal Energy Market	
Develop capacities and mechanisms to integrate the intermittent RESs in the national energy system and in the electrical accumulators systems, including the small storage capacities at the prosumer premises	F1, F4,F5, F6,F7,F8
Encourage domestic, industrial and agricultural prosumers build-up, along with the development of electrical grids and smart meters	F3,F5,F8
Integration of distributed production systems and prosumers into the power grid system	F2,F4,F5
Develop smart metering and smart grids	F4,F5,F6

4.2.13 **Slovakia**

Table 4.27 R&I priority and FUNCTIONALTY mapping: Slovakia

Decarbonisation	Functionalities
Development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy)	F5, F7, F10
Development of nuclear technologies (participation in the EURATOM programme)	F7, F10
Energy Efficiency	
Development of new network, consumption, production and interoperability technologies	F1, F6, F7, F9, F10
Development of technologies to increase energy efficiency and decrease energy intensity	F2, F7, F9, F10
Development of new energy transmission systems (power cables without dispersive electrical and magnetic fields)	F7, F10
Development of energy conversion technologies	F10
Development of the efficient use of domestic deposits of energy raw materials and geothermal energy	F7, F10
Development of high-efficiency cogeneration in district heating systems	F11

Construction, reconstruction and modernisation of heat distribution systems	F11
Energy Security	
Development of energy storage technologies (possibilities of energy storage in the form of mixture of natural gas and hydrogen)	F7, F10
Development of RES and nuclear technologies (will increase energy security)	F5, F7, F10
Creation of new energy transmission systems	F6, F7, F10
Internal Energy Market	
Development of circular economy model	F1, F2, F4, F8
Development of local power consumption management concepts	F3, F4, F5, F8, F10
Research on the involvement of consumers in the electricity system and markets	F3, F4, F5, F10

4.3 R&I Status based on ETIP SNET roadmaps

The 6 countries selected from the countries with below average SG R&I activities are as already mentioned representative. Hence, the number of SG R&I projects that have been implemented in these countries (national/EU project) and these countries have participated (EU projects) are very low. Table 4.28 shows this number of projects on which the analysis of this report is based on. All the projects (EU and National) information have been collected from JRC database and ETIP SNET report. Both project evaluation methodologies have been implemented to understand both the progress, in terms of transmission/distribution network approach (2010-2026 roadmap) and integrated energy system approach (2020-2030 roadmap). The following sub-sections discuss these studies. This exercise will enable also the procedures for the smoother transition between the two roadmaps.

Table 4.28 Number of projects for evaluation

RD	RD1	RD2	RD3	RD4	RD5	RD6
Country	Latvia	Bulgaria	Cyprus	Slovakia	Croatia	Ireland
#	16	23	17	11	15	45

4.3.1 Transmission/Distribution network approach (roadmap 2017-2026)

The projects evaluated have been classified under these criteria, knowing that it is possible that one project is related to more than one cluster and FO, but always highlighting which one is the most relevant. Concerning the tasks, only those encompassed within this main cluster and FO have been studied and hence, indicated in the assessment. Some of these projects evaluation reports are already available in [15] [17].

Figure 4.1 shows the cluster allocation of the projects related to the transmission network in the studied countries. This classification has been arranged by percentage of the total number of projects for each country. It is noticeable that Croatia, Slovakia and Cyprus have no projects been allocated in Cluster 5 (Digitalisation of the Power System), as it also happens with Cluster 1 (Modernisation of the Network) in the case of Slovakia. Nonetheless, it exists a general trend with regard to the percentage of projects fitting in Cluster 2 (Security and System Stability), higher than 30% in all the countries except for Bulgaria and Cyprus, as well as in Cluster 3 (Flexibility from Generation, Storage, Demand and Network), equal or higher than 20% in all the countries, with the exception of Latvia. By contrast, the percentage of projects assigned to Cluster 4 (Economic), is the most variable depending on the country.

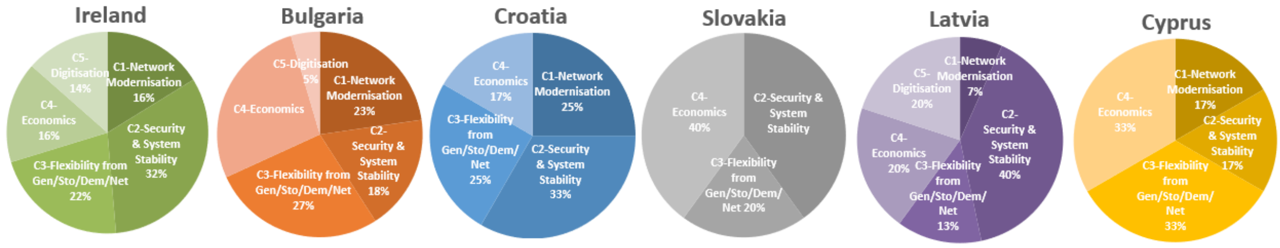


Figure 4.1 Clusters Related to the Transmission network

Following the same approach used for the transmission network, the projects related to the distribution network have been classified in compliance with the clusters, as shown in Figure 4.2. In this occasion, all the countries have projects belonging to every cluster excluding Latvia, which does not account with any project fitting in Cluster 4 (Planning and Asset Management). Furthermore, there is a wider variety of projects distribution among the different clusters, prevailing the Cluster 2 (Integration of Decentralised Generation, Demand, Storage and Networks) with figures overcoming 30% of projects in all the countries, and followed very closely by Cluster 1 (Integration of Smart Costumers and Buildings). Cluster 1 stands out especially in projects from Latvia, where almost the half of the projects assessed cover this cluster (46%), while Cluster 3 (Network Operations) is particularly relevant in projects from Ireland.

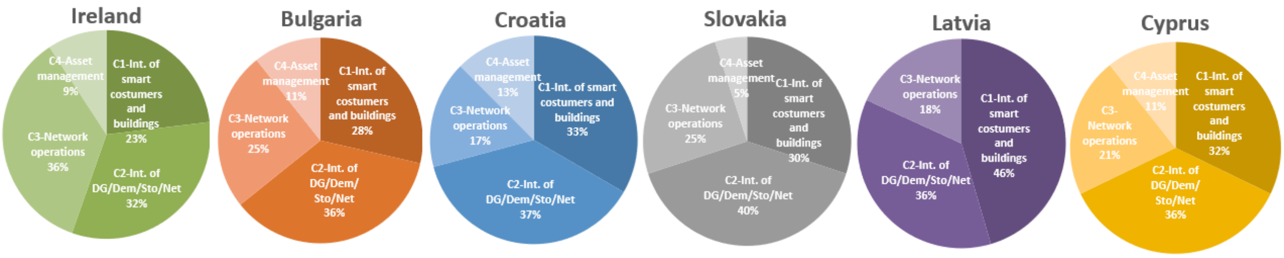


Figure 4.2 Clusters Related to the Distribution network

The ETIP SNET 2017-2026 Roadmap also defines 21 FOs under the 5 clusters to evaluate the SG R&I progress. Hence, Figure 4.3 shows the coverage of FOs for the transmission network projects in each country. It is based on the total number of projects that address one FO. Nevertheless, this fact is very conditioned by the number of projects in which each country is involved.

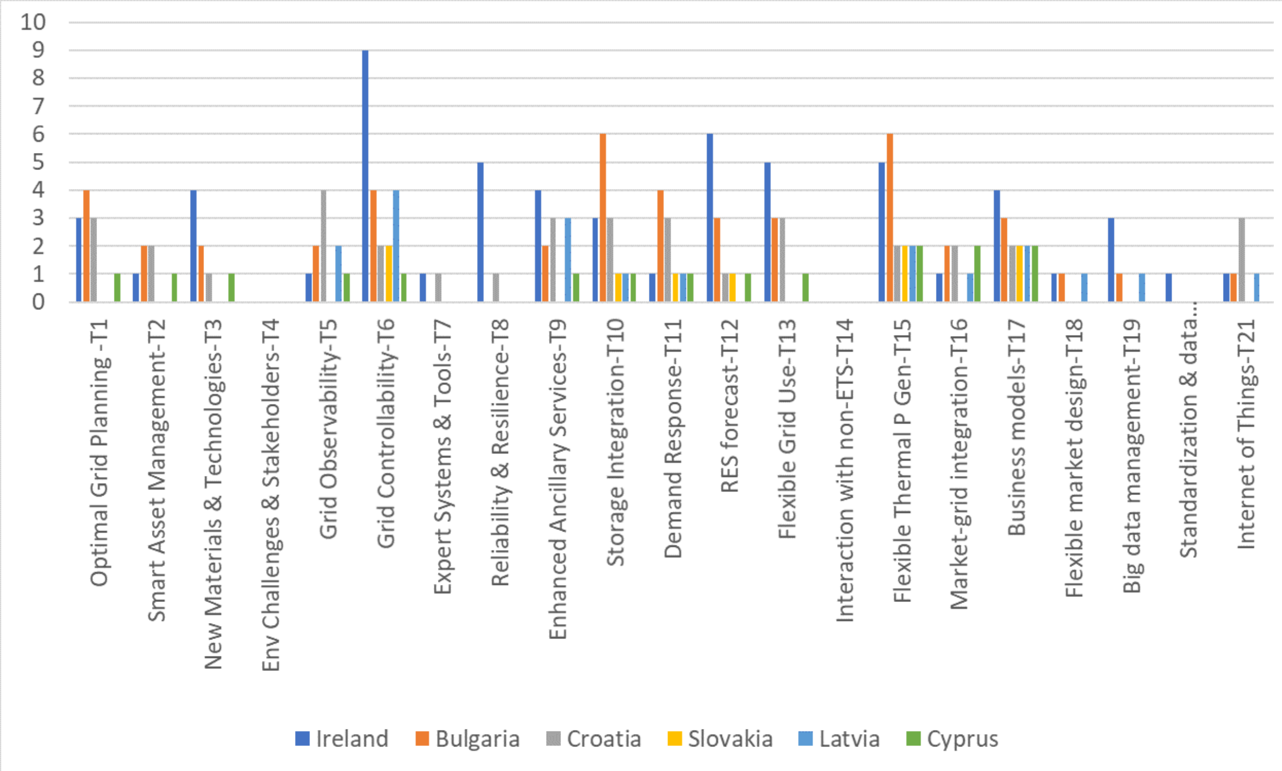


Figure 4.3 FOs related to the Transmission network

In this manner, the FOs covering not only the highest number of projects but also the largest number of countries are T6 (Grid Controllability) and T15 (Market Grid Integration) with a total of 22 and 19 projects, respectively, assigned from all the countries, followed by T10 (Storage Integration) and T17 (Flexible Market Design), with 15 projects allocated. Conversely, these projects are not addressing T4 (Environmental Challenges and Stakeholders) and T14 (Interaction with Non-Electrical Energy Networks).

The coverage of the FO by the distribution network projects are also presented in Figure 4.4. In this case, the total (40 projects) maximum attention is given on D5 (Integration of Storage in Network Management). The next most common FO is D2 (Energy Efficiency from Integration of Smart Costumers and Buildings), being present in 36 projects and followed by D3 (DSO Integration with small DER), with 34 projects overall. On the other hand, D13 (Asset Management) has not been considered by none of these projects, whilst D11 (Cyber Security) has been studied only by 2 projects in Ireland.

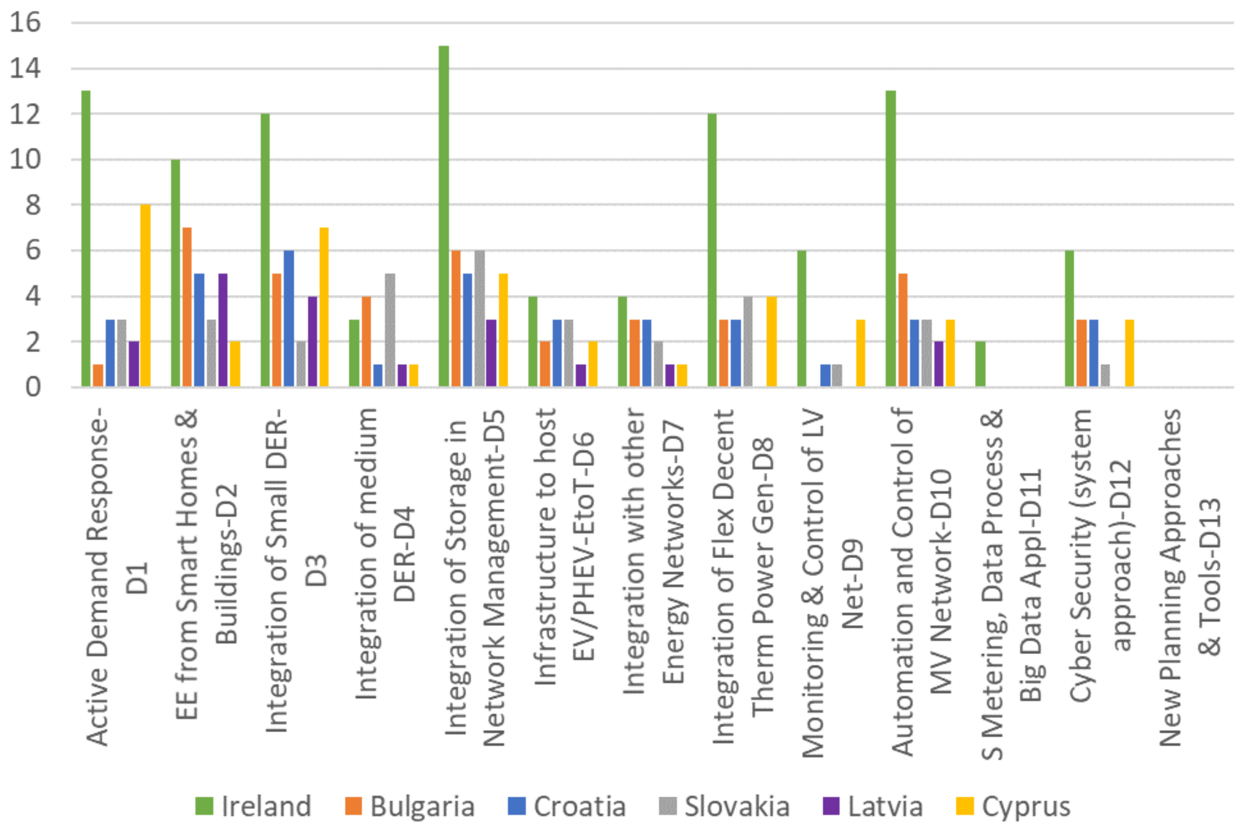


Figure 4.4 FOs related to the Distribution network

4.3.2 Integrated Energy System Approach

One of the main differences between the 2017-2026 and the 2020-2030 Roadmap of ETIP-SNET is that the latter treats the grid as an integrated network that is active at all levels: transmission, distribution and end user. Therefore, the projects are linked to the integrated grid with no distinct division of the point on the grid that it is active and have been processed through the evaluation method as discussed in section 3.2. The projects have been classified using the FUNCTIONALITIES, research areas (RA) and research sub-areas (RSA).

After the processing, the contribution of every country for each FUNCTIONALITIES has been evaluated by percentage, as shown in Figure 4.5. As a result, all the countries assessed have participated in all the functionalities to a greater or lesser extent. For instance, projects from Ireland stand out covering the functionalities of Electricity Systems and Networks (F7) and Business (F8), Croatia and Slovakia spotlight the FUNCTIONALITIES of Transport (F12), while in Latvia is remarkable the focus on Cooperation (F1) and Cross Sector (F2). On the other hand, it is noticeable the importance of Wholesale (F4) and Heating & Cooling (F11) in Bulgaria, whereas Cyprus rises above the functionalities of Digitalisation (F6) and Retail (F5). It is to be noted that this Digitalisation mainly appears in distribution network projects.

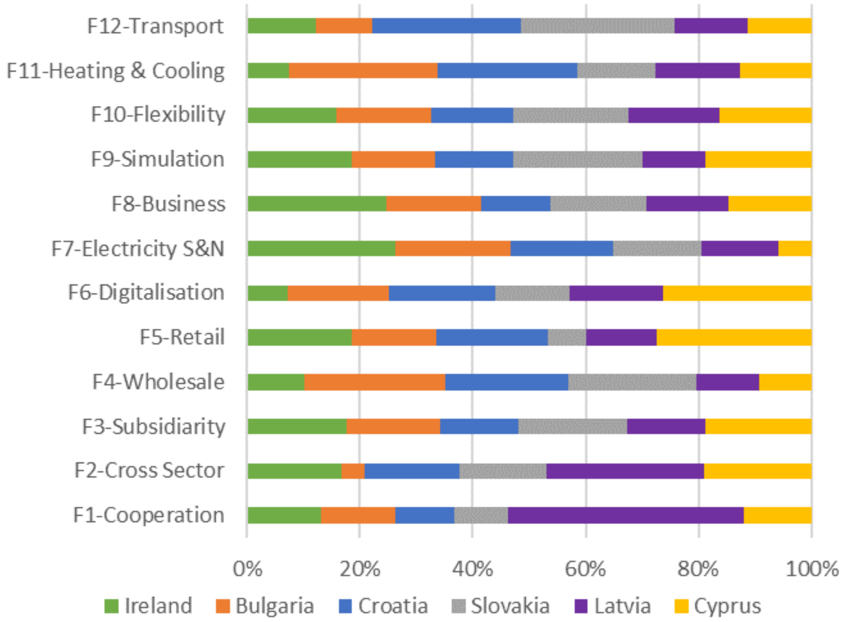


Figure 4.5 FUNCTIONALITIES in relation to the IES analysis

Similarly, to analyse the degree of coverage in the research areas (RA) by the projects, the percentage of projects addressing each RA has been studied for every country, as represented in Figure 4.6.

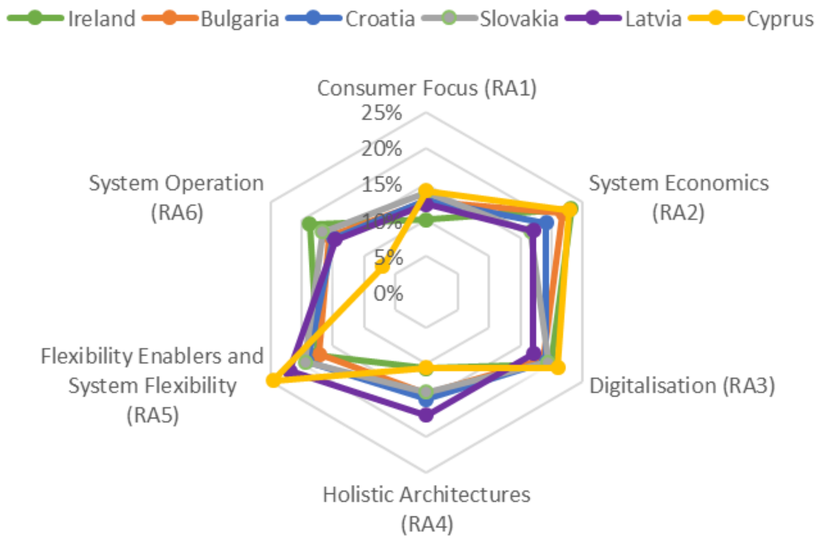


Figure 4.6 Research Area covered by the countries in IES analysis

Ireland, Bulgaria, Croatia, Slovakia and Latvia show similar distributions of their projects among all the research areas, being covered each one by percentages between 10-20% of the projects approximately. Nevertheless, Cyprus has a different layout in this issue since only a few projects address the research area of System Operation (RA6), unlike Ireland, whose projects are particularly focused on this area. Furthermore, only 5% of projects from Cyprus cover the research area of

Holistic Architectures (RA4), in which Latvia stands out. By contrast, 25 % of the projects from Cyprus are related to the area of Flexibility Enablers and System Flexibility (RA5), reaching similar percentages the research areas of System Economics (RA2) and Digitalisation (RA3). To conclude, Consumer Focus (RA1) is the least addressed research area in overall by all the countries.

This analysis along with the R&I priorities as dictated from NECPs of each country can be used to reach safe assumptions on the R&I needs at national level and how these can be aligned with the needs and targets at European level.

5 PANTERA proposed RICAP (R&I status and Continuous gAP analysis) process

5.1 A universal methodology: Linking the past to the present and to the future

Based on the above current methodology adapted in the ten-year plan and Implementation Plan of ETIP SNET but also the metadata approach / methodology adapted in the evaluation of BRIDGE projects it transpires that we need to bring the two together in a direction that will safeguard continuity in the years ahead and also link it to past evaluation work. It is apparent from the above that:

1. What is of fundamental importance to build R&I plans forward is the crystal-clear identification of required FUNCTIONALITIES that constitute the envisioned integrated grid of 2050 that is aligned with the strategy objectives of EU and Member States. Hence, the 10-year plan and IP of ETIP SNET are moving in the correct direction.

2. The identification of Topics and Tasks are of vital importance towards policy decisions and formulation of calls both at European (Horizon Europe) and National / Regional level. These being related to the identified FUNCTIONALITIES is also of prime importance addressing identified needs / objectives for maturing the evolution of FUNCTIONALITIES towards the 2050 envisioned integrated grid.

3. The grouping of identified Topics into Research Areas is a step that does not add any value to the work since what is fundamental is the relation of Topics through Tasks to FUNCTIONALITIES which are the body and soul of the envisioned integrated grid of 2050. This grouping does not serve any purpose.

4. What is of vital importance is the necessary step of linking tasks to technologies as is currently touched in the evaluation process of BRIDGE projects but not to the degree required for a complete evaluation process. This step is fundamental since what links the real world with the envisioned integrated grid of 2050 are the technologies and related FUNCTIONALITIES and not Topics and Tasks which are policy groupings for managing efficiently and effectively R&I calls at both EU and National / Regional level. Thus, it is critical to identify an exhaustive list of systems / technologies that constitute adequately the integrated grid. This needs to cover all layers of the smart grid architecture since the integrated grid requires components, communication systems, data and information systems that are functionally connected to the continuously developing electricity market that completes their operation in the physical world.

5. Building the metadata structure on the following groupings it will give a robust methodology of linking current practices with past and future, help search capabilities in support of gap analysis, project evaluation, R&I needs etc:

a. FUNCTIONALITIES linked individually to an exhaustive selection of systems / technologies with their contribution to the evolution of the specific FUNCTIONALITIES to be estimated in per cent (using engineering judgement through collective contribution of experts). During the evaluation process, individual project contributions will be reported by each consortium separately in their report to BRIDGE, ETIP SNET, ERA NET SES, PANTERA, etc. This reporting is required for building maturity indices towards the evolution of FUNCTIONALITIES and consequently, of the integrated grid.

b. Individual Tasks to be linked to systems / technologies with their contribution to the successful completion of the task in per cent. This is to be reported by each consortium in their report to BRIDGE, ETIP SNET, ERA NET SES, PANTERA, etc. This reporting is required for evaluating success at project level through the declared key performance indicators and success factors at project inception and ratified at contract award.

6. Using the linking matrices of 5 above as historical evidence of progress made that will include detailed linkage to systems / technologies of future or past FUNCTIONALITIES, the current gaps that are missing will be filled for robust transfer from past to the future. All that is needed is a detailed linkage of FUNCTIONALITIES (past, present and future) to systems / technologies with relational percentages. The beauty of this is that future changes in FUNCTIONALITIES and / or Topics and Tasks (these will naturally continuously be growing in number and content) will not require re-visiting Topics and Tasks and their relation to FUNCTIONALITIES. Since these do not move in time and they are not linked in the progressing evaluation of the maturity index of the integrated smart grid. The re-alignment is required for FUNCTIONALITIES and their relation to systems / technologies only.

7. Search engines on the PANTERA platform will facilitate surges based on systems / technologies, tasks, topics and FUNCTIONALITIES and other more specific attributes, irrespective of past, present or future (when is available).

8. The integrated grid will always be a composition of all the active FUNCTIONALITIES that will bear a maturity index that is generated from the maturity of systems and technologies and their corresponding percentage contribution. Individual projects do not complete the maturity cycle of systems and technologies but contribute to a specific degree (say TRL 5 to 7 for very specific systems and technologies) and this is translated into percentage contribution towards the maturity of the respective FUNCTIONALITIES.

9. It is essential for maturity indices of FUNCTIONALITIES to be normalised to 100% at each point in time meaning that if additional systems / technologies are added as contributing to the specific FUNCTIONALITIES and overall percentage is more than 100% then maturity is normalised accordingly to reflect correctly the maturity percentage, hence index.

10. All relational quantities i.e. Topics, Tasks, FUNCTIONALITIES etc should be normalised to 100% depending on the selected systems / technologies that are contributing. This is a need that arises from the fact that the system is constantly growing with new needs and requirements that add to the evolution of the integrated grid and the respective FUNCTIONALITIES. This dynamic process requires this normalization to reflect correctly the growing maturity of the respective relational quantity.

5.2 PANTERA recommendation on Technology/Systems classification in relation to the FUNCTIONALITIES of the ETIP SNET 10-year Plan

In this section, the recommendation of PANTERA on how the projects should be classified under system/technologies are presented. This aims to be a unified approach for the initiatives of DG ENER and all the platforms that will be connected with PANTERA so that we secure a useful data base that can be utilized for further analysis. The connection of these technologies with the FUNCTIONALITIES of the ETIPSNET 10-year plan is the next approach presented in this section. Of course, certain group of technologies that serve one or more than one FUNCTIONALITIES will be the basis of a quantified evaluation of the successfulness of the ETIPSNET vision of 2030 in the next.

As already described in section 3, the PANTERA recommendation on the classification has been inspired by EPRI and BRIDGE classification so far. The following list of technologies were validated by the energy experts of ETIPSNET Working Group 5 under the Working Team 3 Activities. Also, BRIDGE has accepted to adopt the following classification.

In the following table the technologies classification is presented. It is critical to highlight that under technologies we agree to consider a group of items and technical solutions that provide a whole and integral solution for smart grids. This is shown in the description column in the same table.

So, the different projects hosted on the PANTERA platform will be categorized under this classification following the methodology described in section 3. This procedure is critically important for the following reasons:

-Uniformity of results

-Better monitoring of the projects and their results

-Better monitoring of certain technologies employment through the financed projects

-Better R&I needs identification

The platform visualization of this procedure will highlight more the identified advantages above. When a critical mass of projects will be formed, a maturity index of the different technologies shall be formulated. By the term maturity index of technologies, we do not refer solely on TRL index. One factor that the current TRL scale does not address is how well the developed technology fits into the architecture and system structure of the program absorbing it. This is an integral part of the systems engineering job and critical to the success of the technology transition. And this is the need for improving on the maturity index and give to it the identified extended cover.

When program stakeholders give significant attention to new research, technologies, technology development programs or demonstrations, the targeted technology should be objectively evaluated and assessed for maturity as soon as possible before committing any significant program investment funding.

The technologies and thus the different projects that are serving them is of interest to get connected with the FUNCTIONALITIES of the ETIPSNET 10-year Plan. This way, will form the basis of developing a universal methodology for evaluating the maturity index of both Technology/Systems and FUNCTIONALITIES. This approach will have the following benefits

-The maturity of the FUNCTIONALITIES and any needs will be identified

-The technologies that serve the FUNCTIONALITIES will be visualized

-The projects and how they contribute to a specific FUNCTIONALITIES will be highlighted

-The needs and priorities of the power grid of the future can be extracted

In Table 5.1 the connection between FUNCTIONALITIES and technologies is shown. These links are the recommendations of the PANTERA project under close collaboration of the ETIPSNET Working Group 5 under the Working Team 3 Activities. The main rational behind the connection established is the following: How the technologies/systems can serve or contribute to one or more FUNCTIONALITIES at the same time according to the description of Table 1?

Of course both Table 1 and Table 5.1 are going to be validated further through a mutually agreed collaborative methodology among PANTERA, ETIP SNET and BRIDGE.

Table 5.1The PANTERA recommendation on technologies' connection with functionalities

Technologies in support of the Functionalities			
No.	**Group of technologies**	**Technologies/Systems**	**Functionalities**
1	**Integrated Grid**	Flexible ac transmission systems (FACTS)	F7
2		Models, Tools, Systems for the operation analysis, control and the development of the integrated grid including cost elements	F9
3		HVDC	F7
4		Forecasting (RES)	F4,F5,F9
5		Asset management	F1,F7, F9
6		Outage management, fault finding and associated equipment (including protection)	F1,F7
7		Equipment and apparatus of the integrated grid	F7, F1
8		Equipment, sensing, monitoring, measuring for analysis, solutions and control	F7, F6, F1
9		Advance distributed load control	F7, F1
10		Feeder auto-restoration / self-healing	F1,F7
11		Smart metering infrastructure	F6,F7,F8, F1
12	**Customers and market**	Load management & control and demand response including end devices, communication infrastructure and systems	F3,F5,F7,F8,F10,F11
13		Smart appliances	F6,F5, F8
14		Building control, automation and energy management systems	F3,F10,F11,F8
15		Electric vehicles	F5,F8, F2
16		Energy communities	F5,F8,F10, F11, F12
17		Lighting	F10
18		Electricity market	F2, F5,F10, F3,F4, F8, F11, F12
19	**Storage**	Storage Electric	F4, F5,F10, F12,F8
20		Thermal Storage	F2,F10,F11,F8
21		Power to gas	F2,F10,F8
22		Pumped storage	F2,F10,F11,F8
23		Other Storage	F2,F10,F8
24	**Generation**	Flexible generation	F2,F10,F4,F5,F8
25		Solar including PV & CSP	F2, F4, F8
26		Wind	F4,F8

27		Hydropower	F8, F10
28		Hydrogen & sustainable gases	F2,F8,F10,F12
29		Other generation	F8,F10,F12
30	**Digitalization, Communication and Data**	Communication networks including devices and systems for signals and data connectivity and solutions	F6
31		Digital Twins	F6, F9
32		Artificial intelligence	F6,F9
33		Data and cyber security including repositories	F6

5.3 PANTERA RICAP Process: Administrative

One of the key pillars to successfully derive the PANTERA RICAP (Administrative) outcomes and make it more effective for the benefits of low activity/targeted countries is to collect the ongoing and completed projects information and to feed it as input of the RICAP process (Technical). One of the ways to do that is by interacting and integrating stakeholders with the PANTERA activities, as shown in Figure 5.1. PANTERA integrates the stakeholders in two conceptual frameworks: Working Team (WT) and Regional Desk (RD). Both are briefly presented here. Details of the RD activities can be found in PANTERA deliverable D6.3 (Consolidated summary report of desk activities in the target regions) which is due in October 2020.

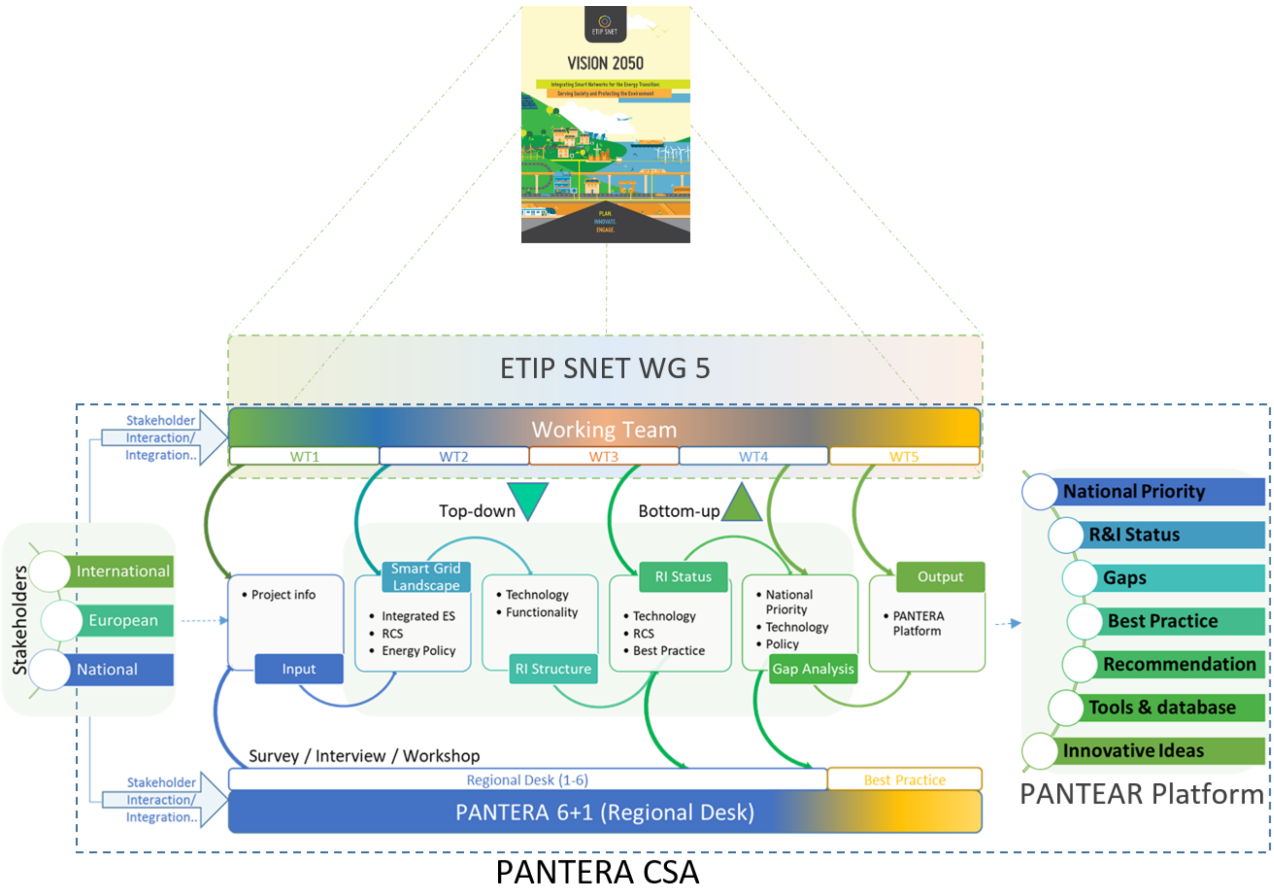


Figure 5.1 PANTERA RICAP (Administrative)

In brief, the five WTs are the part of working group 5 (WG5) of ETIP SNET. Details of the WT under the WG5 is in preparation for WG5 deliverable under the ETIP SNET. The responsibility of the WT members is primarily to support the Secretariat of ETIP SNET through the WG5 activities. PANTERA WT members are being part of these WG5 and WTs and playing double role in a coordinated way by (i) developing a generalised project evaluation method and analyse the projects outcomes through the RICAP (technical) process to feed into the development of future ETIP SNET roadmap and (ii) passing on results/outcomes of the national R&I status and gaps to the PANTERA platform.

To coordinate with the task to identify the national R&I status and gaps under the PANTERA CSA, the PANTERA WTs (team members who are working here for PANTERA) have extended the Smart Grid Landscape area to Integrated Energy System and included the study on RCS (regulation, code and standard) and energy policy to empowering energy citizen. Hence, PANTERA WT will identify the R&I status and needs under the extended SmartGrid landscape. The outcome of landscape will be feed to RI structure framework (to align with ETIP SNET roadmap) where the projects will be analysed based on the proposed PANTERA technologies and mapping with ETIP SNET FUNCTIONALITIES.

RD (regional desk) members also provide relevant input to the RICAP process. Such as, they assist to collect the national, regional and other project information to input in the RICAP process. Through the define activities, RD members also provide information to PANTERA WTs to identify the national R&I status and analyse the gaps. There is a dedicated best-practise Desk that also supports PANTERA WTs by sharing successful practical experience and knowledge which may be utilised for benchmarking and accumulating lessons learned.

There is a dedicated WT for gap analysis (WT3). PANTERA WT members of the WT3 will provide the national R&I gaps analysis (as shown in Figure 5.1 and Table1.1, Gap Analysis). Other PANTERA WT members are also responsible to provide input in the relevant section of the RICAP process to get the best outcomes of PANTERA CSA. For example, Figure 5.1 shows that WT1-research infrastructure team can provide more project information as an input of the RICAP process. WT2- regulation & standardization team has expertise on electrical network technology, ICT and energy market and thus they will assist to classify the projects under the smartgrid landscape and RI structure. Similarly, WT4 will provide innovative market update strategies to consider for technology at national level and thus it supports WT3 team in gap analysis process as well. WT5 supports to present the PANTERA activities in different EU level and international initiatives (EERA JP SG, MI IC1, ISGAN), hence it is connected to the output of RICAP process.

5.4 PANTERA RICAP Process: Technical

Project info:

RICAP process (Technical) starts with the input from different projects. Project information is collected from different stakeholders (International, European and National). Most of the basic information is available through the project websites or other publicly available deliverables and scientific papers. Project-related data are also available in the well-known and established platforms such as Smart Grids projects map of JRC, NER300 projects, CORDIS, ETIP SNET, Expera Smart Grids+, etc. All the WT members and country specific RD members are also active to provide support in this part of the process. For initial analysis of country specific R&I status and to identify the technological gaps, the relevant project information is processed through the “Technologies-FUNCTIONALITIES” cell.

Technologies-FUNCTIONALITIES (T&F) cell:

T&F cell contains the database of proposed PANTERA classified “Technologies” and the its mapping with the relevant “FUNCTIONALITIES”. The details of the classified Technologies and mapping with FUNCTIONALITIES are already discussed in section 3. Based on the project information, this cell identifies which technologies have been researched by the specific project and demonstrated at what level. This cell also evaluates the FUNCTIONALITIES that the technologies have been covered.

R&I Status:

This cell identifies the status of the implemented technologies by mapping it with the ETIP SNET implementation plan along with the priorities as defined in the NECPs at national level. The output will show the R&I status with time, i.e, progress with the implementation plan and to decide its level of inclusion (Research/Demonstration/Deployment) in future roadmap

R&I Needs Identification:

Previous RICAP process steps are leading to the R&I needs identification. This evaluation will be based on the previous blocks and it is crucial not only to have an abrupt identification but also a solid quantification of these needs. R&I needs will be highlighted at both EU and national level. So, this block includes a methodology that quantifies and highlights the needs based on the research activity so far.

Technologies &Functionalities Maturity Index:

In order to have the quantifiable result of these R&I needs both Technology and FUNCTIONALITIES Maturity Indexes will be extracted at the final step of this process. This cell will feed the PANTERA platform but also will close the loop of this process by giving feedback in BRIDGE and more specifically, the R&I priorities Taskforce and to ETIP SNET as vital information for the quantified R&I needs to build the next 10-year roadmap and corresponding Implementation Plan.

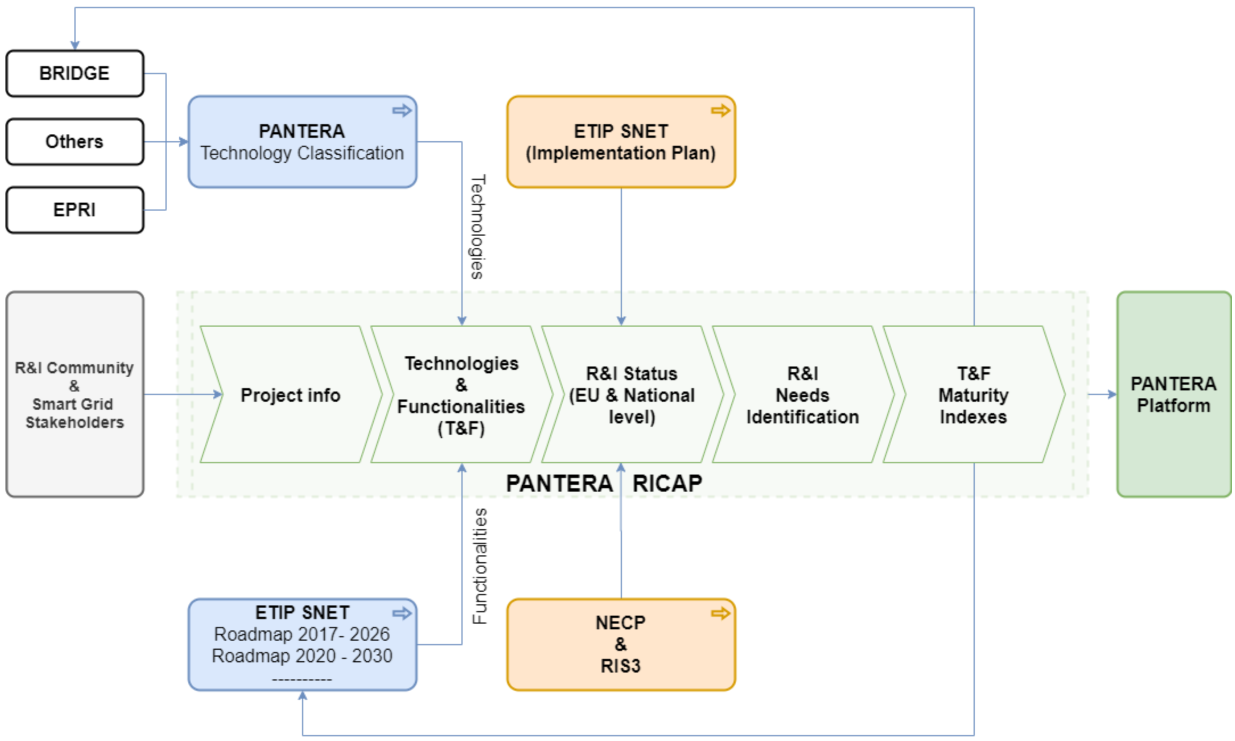


Figure 5.2 PANTERA RICAP (Technical)

5.5 R&I Status Analysis based on the proposed RICAP process: A case study for Ireland

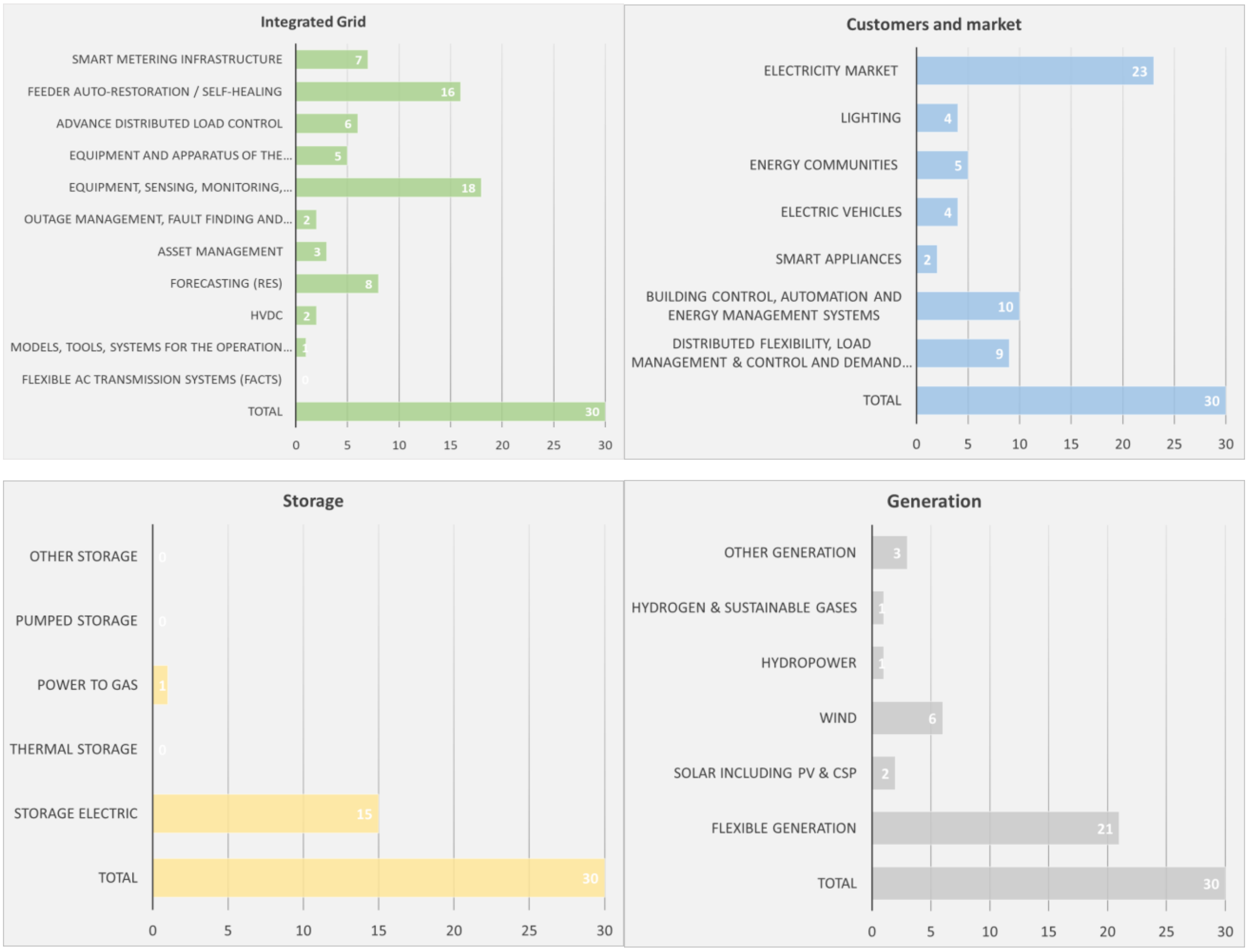
Based on the proposed PANTERA technology/systems classification, the R&I classification is performed here for Ireland as a part of a continuous verification process of the RICAP. In total the information of 30 projects has been collected from JRC database, ETIP SNET and national funding bodies (such as SEAI, EI). The technology/systems mapping is done under the defined 5 categories. Figure 5.3 shows the outcome of the analysis.

In the integrated grid aspect, it shows that technologies for the network equipment, sensing monitoring for network management, control, system security and stability, feeder auto-restoration are getting more importance. On the other hand, HVDC, FACTS for the Transmission/cross-border network are getting less attention yet.

When it comes for Customers and market categories, electricity market is at first preference. Though the empowering energy citizen is one of the key priority in energy policy, projects related to energy communities should get more importance.

Energy Storage and flexible generation are as usual, getting more preferences in Storage and General categories.

Advancement in digitalisation, such as implementing artificial intelligent should be considered in the future projects.



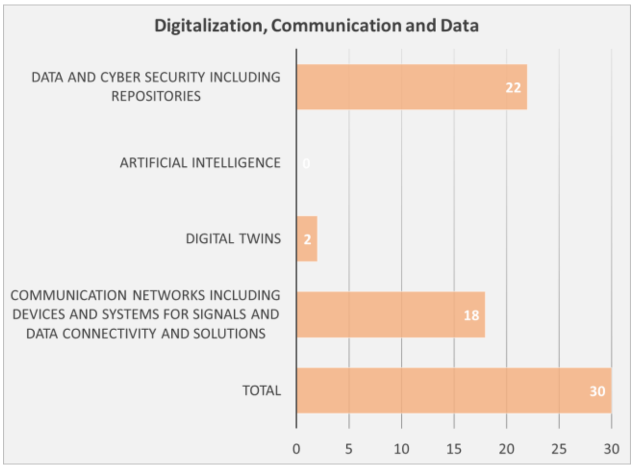


Figure 5.3 Implementation of proposed PANTERA Technologies in Irish projects

6 Conclusions

This deliverable presents the current status and progress in R&I activities for the countries that have low activity in R&I on smart grids, storage and local energy systems. In order to do that in a systematic way the following are performed:

- A thorough review on the EU and world-wide R&I initiatives and their role in the related field
- A thorough review on the different EU approaches on evaluating the R&I status at national and EU level
- A thorough analysis of the NECPs plans of all countries with low activities and R&I priorities identification. Within the same analysis the priorities are linked with the functionalities of the ETIPSNET roadmap 2020-2030.
- An analysis of the R&I activity for 6 representative EU countries based on both methodologies provided by ETIPSNET

From the above analysis, the following needs emerge as critical:

- The need to provide a unified approach/methodology that would support a rolling procedure of identifying the R&I needs at both EU and national level combining a top down and a bottom up approach.
- The need of classifying the projects using a unified classification methodology that would provide a solid baseline for further analysis and a robust data base for the PANTERA platform
- The need of making a both quantitative and qualitative analysis of the R&I needs through the ETIP SNET roadmap approach/FUNCTIONALITIES taking also NECPs under consideration

Moreover, this deliverable goes beyond the analysis and establishes:

- The PANTERA RICAP process and describes how it supports the R&I progress at EU, for other initiatives and the PANTERA platform
- The initiation of a new classification approach for the projects that would promote both technology and functionalities maturity indexes calculation as a quantifiable means of R&I needs identification

In order to validate and verify the PANTERA RICAP process the Ireland case is used as a test case and the outcome is satisfying, highlighting the following:

The R&I activities are progressing well in Ireland on some specific areas such as

- Network monitoring, stability and security issue
- Electricity market
- Electricity storage
- Flexible generation
- Communication for digitalisation

On the other hand, based also in NECPs analysis, Ireland should take care on certain technologies

- Network outage management, fault finding, HVDC, FACTS
- Energy communities
- Other form of storage, sector coupling
- Generation other than wind
- Advancement in digitalisation etc.

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8 APPENDIX

A: NECP

8.1.1 Bulgaria

Current Situation Bulgaria

In 2016, GHG emissions in Bulgaria amounted to 59 060 Gg CO2, excluding the LULUCF sector. Emissions have decreased by 49.41 % compared to 1988 (baseline) and by 4.4 % compared to the emissions in the previous year (2015). The main reasons for the reduction of GHG emissions in Bulgaria are:

- the structural reforms in the economy that resulted from the transition from planned to market economy;
- the reduced electricity generation by thermal power plants (and increased shares of water and nuclear energy);
- the structural changes in industry (including the lower output of energy-intensive enterprises and the improved energy efficiency);
- implementing energy efficiency measures in the housing sector;
- shift from solid and liquid fuels to natural gas in energy consumption;
- the decline in the populations of bovine animals and sheep and in the use of fertilisers.

The Energy sector (GHG emissions from combustion of fuels) held the highest share in total GHG emissions in 2016: 71.8 %. The Agriculture sector ranked second, with 11.0 %, the Industrial Processes and Use of Solvents sector (IPUS) ranked third with 10.3 % and the Waste sector came next with 6.9 %. The share of emissions covered by the emissions trading scheme in total GHG emissions stood at 56.6 % in 2016, and the share of emissions outside the scheme stood at 42.2 %. In 2016, the emissions from the Energy sector decreased by 47.9 % compared to the baseline year (42 386 Gg CO2eq in 2016 compared to 81 320 Gg CO2eq in 1988). Compared to the previous year, in 2016 the emissions decreased by 6.9 % due to the lower electricity output from fossil fuels. The main source of emissions in the sector is the incineration of solid fuels which accounted for 57.8 % of the emissions in the sector in 2016, followed by liquid fuels at 29.0 % and gaseous fuels at 12.2 %. GHG emissions between 1988 and 2016 were driven by the significant reduction in emissions from fuel combustion in the energy industries (35.7 %) and in the use of energy in the manufacturing industry and construction (83.4 %) and in other sectors (commercial, residential, forestry) — 72.3 %, as well as by the clear increase in GHG emissions from transport by 30.2 %.

Final energy consumption (except for 2016) followed the PEC trend, increasing by 7 % over the period 2012-2018. The lowest primary energy consumption was registered in 2013 (8 671 ktoe). The decrease is mainly due to the lower consumption of petroleum products (by 319 ktoe or 11 % compared to 2012), energy for heating (by 78 ktoe or 8 % compared to 2012) and coal and fuels manufactured from coal (by 46 ktoe or 11 % compared to 2012). In 2013, an increase by 47 ktoe (or 4 % compared to 2012) was registered in renewable energy. In 2013, the year in which the lowest primary energy consumption was registered (8 671 ktoe), final energy consumption increased continually, reaching 9 747 ktoe in 2018.

In 2013, primary energy consumption decreased in all sectors, except for the Industry sector, which registered a small increase by 2 %. The most significant decrease by 294 ktoe (or 10 % compared to 2012) was registered in the transport sector, followed by the households sector with 112 ktoe (5

% compared to 2012) and the services sector by 46 ktoe (4 % compared to 2012). In 2014, primary energy consumption in the transport sector began to increase while continuing to decrease in the households and services sectors, reaching its lowest levels in the period 2012-2018 of 2 165 ktoe and 991 ktoe, respectively.

In the period 2012-2018, the transport sector retained its dominant share in primary energy consumption in keeping with the trend registered in 2009. With a share of more than 34 % in 2018, transport was the most energy and fuel intensive sector, with more than 94 % of the fuels used being imported.

The Second national report on Bulgaria's progress in the promotion and use of energy from renewable sources, which was submitted to the European Commission at the end of 2013, stated that in 2012 Bulgaria had overachieved the binding national target of a 16% share of energy from renewable sources in gross final energy consumption for 2020. The next national reports (Third and Fourth national reports on Bulgaria's progress in the promotion and use of energy from renewable sources) indicate an ongoing growth of the energy use from renewable sources and in 2018 a 20.5 % share of energy from renewable sources in the country's gross final energy consumption was achieved. Gross final consumption of energy from renewable sources exceeds the quantity estimate set out in the National Plan for 2020, having reached 2 230.1 ktoe in 2018. In 2018, an increase by 37.2 % compared to 2012 was achieved. Over the period 2012-2018 consumption in the heating and cooling and electricity sectors increased by 22.0 % and 42.0 %, respectively. The use of energy from renewable sources increased significantly in the Transport sector from 5.1 ktoe in 2012 to 151.1 ktoe in 2018.

Future Targets and Objectives Bulgaria

Regarding the **Decarbonisation** dimension, Bulgaria will make efforts to increase the share of energy from renewable sources in gross final energy consumption and reduce GHG emissions. In line with the Commission's recommendation, Bulgaria has raised the level of ambition regarding the share of energy from renewable sources in gross final energy consumption from 25 % to 27.09 % and will thus aim to achieve the target set in Annex II to Regulation (EU) 2018/1999.

In line with the EU's priorities for increasing energy efficiency, Bulgaria considers energy efficiency to be a top priority in view of its importance for improving energy security by lowering dependence on energy imports, for reducing energy costs for businesses and households, for creating more jobs, for improving air quality, for cutting GHG emissions and for improving the quality of life of citizens.

In connection with this, national targets have been set for achieving a 27.89 % reduction in primary energy consumption and a 31.67 % reduction in final energy consumption by 2030 as compared with the PRIMES 2007 reference scenario.

Regarding the **Energy Security dimension**, Bulgaria's top priority is to diversify the sources of - and the routes for – its natural gas supply by implementing the following projects: building an interconnector between Bulgaria and Greece (IGB project), building an interconnector between Bulgaria and Serbia (IBS project), participating in the construction of a liquefied natural gas (LNG) terminal in Alexandroupoli, and gas infrastructure development in connection with the plan to build a regional gas distribution centre (Balkan Gas Hub). Bulgaria aims to increase its energy security by diversifying its energy supplies, making efficient use of domestic energy resources and further developing its energy infrastructure. In order to achieve these goals, efforts will be focused on grid development and enhancing the flexibility of the electricity system, e.g. by further developing the 400 kV and 110 kV transmission grid. Regarding nuclear energy, and in line with the Commission's requirements and the Guidelines published by the EURATOM Supply Agency (ESA), Bulgaria is fulfilling its commitments and is currently conducting a technical and economic analysis to inform its efforts to diversify fresh nuclear fuel supplies for Units 5 and 6 of the Kozloduy NPP. The top national priority in the area of energy security is to implement a robust strategy for diversifying the sources of - and the routes for – its natural gas supply. At the same time, Bulgaria is encouraging crude oil and natural gas exploration in the Black Sea, with several projects currently under way.

Regarding the Internal **Energy Market dimension**, Bulgaria will develop a competitive market by fully liberalising the market and integrating it into the regional and wider EU market, as stated in relation to the Energy Security dimension. The protection of vulnerable consumers is a key element of full liberalisation. In line with the Commission’s recommendation for the development of competitive wholesale and retail markets, Bulgaria will phase out regulated electricity prices by the end of 2025 while promoting competition and transitioning to fully market conditions. The coupling of the day-ahead market with Romania is expected to be completed by the end of 2020, and with other neighbouring countries by 2025. The intra-day market was coupled with Romania in November 2019. Other policy measures for the development of the internal energy market in line with the goals of the Energy Union include the development of a market- oriented capacity mechanism, consumption optimisation, incentives for creating energy communities for renewable energy generation and consumption, and encouraging consumers to play a more active role.

Electricity interconnectivity

In accordance with EU law each Member State must achieve an interconnectivity target of least 10 % and 15 % of domestic installed capacity by 2020 and 2030, respectively. The maximum transmission capacity of power lines and network elements must be ensured in line with applicable safety standards for network operation, including the safety standard for emergency situations. In line with applicable EU requirements, Bulgaria has set an electricity system interconnection target of at least 15 %. The transmission capacity upon import/export indicated in NECP will be achieved on the condition that bottlenecks in the internal electricity grids of Romania and Greece are addressed, an agreement is reached on the application of Article 16(8) of REGULATION (EU) 2019/943 and the capacities available at Bulgaria’s borders with third countries (Turkey, North Macedonia and Serbia) are calculated in coordinated manner.

Energy transmission infrastructure

Bulgarian energy transmission infrastructure consists the infrastructures for electricity, natural gas and heat. The aims of Bulgaria are to increase the capacity of the transmission networks by

- Maintain and develop the transmission capacity of the electricity and gas transmission networks.
- Optimize consumption in the energy system through the development of energy markets
- Increase the electricity and natural gas storage capacity by developing the existing storage facilities and by building new storage facilities.
- Increasing the transmission capacity of the power lines between Bulgaria and neighbouring countries.

Digitization of the energy system

The digitization of the energy system is a prerequisite for preparation and launch of a digital platform for the Bulgarian construction sector in the period 2021—2030:

- Development and implementation of a strategy and national plan for digitalization of the construction sector;
- Development of standards and regulations for the implementation of digitalization and building information modelling (BIM) in the construction sector, including the necessary accompanying analyses;
- Implementation of the digital reform in the construction industry;

Net metering and active consumer schemes

Bulgaria aims to encourage transmission and distribution network operators to make available system services for electricity demand response measures, demand management and distributed generation on organized electricity markets and to improve efficiency in network design and operation, in particular:

- shifting of the load from peak to off-peak times by final customers taking into account the availability of renewable energy, energy from cogeneration and distributed generation;
- energy savings from demand response of distributed generation sources through a combination of making available energy-efficient services and participation in the balancing market for electricity;
- demand reduction to be achieved by energy efficiency measures undertaken by energy efficiency service providers;
- connection and dispatch of electricity generation sources at medium and low voltage levels;
- connection of electricity generation sources from closer location to the point of consumption;
- providing access to the networks for energy storage facilities.

Another objective is to introduce dynamic pricing for demand response measures by final customers by means of:

- time-of-use prices;
- critical peak pricing;
- real time pricing;
- peak time rebates for lower consumption.

Summary of the future targets and objectives of Bulgaria (Per Dimension)

Decarbonization
• limiting the use of conventional fuels in the road and rail transport • increasing the share of new generation biofuels in final energy consumption in transport • limiting the use of biofuels and biogas produced from the feedstock listed in Part B of Annex IX of Directive (EU) 2018/2001 (waste edible oils and animal fat) to a maximum of 1.7 % of the energy content of transport fuels supplied for consumption or use on the market • the share of renewable electricity is considered to be four times its energy content when supplied to road vehicles and may be considered to be 1.5 times its energy content when supplied to rail transport • with the exception of fuels produced from food and feed crops, the share of fuels supplied in the aviation and maritime sectors is considered to be 1.2 times their energy content.
Energy Efficiency

• achieving energy savings of 8 325 GWh by 2020; • achieving annual energy savings of 1.5 % of the volume of energy sales; • taking action to improve the energy performance of at least 5 % of the total gross floor area of all heated and/or cooled public buildings used by the civil service • increasing the number of nearly zero-energy buildings; • ensuring that secure and affordable energy is available to all consumers; • minimizing the adverse effects of energy use on human health and the environment; • improving living standards in Bulgaria. • increasing the competitiveness of the Bulgarian economy.
Energy Security
• efficient use of indigenous energy resources • Increasing the level of interconnection with other countries and information security (cybersecurity); • Coupling of energy exchanges in Southeast Europe; • Diversification of energy sources and routes; • increasing the flexibility of the national energy system;
Internal Energy Market
• Liberalization of the electricity market • Liberalization of the natural gas market • Coupling of intraday markets with neighboring countries (Romania, Greece, North Makedonia and Serbia)
Research, innovation and competitiveness
• promotion of the development of innovations, their subsequent commercialisation and the technological renewal of enterprises • promotion of the development of innovations, their subsequent commercialisation and the technological renewal of enterprises • improvement of ambient air quality; • introduction of new energy-saving technologies that improve the quality of life and working conditions of Bulgarians; • introduction of new insulating materials for glass surfaces; • building smart grids for automated electricity system control to be used by both energy suppliers and consumers with a view to ensuring the highest possible standard of electricity supply to consumers and utilizing to the maximum extent possible energy from renewable sources. The ultimate goal is to upgrade and automate existing electricity systems. • construction of storage facilities supports for research and innovation in the area of nuclear energy and sustainable and safe management of nuclear waste enhancing the competitiveness and market positions of Bulgarian industry and promoting the development and manufacturing of innovative products with high added value; • preserving the competitiveness of basic energy-intensive industries and limiting the risks of ‘carbon leakage developing electric cars and hydrogen technologies;

In 2018, total research and development (R&D) costs in Bulgaria in all sectors stood at 0.75 % of GDP (against an EU average of 2.11 % according to Eurostat data). In 2017, R&D costs in the private sector stood at 0.53 % (as compared to the EU average of 1.36 %), despite the significant improvement compared to 2007, particularly in the sector of Information and Communication Technologies. The share of large multinational companies in R&D investment account for more than half of total investments in the business sector. Regional concentration is also a prominent feature of the process, with more than 70 % of R&D activity concentrated in the Southwest region, and more specifically Sofia. In 2017, R&D costs in the public sector stood at 0.21 % of GDP as compared to the EU average of 0.69 %. In 2018, Bulgaria doubled its R&D budget with a view to supporting the implementation of the Scientific Research Strategy for the period 2017-2030 and had committed to gradually increase public spending on R&D to 1 % of GDP in 2025.

There is a clear need for the implementation of the latest energy technologies. Bulgaria aims to accelerate this process in order to speed up transition to clean and highly efficient energy technologies. This is one of the mechanisms for achieving a secure, sustainable, environmentally friendly and highly efficient energy sector. The implementation of new technologies will contribute to lowering technological losses in existing networks, expand the energy market, contribute to finding solutions to the challenges of decarburization, lower energy costs for consumers and reduce harmful emissions, thereby improving quality of life for citizens. In connection with this, the goals of the Bulgarian government in the area of research, innovation and competitiveness are summarized as follows:

Decarbonisation
• Improvement of ambient air quality; • Support for local industries for the introduction of low-carbon technologies and • for the public administration and household sectors for the use of new highly • efficient energy-saving technologies; • Developing smart energy systems, grids and storage capacity outside TEN-E • Development of hydrogen technologies
Energy Efficiency
• Introduction of new energy-saving technologies that improve the quality of life and working conditions of Bulgarians • Reducing technical losses in electricity transmission and distribution • Increasing the reliability of measuring the quantity of electricity that is received in or leaves the electricity distribution grid and limiting the option for its unauthorized use • building Smart Grid networks
Energy Security
• Development of innovative technologies for energy storage, such as capacity of back-up systems for the integration of electricity from renewable sources through battery storage system • Digitalization of energy networks through the development of smart grids and smart metering, smart medium-voltage and low-voltage electricity distribution systems and efficient use of local energy sources. • Consumer protection and addressing energy poverty.
Internal Energy Market
• Development of system services for electricity demand response measures, demand management and distributed generation on organized electricity markets and to improve efficiency in network design and operation • Introduce dynamic pricing for demand response measures by final customers • Transmission network improved observability

Regulatory/ legislation steps contributing to the realization of the NECP priorities Bulgaria

- The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities, are summarized as follows:
- Development of electricity transmission and distribution infrastructure, of smart networks, of storage facilities and interconnectors
- Requirements for the use of renewable energy in buildings
- Strengthening the role of central and local authorities to enable a higher penetration of renewable energy
- Introducing a simplified procedure for grid connections when installations of renewables self-consumers and demonstration projects that use renewable energy with an electrical capacity of 10.8 kW or less are to be connected to electricity distribution networks
- Assessment of the potential energy from renewable sources and the potential use of waste heating and cooling in the heating and cooling sector
- Access to and operation of grids
- Creating conditions for renewables self-consumers and renewables communities
- Promoting the use of heating and cooling energy produced from renewable sources
- Promotion of the use of geothermal energy
- Introducing legal requirements for issuance of guarantees of origin for energy from renewable sources
- Streamlining the legal framework for application of the stricter requirements stipulated in Directive (EU) 2018/2001 as regards sustainability criteria and GHG emission reductions when using biofuels and liquid, gaseous and solid fuels from biomass.
- Introducing an obligation for fuel and electricity suppliers for achieving the target set for the transport sector
- Promoting the use of renewable energy in public transport
- Creating conditions for the development and use of advanced biofuels, renewable liquid and gaseous biofuels of non-biological origin and recycled carbon fuels
- Promotion of the development and deployment of electric mobility in transport, including by building road transport infrastructure and introducing new technologies in railways
- Creating appropriate financial incentives to ensure the achievement of the target in the transport sector
- Production of hydrogen from renewable sources

8.1.2 Czech Republic

According to the latest available inventory of greenhouse gas emissions and removals, the Czech Republic’s greenhouse gas emissions in 1990–2016 decreased by 34.69%, including the LULUCF sectors and 35.24% excluding the LULUCF (land use, land-use change and forestry) sectors. The energy sector accounts for the largest share (81%) of total emissions, of which 96% is related to the combustion of fuels.

Verified emissions from stationary sources included in the EU ETS decreased by 18.11% between 2005 and 2016. Emissions in non-ETS sectors show a rather fluctuating trendover the same period. In particular, emissions from the waste and transport sectors are increasing. However, the Czech Republic should, with a large margin, meet its target for non-ETS sectors by 2020, which allows for a maximum emission increase from these sectors of 9% compared to 2005.

When making projections of greenhouse gas emissions there is a specific focus on forest land category, which is a key category in the LULUCF sector, but also in the whole national inventory of greenhouse gas emissions and removals. In relation to the LULUCF sector and carbon neutrality, it should be emphasised that in the coming years the role of forestry in the Czech Republic will change in terms of CO_2 sinks due to extraordinary logging related to the elimination of bark beetle calamity. For these reasons, it is likely that the category of the managed forest land will temporarily show CO_2 emissions.

Current final energy consumption in the economy and per sector:

- Total final energy consumption: 2014 - 945 381 TJ; 2017 - 1 028 132 TJ
- industry: 2014 – 265 386 TJ; 2017 - 280 135 TJ
- transport: 2014 – 249 068 TJ; 2017 - 277 019 TJ
- households: 2014 – 279 392 TJ; 2017 - 307 418 TJ
- services: 2014 – 122 651 TJ; 2017 - 133 690 TJ

Current energy mix

In 2016 total primary energy sources amounted to 1 790.6 TJ. Solid fuels, especially brown and black coal, accounted for the largest share – 38.69 % (excluding electricity, which was negative). The second biggest source of energy is crude oil (and derived petroleum products), which accounted for 19.42 % in 2016. Natural gas accounted for 16.41 %. Nuclear reaction heat contributed 14.69 %. Renewables accounted for 10.08 %, and waste (its non-renewable component) accounted for around 1 % of the total energy mix.

The total share of renewable energy sources in gross final energy consumption according to EUROSTAT methodology stood at 6.83% in 2004 it grew to 14.89 % in 2016.

- Electricity: **2004** – 3.55%; **2016** – 13.61%
- Transport: **2004** – 1.57 %; **2016** – 6.42%
- Heating: **2004** – 9.93 %; **2016** – 19.87%

In regard of research, innovation and competitiveness, the Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. However, research, development and innovation in sustainable energy are one of the priority areas of key strategic documents such as the National R&D Strategy for Smart Specialisation and the National Priorities for Oriented Research, Experimental Development and Innovation. In the development of priorities in this area, the Czech Republic also seeks to take into account the priorities at EU level, especially the priorities of the European Strategic Energy Technology Plan. It is not possible to precisely determine the exact level of public funding of research, development and innovation for low-carbon technologies. However, the National Plan shows the estimate of public finances allocated to the energy sector.

The Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. The difficulty of setting energy and climate targets is due, inter alia, to the structure of public funding for research, development and innovation, which is not sector-focused, but is provided under national and ministerial support programmes.

The National Policy also proposes changes in the management and funding of science so that more top-level scientific results are produced and companies become more engaged in R&D.

<u>Future Targets and Objectives Czech Republic</u>

The National Energy and Climate Plan of the Czech Republic was prepared on the basis of a Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action and it contains the main targets and policies in all five dimensions of the Energy Union for the period 2021–2030 with a view to 2050. The main part of the National Plan is the setting of the Czech Republic's contribution to the European climate and energy targets concerning the reduction of greenhouse gas emissions, the increase in the share of renewable energy sources and increase of energy efficiency.

The main target of the Czech Republic is to reduce the total greenhouse gas emissions by 30 % by 2030 compared to 2005, corresponding to a reduction of emissions of 44 million tonnes CO2 eq.

Decarbonisation also includes renewable energy sources. An EU-wide target by 2030 of 32 %, expressed as a share of renewable sources in gross final energy consumption, was agreed. The recast of the Renewable Energy Directive (2018/2001) furthermore includes requirements for sub-targets in heating and cooling and in transport. The Czech Republic proposes a 22 % contribution to the European target by 2030, an increase of 9 percentage points compared to the Czech national target of 13 % for 2020.

The EU's climate and energy policy framework for 2030 sets the EU-wide target of achieving a GHG reduction of at least 40 % by 2030 compared to 1990. This target is further broken down to emission reduction in EU ETS and non-ETS sectors by 43 % and 30 %, respectively, compared to 2005.

The targets for individual Member States range from 0 to 40 % compared to 2005. The regulation sets for the Czech Republic a binding emission reduction target of 14 % compared to 2005 and a binding linear trajectory of its achievement starting on the average of its greenhouse gas emissions for 2016, 2017 and 2018 and ending in 2030.

By 2020, reduce emissions of the Czech Republic by at least 32 Mt CO2 eq. compared to 2005 (corresponding to a reduction of 20 % compared to 2005).

By 2030, reduce emissions of the Czech Republic by at least 44 Mt CO2 eq. compared to 2005 (corresponding to a reduction of 30 % compared to 2005).

Energy efficiency dimension

The Czech Republic considers the indicative national target defined in Article 3 of Directive 2012/27/EU as a non-binding framework target, which does not create a specific and legally enforceable obligation for both the Czech Republic and other entities. Achieving the 2020/2030 target for final and primary energy consumption is influenced by a number of factors and assumptions, which may evolve over time. For this reason, the contribution of the Czech Republic is supplemented to include a specification of 'boundary conditions'. A significant change in these input parameters may in the future trigger the need for the Czech Republic to reassess the indicative national targets.

Contribution of the Czech Republic to the non-binding EU target by 2030

For the period until 2030, the Czech Republic considers it most appropriate to set a national target for the energy performance of the economy which better reflects the influence of external factors on final energy consumption, such as the economic growth. The 2030 national target of the Czech Republic corresponds to the reduction of the energy intensity of GDP creation to the level of 0.157 MJ/CZK and the creation of GVA to the level of 0.174 MJ/CZK. With regard to the obligation arising from Article 3(1) of the Energy Efficiency Directive, the national target of the Czech Republic is also expressed in the final energy consumption, which should not exceed 990 PJ or 1 735 PJ in primary energy consumption.

In line with the text of the revision of Directive 2012/27/EU and the rules for setting the commitment, the Czech Republic's target under Article 7 for 2021–2030 was set at 84 PJ of new energy savings, i.e. 462 PJ of cumulated energy savings by 203025. The commitment respects the requirement to meet the minimum annual energy savings of 0.8 % of annual final energy consumption in accordance with Article 7(1)(b).

Dimension of energy security

Cross-cutting targets - Diversification targets are summarised in the target corridors of the State Energy Policy of the Czech Republic.

Share of individual fuels in total primary energy sources (excluding electricity):

- Coal and other solid non-renewable fuels: 2016 level - 40 %; 2040 target level - 11–17 %
- Oil and petroleum products: 2016 level - 20 %; 2040 target level - 14–17 %
- Gaseous fuels: 2016 level - 16 %; 2040 target level - 18–25 %
- Nuclear energy: 2016 level - 15%; 2040 target level - 25–33 %
- Renewable and secondary energy sources: 2016 level - 10%; 2040 target level - 17–22 %

The import dependence target is not to exceed 65 % of import dependence by 2030 and 70 % of import dependence by 2040.

In the electricity sector, the Czech Republic has the following main targets:

- Maintaining the high quality of energy supply and meeting the parameters of the adequacy of production capacities.
- Ensuring self-sufficiency in electricity generation, based in particular on advanced conventional technologies with high efficiency of conversion and increasing share of renewable and secondary sources.
- Gradual decline in electricity exports and maintaining the balance between +/-10% of domestic consumption in line with the conditions of the internal market.
- Maintaining a positive power balance and ensuring the adequacy of the power reserves and control outputs (providing for the necessary support services) and permanently ensuring the power adequacy of -5 % to +15% of the maximum load of the electricity system (free available capacity according to the ENTSO-E methodology).
- Ensure a systematic solution to the loop electricity flows and transit from a safety and cost compensation perspective.
- Ensure diversification of primary energy sources in accordance with the target corridors of the State Energy Policy of the Czech Republic, which, inter alia, means the continued development of nuclear energy in the Czech Republic.

In the gas sector, the Czech Republic has the following main targets:

- Ensure diversification of gas sources and transport routes through the implementation of planned infrastructure projects as well as the effective functioning of domestic gas storage facilities.
- Ensure effective access to transit capacities for natural gas supplies to Czech consumers.
- Permanently ensure the ability of reverse flow and the renewal and development of the gas transmission system. Ensure capacities for an increase in natural gas supply (increase necessary for heat supply, electricity generation and transport).
- Maintain and potentially further strengthen the transit role of the Czech Republic in gas transmission.
- Support projects ensuring the capacity of gas storage facilities in the Czech Republic at 35–40% of annual gas consumption and deliverability guaranteed for at least 70% of the peak daily consumption in the winter. Create conditions for the reverse flow of the transmission system and the capacity to deliver gas from the North or the West of at least 40 million m3 per day.

- Support financially and institutionally both the transformation of existing biogas stations to biomethane production, synthetic gas production stations and hydrogen production equipment, and new biomethane stations including their connection to the gas system.
- Provide for the connection and potential gas transmission and distribution capacities for substitution of coal with gas for large customers (heat plants).
- In connection with the decarbonisation targets, prepare the gas transmission and distribution system for a higher share of new gas types and sector coupling.

In the oil sector, the Czech Republic has the following main targets:

- Support other projects increasing the diversification of oil and petroleum product supplies to the Czech Republic, e.g. increasing the capacity of the TAL oil pipeline, construction of an oil pipeline connection between the Litvínov and Leuna (Spergau) refineries.
- Support the development and strengthening of the existing system for oil transport to the Czech Republic in order to provide for and maintain sufficient transport capacity for the needs of refineries in the Czech Republic and, in cooperation with other countries (Slovakia, Ukraine, Russia), maintain the operability of the entire transmission system built in the past at high costs.
- Preserve two functional supply routes for the transport of oil to the Czech Republic from two different directions as the basis of the Czech Republic's oil security.
- Maintain emergency stocks of oil and petroleum products in accordance with the new calculation methodology under Council Directive 2009/119/EC of at least 90 days of net imports and verify their availability for crisis use.
- Ensure that oil processing capacities in the Czech Republic are permanently operational at least at 50% of usual domestic consumption.

In the heating sector, the Czech Republic has the following main targets:

- As a priority, maintain economically efficient and energy-efficient heat supply systems.
- Cover at least 60% of heat supply from heat supply systems by high-efficiency cogeneration.
- Renewal, transformation and stabilisation of heat supply systems, based primarily on national sources (nuclear, coal, RES, secondary sources) supplemented with natural gas.
- Promote the transition of especially medium and small heat supply systems, multi-fuel systems using locally available biomass, natural gas, or, if applicable, other fuels, where especially natural gas will play the role of a stabilising and supplementary fuel.
- Create conditions in heat supply systems for the efficient use of heat from renewable and secondary energy sources available at regional and local levels.
- Provide for the necessary long-term supply of coal for the heat sector in a situation of decreasing exploitable reserves using legislative and regulatory measures, while respecting competition rules, giving priority to increasing efficiency and savings.
- Significant increase in the recovery of wastein waste energy recovery facilities in order to achieve a high recovery rate of the incinerable component of waste after sorting by 2024.
- Promote the use of preferably larger heating plants for regulatory services.
- Create conditions for heating plants in island operations of individual areas to play their role in emergency situations.
- Ensure the integration of smaller heat plants into smart grids and decentralised management.
- Support and develop the energy supply capability in local (island) subsystems in the event of a system breakdown due to large-scale failures caused by natural events or terrorist or cyber attacks to the extent necessary to ensure the minimum supply to the population and maintain the functioning of critical infrastructure.

- In connection with the ongoing decentralisation of electricity sources, it will be necessary to ensure the overall flexibility of the energy system. From this perspective, heating sources should be more involved in the provisionof support services at the distribution and transmission system level. At the same time, thanks to the possibility of using cogeneration, production sources contribute to flexible electricity supplies; on the other hand, technology such as electric boilers and heat pumps have the potential to increase the ability to control electricity generation/consumption.

The Czech Republic has a relatively well diversified energy mix. The targets for the diversification of energy sources are mainly incorporated in the target corridors of the State Energy Policy of the Czech Republic. With regards to the targets concerning the supply of energy commodities from third countries.

In relation to reducing the dependence on energy imports / increasing the diversification of consumed (imported) resources, the following targets (or, more precisely, quantifiable indicators) can be emphasised.

- ensure permanent self-sufficiency in electricity supply at a minimum level of 90%;
- reduce and sustain the diversification of primary energy sources below 0.25;
- reduce and sustain the diversification of gross electricity generation below 0.35;
- reduce and sustain the diversification of imports below 0.30;
- reduce the share of energy imports in gross value added below 2010 levels;
- stabilise the effect of energy imports on the balance of payments.

Internal energy market dimension

Electricity interconnectivity (2030 Framework target)

The level of electricity interconnectivity that the Member State aims for in 2030 in consideration of the electricity interconnection target for 2030 of at least 15 %, with a strategy with the level from 2021 onwards defined in close cooperation with affected Member States, taking into account the 2020 interconnection target of 10 % and the following indicators of the urgency of action:

1. Price differential in the wholesale market exceeding an indicative threshold of EUR 2/MWh between Member States, regions or bidding zones;
2. Nominal transmission capacity of interconnectors below 30 % of peak load;
3. Nominal transmission capacityof interconnectors below 30 % of installed renewable generation.

Each new interconnector shall be subject to a socioeconomic and environmental cost-benefit analysis and implemented only if the potential benefits outweigh the costs.

The 2030 framework transmission system interconnectivity target corresponds to maintaining the transmission system import and export capacity relative to the maximum load at a level of at least 30% and 35%, respectively. However, this target is not directly comparable to the 2030 EU target of 15%, as this target is expressed in relation to installed capacity. In general, it can be stated that the target under the State Energy Policy of the Czech Republic corresponds to the 15% target, because the share of the maximum load in relation to the installed capacity corresponds to approximately 50% (53% in 2017). The Czech Republic therefore commits itself primarily to fulfilling the target under the State Energy Policy of the Czech Republic, which is already achieved and way above the target, but the achievement of this target should correspond to the implementation of the Barcelona Agreement (2030 target of 15%), even though the developments of the maximum load and the installed capacity may be somewhat different.

The transmission system operator, both on the national level in accordance with theState Energy Policy of the Czech Republic, which directly requires to maintain import and export capacity of the Czech transmission system in relation to the maximum load at least at 30% and 35%, respectively, and at European level within the European Ten-Year Network Development Plan, which assesses the progress towards the 2012 Barcelona criterion of 10% of the transmission systems interconnectivity and the 2030 connectivity target at 15%. Table 8 specifies the projected 2030 interconnectivity level (both for export and import) relative to the maximum load in two scenarios. In both cases, the 30% and 35% targets should be achieved with a relatively significant margin. Table 9 then shows the assumed interconnectivity level relative to the installed capacity. Both Scenario A and Scenario B assume the same installed capacity in this respect, so there are no differences between these scenarios.

<u>Energy transmission infrastructure</u>

Electricity sector

In accordance with the Energy Act, ČEPS, a.s., the transmission system operator, prepares every two years the ‘Ten-Year Plan for the Development of the Transmission System of the Czech Republic’, which is approved by the ERO following an opinion of the Ministry of Industry and Trade. The Ten-Year Development Plan is published on the ČEPS website35. The Czech Development Plan complies with the obligations imposed on its subject matter in the Energy Act, the subject matter being the measures taken to ensure appropriate capacity of the transmission system so that it meets the requirements necessary to ensure the security of electricity supply.

The above Czech Development Plan is also reflected in the content of the regional investment plan of Central and Eastern Europe and the Ten-Year EU Network Transmission Plan, which are adopted by ENTSO-E at a two-year interval. The Czech Development Plan contains not only PCI projects, but also projects that ensure appropriate capacity of the Czech Republic’s transmission system so that it meets the requirements necessary to ensure electricity supply security.

Gas sector

In accordance with the Energy Act, NET4GAS, a transmission system operator, prepares each year the Ten-Year Plan for the Development of the Transmission System of the Czech Republic, which aims to analyse the development of maximum daily and annual consumption and the adequacy of input and output capacity for the Czech Republic. The plan includes completed and upcoming investment projects which increase the capacity of the transmission system, and also a supply security analysis. The Ten-Year Plan is approved by the ERO following an opinion of the MIT, and is published on the NET4GAS website.

According to the State Energy Policy of the Czech Republic, the objective is to maintain the transition role of the Czech Republic, diversify gas sources, deepen the integration of European gas markets, and increase the resilience and use of the Czech transmission system. Operating conditions for North or West flows should reach capacity levels of at least 40 million m3/day. This criterion is currently met. Both the transmission and distribution systems will have to be able to supply the energy source base (power stations and heat plants) – expanding sources firing natural gas to 15 % of installed capacity (currently over 8 %) and with BAT (Best Available Technology) parameters, expansion of micro-cogeneration sources and the use of gas in transport. This will mean potential connection of new direct gas customers from both the transmission system and especially distribution systems (power plants, heating plants) and creation of adequate capacities on these systems. If the SEP targets are to be achieved in a liberalised gas sector, cooperation of all stakeholders is necessary.

Market integration

Electricity sector

- Complete, further develop and last but not least operate the single day-ahead and intraday electricity market in the EU as required by Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACMRegulation).
- Implement the 'MCO plan'.
- To secure, within the framework of the long-term electricity market, the supply of all the products of long-term capacity rights relevant to the bidding zone border of the Czech Republic through the Central Auction Office.
- To secure, within the framework of the day-ahead electricity market, the interconnection of the Czech electricity market with the remaining markets in Europe by 2021.
- To implement, within the intra-day electricity market , the LIP 15 project and to continue according to the XBID project schedule to achieve the integration of the Czech Republic within the single intra-day coupling (SIDC) in the EU according to the CACM Regulation.
- To harmonise, within the balancing services market, the valuation of regulatory energy from standard products with the rest of Europe by connecting to all relevant regional platforms by the end of 2023.
- The goal within the balancing services market is to introduce a 15-minute interval for the settlement of imbalances by early 2025 at the latest.

Gas sector

The Czech Republic intends to help complete the internal energy market, in particular the internal gas market, by removing infrastructure bottlenecks between the Czech Republic and its neighbours, namely Poland and Austria. This should be facilitated by the fact that the national gas market legislation has been adapted to two regulations designed to ensure uniform principles for the creation of a single internal gas market in the EU – Regulation (EU) No 2017/460 establishing a network code on harmonised transmission tariff structures for gas, Regulation (EU) No 2017/459 establishing a network code on capacity allocation mechanisms in gas transmission systems and repealing Regulation (EU) No 984/2013.

This should be further facilitated by the support for the implementation of PCI status projects (projects of common interest), enabling direct interconnection with the gas systems of neighbouring countries. These projects contribute to the integration of national markets in the region and the creation of a Central European gas market. The interconnection with Germany and Slovakia is already sufficiently robust. The Czech Republic is interconnected with Poland by the STORK gas pipeline. There is no physical interconnection between the Czech Republic and Austria.

Net metering

The conditions for the implementation of smart metering in the Czech Republic are being prepared within the framework of the National Action Plan for Smart Grids. The prepared solution also takes into account legislative measures issued under the 'Clean Energy for All Europeans' package in the field of the internal electricity market (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).

Summary of the future targets and objectives of Czech Republic (Per Dimension)

Decarbonization
• Annual emission allocations for each year between 2021 and 2030 will be set out in implementing acts in accordance with the Regulation. • Reducing health risk emissions to the air. • Transition to a sustainable low-emission economy by 2050. • Increase in the energy use of agricultural biomass by 2030 by 20 %, but only on condition of maintaining the strategic level of agricultural production for food use. • Covering at least 20 % of heat supply from heat supply systems to be covered by renewable energy sources by 2040.
Energy Efficiency
• Energy performance of the economy which better reflects the influence of external factors on final energy consumption, such as the economic growth. • Reduction of the energy intensity of GDP creation. • Renovation of at least 3 % of the total floor area of buildings with a total useful floor area over 250 m2
Energy Security
• The import dependence target is not to exceed 65 % of import dependence by 2030 and 70 % of import dependence by 2040 • Ensuring self-sufficiency in electricity generation, based in particular on advanced conventional technologies with high efficiency of conversion and increasing share of renewable and secondary sources. • Support projects ensuring the capacity of gas storage facilities in the Czech Republic at 35–40 % of annual gas consumption and deliverability guaranteed for at least 70 % of the peak daily consumption in the winter. Create conditions for the reverse flow of the transmission system and the capacity to deliver gas from the North or the West of at least 40 million m3 per day. • Cover at least 60 % of heat supply from heat supply systems by high-efficiency cogeneration.
Internal Energy Market
• Electricity interconnection target for 2030 of at least 15 % • Maintaining the transmission system import and export capacity relative to the maximum load at a level of at least 30 % and 35 %, respectively. • Increasing system flexibility, in particular related to the promotion of competitively determined electricity prices in line with relevant sectoral law, market integration and coupling, aimed at increasing the tradeable capacity of existing interconnectors, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment, and real-time price signals.
Research, innovation and competitiveness
• The Czech Republic has not set any specific quantifiable targets in public research, development and • innovation specifically related to the Energy Union. • Research, development and innovation in sustainable energy are one of the priority areas of key strategic documents such as the National R&D Strategy for Smart Specialisation and the National Priorities for Oriented Research, Experimental Development and Innovation. • The introduction of specific technologies should be primarily market-driven.

Research, innovation and competitiveness dimension

The fifth dimension of the Energy Union is that of research, innovation and competitiveness. In this regard, the Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. However, research, development and innovation in sustainable energy are one of the priority areas of key strategic documents such as the National R&D Strategy for Smart Specialisation and the National Priorities for Oriented Research, Experimental Development and Innovation. In the development of priorities in this area, the Czech Republic also seeks to take into account the priorities at EU level, especially the priorities of the European Strategic Energy Technology Plan. It is not possible to precisely determine the exact level of public funding of research, development and innovation for low-carbon technologies. However, the National Plan shows the estimate of public finances allocated to the energy sector.

The Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union. The difficulty of setting energy and climate targets is due, inter alia, to the structure of public funding for research, development and innovation, which is not sector-focused, but is provided under national and ministerial support programmes. The strategic objectives are then described in more detail in the relevant strategy papers. These documents include in particular the National Research and Innovation Strategy for Smart Specialisation and National Priorities of Oriented Research, Experimental Development and Innovation.

National priorities for oriented research, experimental development and innovation include indicative share of funds by priority area, which should be allocated for implementation within the overall R&D&I budget. On the basis of this strategic document, approximately 18% of the total research, development and innovation budget should be allocated to the priority Sustainable Energy and Material Resources.

The area of research, development and innovation is also addressed specifically in the State Energy Policy of the Czech Republic. The research, development and innovation areas are also partially addressed by other strategic energy documents such as the National Action Plan for the Development of Nuclear Energy in the Czech Republic, the National Action Plan for Smart Grids, or the National Action Plan for Clean Mobility.

The Czech Republic’s priority areas of research and innovation, in terms of the **decarbonisation**, **energy efficiency**, **energy security** and **internal energy market** dimensions, are listed in the table below.

Decarbonization
• Increase in the use of renewable energy sources (solar, geothermal, biomass) • Development of new photovoltaic systems including control elements • Development of advanced biofuels made from non-food biomass and waste • Development of the energy use of hydrogen including fuel cells • Research in 3rd and 4th generation nuclear technologies • Development of intelligent transport systems
Energy Efficiency
• Development in the construction technologies for nuclear power in relation to material engineering • Development of high temperature materials • Research in more efficient use of fossil energy sources • Development of high-efficiency cogeneration (trigeneration) in district heating systems • Research and innovation of gas and steam turbines • Increase in the use of heat pumps with high efficiency • Development of new technologies for the energy recovery of secondary raw materials and wastes
Energy Security
• Increase in the efficiency and reliability of energy systems and distribution networks • Development of production and consumption management • Development of protection against cyber-attacks and the protection of telecommunication systems
Internal Energy Market
• Development of technologies aiming at increasing the flexibility of the energy system • Research in the implementation of the circular economy model • Development of local energy production

8.1.3 **Croatia**

Current Situation Croatia

Between 2012 and 2017, the GDP grew at an average annual rate of 1.6 percent. There was also an increase in electricity consumption, so total electricity consumption grew at an average annual rate of 0.8 percent and net electricity consumption at an average annual rate of 1 percent. Losses of transmission and distribution of electricity also decreased at an average annual rate of 1.3 percent.

During the six-year period from 2012 to 2017, primary energy production in Croatia increased at an average annual rate of 0.9 percent. A downward trend was observed in the production of natural gas, while an upward trend was achieved in the production of other primary forms of energy. Natural gas production declined at an average annual rates of 5.6 percent. The fastest growth was achieved in renewable energy production with an annual growth rate of 23.3 percent, while the production of crude oil increased at an average annual rate of 4.4 percent. The energy of utilized water resources increased at an average annual rate of 2.6 percent. In the production of heat produced by heat pumps and in the production of firewood and other solid biomass, production increased at an average annual rate of 1.7 percent and 1.4 percent respectively.

During the period from 2012 to 2017, there was a trend of increase in import of energy to Croatia at an average annual rate of 4.2 percent. Only coal and coke imports saw a downward trend at an average annual rate of 3 percent, while imports of all other forms of energy increased. Imports of wood and biomass increased at an average annual rate of 43.7 percent, import of natural gas 6.4

percent, import of petroleum products 6.7 percent and import of crude oil 3.9 percent. The average annual rate of increase in electricity imports was 0.6 percent.

Since 1 January 2013, plants in the Republic of Croatia participate in the EU Emissions Trading System for GHG. The emissions from ETS and non-ETS sectors are available for 2005 and for the period from 2013 to 2017.

In Croatia, there is the CROPEX power exchange with the possibility of day-ahead and intraday trading. In December 2015, CROPEX became NEMO (Nominated Electricity Market Operator), i.e. an exchange with the right and responsibility to participate in the implementation of day-ahead and intraday market coupling processes at the EU level. Since 19th June 2018, the Croatian day-ahead market has been connected to MRC (Multi- Regional Coupling) day-ahead market, i.e. to the uniform European day-ahead market via the Croatian-Slovenian border.

In 2018, about 12.7 TWh was entered into the Croatian electricity system, and about 6.5 TWh came out for the period 2016-2018. The largest exchange is performed with the electricity system of Slovenia and Bosnia and Herzegovina, which is expected given the very high level of installed interconnected capacities. With BiH alone, Croatia has as many as 21 interconnectors, and with Slovenia 8 interconnectors.

According to the estimate for 2017, Gross Domestic Expenditure on Research and Development (GDERD) amounted to 0.86% of GDP. By 2020, the target of 1.4% of shares in GDP was set while the target at the EU level is 3%, which indicates that the Republic of Croatia lags behind in terms of financing research, development and innovation compared to the EU average. In 2017, the share of public expenditure on research and development in GDP during 2017 was 0.43%, while the EU average was 0.69%. During 2017, the share of expenditure by private companies in GDP was also 0.43%, while the EU average was 1.36%.

Future Targets and Objectives Croatia

In terms of **decarburization**, The Republic of Croatia has set the following targets for reducing greenhouse gas emissions by 2030 in the ETS sector: at least 43% compared to the 2005 level and for non-ETS sectors: at least 7% compared to the 2005 level.

The expected reduction in emissions for the ETS sector is at least 43% by 2030 compared to 2005, with an annual reduction of the total EU quota of 2.2% for the period from 2021 to 2030. For the non-ETS sectors, a common target of at least 30% reduction in emissions by 2030 compared to 2005 (Regulation (EU) 2018/842) has been set, and the commitments ranged from -40 to 0% for different EU Member States (-7% for Croatia).

Immediate energy consumption is expected to amount to 286.9 PJ in 2030, representing a change of 8.1% and -15% in comparison to 2005 consumption.

The energy efficiency dimension

The national targets for increasing energy efficiency by 2030 are 8.23 Mten for Primary energy consumption and 6.85 Mten for Final energy consumption. The specified target of cumulative savings in the amount of 1,289.8 ktoe (54.0 PJ) is calculated with the assumed maximum allowable target reduction of 35%.

The renovation rate in the period 2021 to 2030 is growing from the current 0.7% per annum for the period 2014-2019 in steps of 1.1% to 3.0%, reaching a 10-year average of 1.6%. The rate of abandonment of the existing building stock is significantly increased, as evidenced by the increase in temporarily unoccupied units in the period between two consecutive censuses. An important element is the introduction of additional measurable indicators of energy renovation of buildings, which will strengthen the process of conversion of the stock into nearly zero-energy buildings, i.e. climate neutral.

The average final energy consumption in the residential sector will be 30 kWh/m²a for newly- built and renovated buildings, and it is expected that there will be no significant variations for the non-residential sector.

The Republic of Croatia is strongly committed to achieving an energy-efficient and decarbonised building stock by 2050. For the purposes of mobilizing all stakeholders in the process of building and renovating buildings to achieve the long-term target of reducing CO 2 emissions by 80% in the building construction sector by the end of 2050.

The penetration of electric, hybrid and hydrogen-powered vehicles is expected to reach 3.5% of total road passenger activity in 2030

It is expected increase in the share **of renewable energy sources** in gross final energy consumption to 36.4% by 2030.

In the building sector, a continuation of good practices and strengthening of energy efficient of all buildings (residential and non-residential) is expected, **targeting renovation** according to the nZEB standard, which also implies a greater utilization of RES (photovoltaic systems, solar thermal collectors, biomass boilers, heat pumps).

The most important objective within **the dimension of energy security** is to ensure a lasting, secure and quality supply of all energy-generating products. In order to achieve this objective, it is necessary to introduce integral and systematic planning of supply of all energy-generating products and forms of energy.

- One of the objectives in the context of energy security is to *increase the capacity of gas storage facilities, diversify supply routes and fulfil obligations of security of supply* according to the infrastructure standard (N-1 criterion) pursuant to Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply.
- Ensure the *realization of the liquefied natural gas* (LNG) terminal project on the island of Krk in accordance with the Energy Development Strategy of the Republic of Croatia, the Natural Gas Storage Strategy of the European Union and the Energy Security Strategy of the European Union. The realization of the LNG terminal project on the island of Krk will provide a new delivery route for natural gas and will diversify the natural gas supply routes and sources on the markets of the Republic of Croatia and European Union, which will significantly affect the security of natural gas supply.
- For the purposes of *diversification of gas supply routes*, in addition to the construction of the LNG terminal, it is planned to connect to the Ionian Adriatic gas pipeline. For the purposes of diversification of electricity supply routes, construction of interconnectors to Bosnia and Herzegovina, Hungary and Serbia is being considered.
- For the purposes of *increasing the gas storage capacity*, it is planned to develop a gas storage system (extension of existing storage facilities and construction of a new underground storage facility). Energy storage within the power system will be enabled by the construction of pumped-storage power plants, which will also provide greater system flexibility and greater integration of variable renewable energy sources, primarily the sun and wind.
- Increasing the *share of RES* in the structure of used energy-generating products will contribute to reducing dependence on imports, *including imports from third countries*.

- In addition to energy storage, the possibility of *participation of demand* response in the operation of the power system will also contribute to system flexibility

Market integration and competitive energy markets

In order to enable the further development of energy markets and the active role of energy buyers in energy markets, it is planned to introduce advanced metering devices and systems at the consumption level.

Reduction of heat demand and energy consumption in public and residential buildings and increase in RES usage and consequently reduction in CO 2 emissions;

Although the wholesale electricity market in Croatia is fully open, it is characterized by the existence of a dominant electricity producer. It is necessary to **increase the number of participants in the wholesale market**, especially in the area of electricity generation, in order to increase competitiveness on the supply side. It is necessary to enable aggregation of end customers as well as participation of demand response in the electricity market.

Level of electricity interconnectivity

The sum of installed transmission capacities of existing interconnectors/interstate powerlines is about 13,450 MVA, which is 290% in relation to the total installed capacity of power plants of 4,639 MW (at the end of 2016), while compared to the peak system load of about 3,100 MW this amounts to 434%. The total available cross- border capacity for import is estimated at 4,210 MW, while the total cross-border capacity for export is estimated at 3,830 MW, and in relation to the sum of transmission capacity of interconnectors, it is limited by potential congestion in the internal grid in terms of meeting the operational safety criteria. The development of new interconnection projects will be based on technical and economic considerations and based on cost-benefit analysis in accordance with the ENTSO-E methodology.

Energy transmission infrastructure

- Key targets for the **electricity transmission infrastructure** are:
  - maintaining a high reliability of the transmission system and the security of electricity supply of stipulated quality to customers,
  - accelerated integration of variable RES into the power system, and increased availability of regulatory reserves to balance their production,
  - timely realization of investment plans, in particular capital investments that enable the integration of RES into the power system,
  - supporting market transactions in the territory of the state and the region so that the transmission network does not represent a constraint on competitiveness,
  - revitalization and replacement of old/deteriorated grid units,
  - increasing the transmission capacity of individual lines planned for revitalization by using high-temperature low-sag conductors (HTLS), and reducing losses in the transmission of electricity,
  - application of new technologies in transmission, if they are technically and economically justified.
- Key goals for the gas transmission infrastructure
  - The development of the gas storage system is expected, primarily for the **purpose of domestic natural gas c**onsumption, but also for the purpose of new delivery projects.
  - Energy storage facilities and facilities for receipt, storage and gasification or decompression of liquefied natural gas (LNG) and compressed natural gas (CNG) have

an increasingly important role in the European energy infrastructure. Expansion of such infrastructure facilities is an integral part of the functional network infrastructure.
- The energy infrastructure for gas that needs to be built in order to implement priorities in the area of energy infrastructure of common interest is defined in the 10-year plan for the development of the gas transport system.

The digitisation of the energy system is presented as a part of promotion of smart grids and smart technologies that allow buildings to support further reduction of green houses and participation of consumers in the energy system including self-generation and start metering

Net metering and active consumer schemes

The contribution of **net metering** and energy community schemes is twofold, as they will contribute both to the implementation of RES and energy saving investments and to the more active participation of the local community and ultimately to the strengthening of the role of people in energy activities.

Summary of the future targets and objectives of Croatia (Per Dimension)

Decarbonization
• Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change • Supporting the establishment and capacity building of regional energy and climate agencies • Promoting the use of innovative information and communication technologies (ICTs) to reduce GHG emissions • The EU emissions trading system • CO_2 emission tax for the non-ETS stationary sources • Covenant of Mayors for Climate and Energy in the Republic of Croatia • Charter of Cooperation for the Decarbonisation of Buildings by 2050 • Establishing a platform for the collection, use and storage of CO_2 • Improving sustainability of urban areas • Establishing of Programme for Carbon Footprint Calculation and Reduction in Businesses • Establishing of platform for circular economy • Establishing a platform for bioeconomy • Establishing a platform for hydrogen technologies
Energy Efficiency
• Energy efficiency obligation scheme for suppliers, Energy efficiency of the electricity transmission system • Promoting nearly-zero refurbishment energy standard in buildings construction and refurbishment • Energy renovation programme for multi-apartment buildings, for single family houses, for public sector buildings, for heritage buildings • Energy management system in the public sector, in business (service & production) sector • Energy renovation programme for public lighting • Green public procurement • Increasing efficiency of district heating system, the gas transport network • Monitoring, reporting and verification of greenhouse gas emissions in the life cycle of fuels and energy
Energy Security

• Diversification of supply routes of energy and energy-generating products • Increasing gas and energy storage capacity in the energy system • increasing the flexibility (and thus resilience) of energy systems • Protection of critical infrastructure and mitigating risks related to cyber security and climate change. • Plan of protection of the power system from large disturbances • Integrated planning of energy security and energy products supply • Construction and use of energy storage facilities • Improvement of power system management
Internal Energy Market
• Ensure the implementation of an assessment of the potential for increasing energy efficiency of the gas and electricity infrastructure, in particular regarding transmission, i.e. transport, distribution, load management, interoperability and connection of energy generation facilities, including possibilities of access for energy micro-generators • Increase the participation of end customers with their own generation in the electricity market, to ensure flexibility and sufficiency and to consider the possibility of forming capacity markets • Necessary to enable aggregation of end customers as well as participation of demand response in the electricity market • Advanced biofuels market development plan
Research, innovation and competitiveness
• Research, innovation and competitiveness status quo analysis and determining targets, indicators and monitoring system • Co-financing industrial research and experimental development projects aligned with the National Development Strategy • Supporting low carbon entrepreneurship development • Supporting knowledge and technology transfer from science to economy with focus on low carbon technologies • Supporting further work of excellence centres active in the field of natural, technical, biotechnical and biomedical sciences • Capacity building for stimulating research and innovation and increasing competitiveness in the low carbon economy • Spatial planning requirements for using RES • Promoting the RES use for production of electricity and thermal energy • Regulatory framework development for cleaner transport • Development of alternative fuels infrastructure

The Act on State Aid for **Research and Development Projects** regulates requirements for granting state aid for research and development projects in the horizontal aid category for research and development, the competences of the bodies of the Republic of Croatia with regard to granting state aid for research and development projects, the procedure for determining the fulfilment of conditions for exercising rights, record keeping and reporting as well as other issues related to the exercise of the right to aid for research and development projects. The purpose of the Act is to increase private sector investments in research and development, increase the number of entrepreneurs investing in research and development and foster cooperation between entrepreneurs and organizations for research and dissemination of knowledge in research and development projects, whereby research and development includes creative and systematic work undertaken for the purpose of increasing knowledge - including knowledge of humanity, culture and society - and developing new applications of existing knowledge. Research and development activities must include five basic criteria: new knowledge (as the objective of activity), creative (new concepts, ideas and methods that enhance existing knowledge), uncertain in terms of outcome, systematic (planned with secured funds and by recording outcomes) and transferable (outcomes are transferable as new knowledge) and/or reproducible (outcomes can be reproduced).

Major technological advances are expected in the application of ICT technologies in all sectors, with particularly great impact in energy and transport sectors. The development of energy storage systems, electric vehicle and battery infrastructure, autonomous systems in various sectors and robotics will play a decisive role.

Increasing energy efficiency is strongly present in all sectors of consumption, with the strongest effects expected in the building sector and transport.

Utilities and energy market integration:
The changes that are expected in the energy sector are economically viable and will not ultimately entail higher costs. In doing so, the nature of costs will change - investment costs will increase and operating and energy costs will be reduced. Ultimately, energy markets will be fully integrated, both geographically - at the level of the European Union and neighbouring countries, as well as across sectors - there will be an interconnection of the electricity, heat, gas and transport sectors.

Decarbonisation
• Energy management systems for planning, investment, real-time management and monitoring energy efficiency and reducing CO 2 emissions • Systems for CO_2 capture, transport, use and storage. • Reduce the vulnerability of natural systems and society to the negative impacts of climate change • Increase the ability to recover from the effects of climate change • Exploit the potential positive effects that may also be due to climate change. • Development of the Programme of Green Infrastructure Development in Urban Areas • Development of new and improvement of existing primary and secondary equipment for power system (primary equipment: turbines, generators, motors, transformers, switches, measurement, protection, supervision, management) power lines and cables, secondary energy equipment control.
Energy Efficiency
• Advanced conventional energy solutions • New technologies and improvements related to power plants, substations, components and systems related to renewable energy sources • New research related to increasing the efficiency and production capacity of industrial, agricultural and forestry plants and machinery • Establishment of a certification system and lifelong learning of construction workers on the subject of energy efficiency • Application of advanced grids and complex energy systems • Energy-efficient lighting • Sustainable conversion of biomass into energy, biogas technologies for electricity and heat generation • Development of the Circular Spatial and Building Management Development Programme
Energy Security
• Advanced energy storage systems • Diagnostics and better management of energy equipment
Internal Energy Market

- Systems for energy management and support to functioning of the energy market at the levels of microgrids, advanced grids and smart cities
- Developing/amending the evaluation study of storage capacities available in the territory of the Republic of Croatia

Regulatory/ legislation steps contributing to the realization of the NECP priorities Croatia

In order to define the scope of work, work methods, funding sources and the institutional framework in the field of research and innovation, clear and comprehensive legal regulations are required. National legislation transposes all relevant regulations, directives and other EU legal acts to ensure that the legal framework of the Republic of Croatia complies with the basic operational principles of other EU Member States. The legal framework encompasses legal acts related to research and innovation in general and specific legal regulations governing the area of energy and climate.

Five national priorities have been identified under which climate change adaptation measures need to be implemented. These are:

1. ensuring sustainable regional and urban development
2. ensuring preconditions for the economic development of rural areas, coastal areas and islands
3. ensuring sustainable energy development
4. strengthening management capacity through a networked monitoring and early warning system
5. ensuring continuity of research activities.

Obligation of regular inspections of heating systems and cooling or air conditioning systems in buildings and energy certification of buildings

The Small Business Development Promotion Act regulates the basis for the implementation of small business incentives, including grants for research, development and application of innovations and introduction of modern technologies. In addition to the said acts, the area of research, development and innovation is regulated in more detail by various ordinances and guidelines.

In order to stimulate the development and growth of the Croatian economy, the Government of the Republic of Croatia has decided to group all public, private and science and research representatives in innovative sectors, with the aim of strengthening the competitiveness of Croatian companies, and consequently the Croatian economy and society.

8.1.4 Cyprus

Current Situation Cyprus

Regarding the **dimension of decarbonization**, the high dependence of the energy sector on fossil fuels, of transport on private cars and of solid waste management on landfilling is evident in the trends and associated to high values of the greenhouse gas intensity indicator compared to other member states of the European Union. According to the latest GHG inventory report submitted to the UNFCCC secretariat in November 2019, the total greenhouse gas emissions in 2017 (including LULUCF), showed a decrease of 6% between 2005 and 2017. Compared to 1990, the total emissions increased by 55%

The ETS in Cyprus includes the three electricity production installations, one cement producing installation and six installations producing ceramics. These installations contributed 52% to the total national emissions in 2017. According to the latest GHG inventory, the majority of the non-ETS emissions come from road transport with 49%, followed by non-ETS energy (18%), solid and liquid waste management (14%), agriculture (12%) and use of fluorinated gases (6%). The remaining 2% comes from non-ETS industrial processes. For the ETS sectors, the majority of the emissions come from the production of electricity (70% in 2017) followed by cement production (29% in 2017) and ceramics (1% in 2017). The existing contribution of RES in Cyprus, shows that Cyprus can exceed the overall target of 2020 for 13% of RES, arising from the preliminary results of 2018, based on directive 2009/28/EC, since the RES contribution in 2018 was calculated at 13.8%. This is not the case though for transport target, while there are a lot of efforts needed in the next period to achieve the RES target.

In terms of the **energy efficiency dimension**, the *Comprehensive assessment* ,conducted by the Ministry of Energy, Commerce and Industry, of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling identified an economic potential for high-efficiency cogeneration of around 50 MW in 2020.

The first minimum energy performance requirements for buildings have been adopted on the 21st of December 2007, and since then they have been revised three times. From 2013 and onwards any revision of the requirements is based on the results of calculating the cost-optimal levels of minimum energy performance requirements as it is foreseen by article 5 of Directive 2010/31/EU. The following tables show the development of minimum energy requirements through time for new and existing buildings.

The results of the second calculation of cost-optimal levels, which took place in 2018, have clearly indicated that new residential buildings and offices should be Nearly Zero Energy Buildings (NZEB), as they are in the spectrum of cost-optimality. Exception appears to be hotels, though tightening of current minimum energy performance requirements for this type of buildings also applies. Considering existing buildings which are renovated, higher energy performance should be required than category B, but lower than the NZEB level. It has to be noted that the definition of NZEB is the same for new and existing buildings.

In the **dimension of energy security**, in Cyprus almost all domestic energy resources are renewables and an amount of 0.3 ktoe (0.2%) is from industrial waste. The share of oil products is more than 92% of the country energy mix. The oil products of retail market are imported from neighbouring countries, Greece and Israel. For 2018, oil products for the production of electricity were mainly from Spain and Italy.

Oil Companies conclude and sign an annual contract with a refinery for the supply of oil products. Electricity Authority Cyprus supplies heavy fuel oil and gas oil after tender and the relevant contract includes strict conditions regarding delays in supply. In the case of oil companies, the relevant risk in supply is considered high as they depend on one import source, but in the case of EAC, the risk is low as according to the contract, the trader is obliged to deliver the product..

In terms of the **Internal Energy market dimension**, it is expected that the EuroAsia Interconnector construction will be completed by the end of 2023. The statutory permit granting procedure for PCI "EuroAsia Interconnector" started in November 2019 and will be completed until the comprehensive decision is taken by NCA, by end of 2020. Immediately after the completion of the granting procedure, construction phase will begin and will last for three years. Consequently, commercial operation will start by the first quarter of 2024, where an interconnectivity level of 15% will be achieved. To date, there is zero interconnection level.

Also, the expansion and upgrade of existing electricity network planned for the period 2019-2028 is described in the Ten Years Transmission Network Development Plan for the period 2019-2028.

As for the **Research, innovation and competitiveness dimension**, according to Smart Specialization Strategy, Cyprus has a high level of research potential in human capital that should be exploited to the greatest extent possible. This potential must include Cypriot scientists living and working outside Cyprus and foreigners working in Cyprus.

Additionally, the development of public and private universities the last 10 years has significantly improved the research facilities. Especially, the establishment of research centres of KOIOS and FOSS by University of Cyprus and the establishment of Cyprus Institute have provided useful infrastructure dedicated research and innovation in energy and climate. Recent developments in establishing centres of excellence in research such as the Research Centre of Excellence on Interactive media, Smart systems and Emerging technologies (RISE), the Cyprus Marine and Maritime Institute (CMMI/ MARITEC- X) and the Eastern Mediterranean and Middle East – Climate and Atmosphere Research Centre (EMME-CARE), are expected to further enhance infrastructure.

Cyprus's largest share of investment is associated mostly with the integration of DG and Storage technologies, aiming to ensure the stability of the network. Also, Demand Side Management along with Smart Network Management technologies are at about the same level of investments, a little lower than those of DG and Storage.

Additionally, there is a growing trend of investments in e-mobility technologies. Those investments are expected to increase even more, over the next years, having in view the eventual reduction in the use of fossil fueled vehicles.

Future Targets and Objectives Cyprus

In the **dimension of decarbonization**, the goal of the national energy and climate plan is to achieve a reduction of greenhouse gas emissions of 24% by 2030 compared to 2005. For non-ETS sectors, a target to reduce greenhouse gas emissions by at least 24% compared to the respective emission levels for 2005 is set. The sectors covered by the Emissions Trading Scheme (ETS) are subject to the overall European GHG reduction target of 43% compared to the corresponding 2005 emission levels.

The NECP also adopts the quantitative targets set in the context of the implementation of Directive 2016/2284/EC on the reduction of national emissions of certain air pollutants for the period 2020-2029 and for the year 2030 compared to 2005, which also requires the development, establishment and implementation of National Air Pollution Control Programmes, as well as the monitoring and reporting of the emission levels for relevant pollutants [sulphur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds other than methane (NMVOC), ammonia (NH3) and fine particulate matter (PM2.5)] and other pollutants (CO, heavy metals, POPs, BC). These emissions are not simulated or further analysed within the framework of the NECP, as their evolution is an obligation of other national emission inventories and of the National Programme for the Control of Air Pollution, further analysing the impact of the NECP on the achievement of the targets set for Cyprus under Directive 2016/2284/EC.

The introduction of natural gas and the stricter restrictions regarding emissions of greenhouse gases and air pollutants that will be introduced after 2021, affect the electricity generation, transportation, and heating and cooling sectors. Similarly, once domestic gas reserves become operational, demand for natural gas may not be confined to just conventional power generation. Compressed natural gas may become a viable alternative in the transport sector. Also, the use of natural gas for residential heating purposes or for gasification of the transport sector, are potential alternatives.

The renewable energy share in generation is limited between 15% and 25% for the period 2021-2030. However, as gas prices and CO2 costs increase and investment costs of renewable energy technologies decrease along the model horizon, the share of renewable energy in generation increases in a non-linear way towards the years of 2029-2030. Solar PV is the most competitive of the renewable energy technologies and, as such, this is responsible for the increase in renewable energy.

As for the heating and cooling sector, oil boilers and electric resistance heaters, are being displaced by heat pumps and split units, which pose as the most competitive technology in this particular sector. Also, in the residential sector heat pumps/heat pump split-units take up the majority of the heating demand, as they are conceived to be the most cost-competitive technology.

Regarding the **dimension of energy efficiency**, based on the National Energy Efficiency Action Plan of 2017 (4th NEEAP 2017), Cyprus´ national indicative target for energy efficiency was expressed in primary energy consumption of 2.2 Mtoe in 2020. However, based on the latest modelling results, the anticipated level of national primary energy consumption in 2020 is estimated to be about 2.5 Mtoe.

The household sector accounts for 19% of the final energy consumption, while another 13% of final energy consumption is due to commerce, hotels and services. The building stock comprises of 431,059 residential buildings and more than 30,000 non-residential buildings. 94% of residential buildings and 83% in the service sector were built before the introduction of mandatory energy performance requirements and 50% do not have any kind of thermal insulation.

In respect to the household sector, taking into account indicative nominal savings per investment and their cost and a mean mix of single interventions along with deep renovations, it results that on average around 33.000 dwellings, assuming that only 1 out of the 6 affected dwellings will undergo a deep renovation. This would include all different building typologies: single-family house up to multi-family blocks of flats. This housing stock that undergoes a kind of energy efficiency upgrade and improvement, after considering some market related characteristics and stakeholder's opinion, could be indicatively allocated per construction period as follows:

- 4% renovation of the building stock constructed before 1970 (1.635 dwellings)
- 9% renovation of the building stock constructed during 1971-1990 (10.250 dwellings)
- 20% renovation of the building stock constructed during 1991-2007 (21.200 dwellings)
- 1% renovation of the building stock constructed from 2008 up to now (315 dwellings)

However, the optimum cost-efficient distribution of interventions will result in a possible range of affected households between 43,000 and 79,000, with a most likely number in the range of around 63,000 households that could proceed to a mix of energy interventions until 2030. On an annual basis this translates to an average number of close to 5.000 households that could be energy upgraded. Around 25% of these are expected to proceed only to renovation and substitution of their lighting equipment/electronic appliances to the most energy-efficient ones and/or to the installation of solar thermal systems.

Additionally, Article 5 of Directive 2012/27/EU that Member States should either renovate annually 3% of the total area of buildings owned and used by central government authorities or choose an alternative approach including other cost-effective energy-saving measures in selected privately-owned public buildings (including, but not limited to, deep renovations and measures to change the behavior of users), in order to achieve by 2020 an equivalent amount of energy savings. The annual obligation was calculated assuming that 3% of the public building stock will be renovated from energy class E to energy class B. The primary energy consumption before and after renovation is assumed to be the one calculated for the typical building, as this is set in the cost–optimum calculation of minimum energy performance requirements

The same approach will be followed for the period 2021 – 2030, though the annual energy saving obligation that has been recalculated based on the modifications of public building stock. These are:

- Renovation to at least energy class B: 3 office buildings have undergone major renovation, while one more is expected to be completed by the year 2020.
- New buildings as replacements for specific central government: 2 new office buildings have been built as replacements of existing buildings.

Cyprus is a small isolated energy system, with high dependency on oil products for its energy needs. More than 90% of Cyprus energy inland consumption is from oil products and the rest is from renewables. The introduction of natural gas via Liquefied Natural Gas (LNG) imports, the development of the necessary infrastructure to import natural gas to Cyprus by early 2022 (via the "CyprusGas2EU" project of common interest) as well as the two other projects of common interest, the "EuroAsia Interconnector" and the "EastMed Pipeline", will end the current energy isolation and contribute to the diversification of Cyprus' energy sources, as related to the **energy security dimension**.

The Cyprus Government decided the relocation of the oil, including liquefied petroleum gas (LPG), terminals as well as other related facilities from the seafront of Larnaca area. Based on that decision and following the decision to develop the necessary infrastructure for LNG import, the New Energy and Industrial Area of Vasilikos was established in November of 2014. The relocation of the oil products except LPG is expected to be completed in the first quarter of 2020 and that of LPG around the end of 2020 early 2021. The modern and upgraded larger oil storage facilities will contribute to security of supply, since larger quantities of petroleum products would be stored on the island as it will also be possible to unload larger ships. Alongside with the abovementioned procedures, the Cyprus Organization for the Storage and Management of Oil Stocks (KODAP), the Central Stockholding Entity of Cyprus established by "The Maintenance of Oil Stocks Law of 2003", (N.149(I)/2003), is planning to build its own oil storage terminal to the Energy and Industrial Area of Vasilikos in order to relocate its own oil stocks which are held abroad and in private terminals in Cyprus, as well as, to reduce the annual storage cost.

Also, the use of indigenous sources of energy, such as hydrocarbon deposits and RES will contribute to increasing the flexibility of the national energy system and ensuring the security of energy supply. Regarding indigenous hydrocarbon deposits offshore Cyprus, the Aphrodite natural gas field contractor and the Republic of Cyprus have completed discussions on the Aphrodite Field Development and Production Plan (AFDPP), which was approved. As a result, an Exploitation License for the production of the Aphrodite Field has been issued in November 2019. According to the AFDPP, natural gas production is expected to begin in 2025.

In terms of the **Internal Energy market dimension**, as already noted, it is expected that the EuroAsia Interconnector construction will be completed by the end of 2023. It is a cross border interconnector between Crete, Cypriot, and Israeli power grids via the world's longest submarine HVDC power. HVDC onshore converter stations with a total capacity of 2000MW will be located at each connection point. It is also a priority Electricity Highway Interconnector Project. The Interconnector is an energy highway bridging Asia and Europe. The quantified objective is the market integration but also ending the energy isolation of Cyprus, contributing to energy security of supply.

This Project of Common Interest (PCI) is also related to Energy Security Dimension, as it promotes diversification of energy sources and ends the energy isolation of Cyprus. In addition, it contributes to the **decarbonisation dimension** because electricity imports will preferably come from natural gas or renewable sources which contribute to the reduction of greenhouse emissions.

Apart from the EuroAsia interconnector, another Project of Common Interest (PCI), is the EastMed pipeline, promoted by IGI-Poseidon S.A. aims at connecting the European market with the gas resources of the Eastern Mediterranean region. This Project of Common Interest is also related to the Energy Security Dimension, as it promotes diversification of energy sources and routes, ends the isolation of Cyprus and Crete, supports new gas production in the Eastern Mediterranean, including EU indigenous sources, and facilitates gas exchanges in South-eastern Europe. It also contributes to the Energy Efficiency Dimension, as natural gas is more efficient fuel than the other fossil fuels and to the Decarbonisation Dimension because of the import of natural gas in Cyprus fuel market which has lower greenhouse gas emissions than those from conventional fuels.

CyprusGas2EU, is another Project of Common Interest, promoted by MECI and aiming at introducing Natural Gas via LNG imports to the island of Cyprus in order to end the current energy isolation of Cyprus, by establishing the required infrastructure. This Project of Common Interest is also related to the Energy Security Dimension, as it is removing internal bottlenecks in the Trans-European Networks of Energy (TEN-E), it is ending the energy isolation of Cyprus and allowing transmission of natural gas from Eastern Mediterranean. It also contributes to the Energy Efficiency Dimension, as natural gas is more efficient fuel than the other fossil fuels and to the Decarbonisation Dimension, because LNG has lower greenhouse gas emissions than those from conventional fuels

There are also several main infrastructure projects, other than Projects of Common Interest, that are envisaged to be implemented and are presented as follows:

- **EuroAfrica Interconnector**: Interconnector between Greek, Cypriot, and Egypt power grids via submarine power cable. The interconnector will link Egypt with Cypriot and Greek power grids through the island of Crete. It is an energy highway bridging Africa and Europe. The project ensures secure energy supply for Cyprus, Greece and Egypt connecting them with Trans-European Networks of Energy (TEN-E), allowing significant economic and geopolitical benefits to the three involved countries.
- **Aphrodite-Egypt Export pipeline**. The Aphrodite-Egypt Export pipeline is designed to export gas produced from the Aphrodite field to gas buyers in Egypt. The pipeline will mainly transmit gas from the Aphrodite field to Idku LNG Terminal. An Intergovernmental Agreement between Cyprus and Egypt was signed in 2018 to facilitate the project.

Summary of the future targets and objectives of Cyprus (Per Dimension)

Decarbonization
• Development, establishment and implementation of National Air Pollution Control Programmes, as well as the monitoring and reporting of the emission levels for relevant pollutants [sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds other than methane (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$)] and other pollutants (CO, heavy metals, POPs, BC) • Increase in RES power generation (Solar PV as the most mature application) • Gasification of the transport sector, introducing compressed natural gas as a viable alternative fuel option • Increase in the penetration of RES to cover heating and cooling needs (heat pumps/heat pump split-units) • Increase in the use of natural gas for heating/cooling needs

Energy Efficiency
• Renovation of the residential building stock • Renovation of the governmental building stock • Energy Security • Introduction of natural gas via Liquefied Natural Gas (LNG) imports • Development of the necessary infrastructure to import natural gas to Cyprus (CyprusGas2EU PCI) • Development of the EuroAsia interconnection (Cyprus - Greece – Israel) in the electricity sector • Development of the EastMed pipeline (Cyprus – Greece – Israel) in the gas sector • Organization for the Storage and Management of Oil Stocks in Vasilikos Area, building an oil storage terminal • Development of the Aphrodite Field, for natural gas production, via the use of indigenous sources of energy (Hydrocarbon deposits)
Internal Energy Market
• Development of the necessary infrastructure to import natural gas to Cyprus (CyprusGas2EU PCI) • Development of the EuroAsia interconnection (Cyprus - Greece – Israel) in the electricity sector • Development of the EastMed pipeline (Cyprus – Greece – Israel) in the gas sector • Development of the EuroAfrica Interconnection, connecting the power grids of Cyprus, Greece and Egypt • Development of the Aphrodite-Egypt Export Pipeline, exporting natural gas produced in the Aphrodite field to Egypt
Research, innovation and competitiveness
• Development of the "Innovate Cyprus" - Cyprus Strategy Framework for Research and Innovation 2019 – 2023

On the **Research, innovation and competitiveness dimension**, The National Board for Research and Innovation has issued in May 2019 the Cyprus Strategy Framework for Research and Innovation 2019 – 2023, entitled "Innovate Cyprus". The current strategic framework adopts the following vision:

"Cyprus to become a dynamic and competitive economy, driven by research, scientific excellence, innovation, technological development and entrepreneurship, and a regional hub in these fundamental areas".

"Innovate Cyprus" will be put into action through a first set of policy measures and activities. For this purpose, an implementation roadmap is designed for the initial period of 2019-2021. Moreover, the roadmap will be updated and further enhanced according to progress and developments in the national R&I ecosystem, as well as with the support of further case-studies and the elaboration of a detailed R&I strategy.

Energy and water resource efficiency, as well as mitigation of climate change are among the sectors which are considered crucial to be addressed by R&I according to "Innovate Cyprus". Thus, the objective in R&I in energy and climate is the best possible production of research work and innovative products and services that will help increase energy efficiency, energy security, and renewable energy and tackle climate change. At the same time R&I must add value to businesses and provide useful insights for policy makers.

In terms of **decarbonization**, Cyprus is expected to become an exporting country in electricity generation mainly produced from solar energy. At the same time, gas will be available for backup purposes and for security of energy supply. In addition to photovoltaics, other technologies such as concentrated solar thermal systems will contribute to the dominance of RES in the energy system.

The most important projects relating to power generation from RES concern wind parks and photovoltaic (PV) parks, concentrated solar thermal plants and biomass and biogas utilisation plants. 6 wind parks are currently in operation, while as regards solar energy, 4 PV parks have been connected to the national grid so far.

As for the **energy efficiency dimension**, a key priority is to step up research into innovative applications of heating and cooling systems. At the same time, the maturation and integration of innovative energy-saving technologies that contribute significantly to improving energy efficiency, will be facilitated.

In particular, research and innovation activities related to improving the energy efficiency of buildings will include:

- Roof insulation
- Heat pumps for heating
- Photovoltaic panels
- High efficiency air conditioning units
- LED lighting
- Solar Water Heaters for hot water
- Biomass boiler

Regarding the **energy security and the internal energy market dimensions**, the main research and innovation actions are focusing on:

- Advanced Metering Infrastructure (AMI)deployment
- Meter Data Management System (MDMS) installations
- Design, engineering, supply, installation, configuration, testing and commissioning of a Supervisory Control and Data Acquisition/Advanced Distribution Management System (SCADA/ADMS)

The deployment of an **Advanced Metering Infrastructure**, including the roll-out of 400.000 smart meters by January 2027 will enable the optimization and control of the distribution system, increase the penetration of distributed renewable sources, enable aggregation of RES, demand response and storage and increase direct final customer participation in all market stages (active customers). Furthermore, it will contribute to increased system observability, load and generation forecasting accuracy, accurate system analysis and planning, load management alternative to ripple control, optimization of the operation of the distribution system, supervisory control and data acquisition of photovoltaic systems. The existence of a smart meter is necessary for the provision of consumer FUNCTIONALITIES, such as near real-time feedback on their energy consumption or generation.

The installation of an MDMS system is essential for the central data management of the Advanced Metering Infrastructure (AMI). The MDMS shall provide integration with the Meter Data Collection Systems and other utility information systems (SCADA, GIS) and FUNCTIONALITIES such as Data Warehousing and Management, Meter Operations, Data Validation-Editing-Estimation (VEE).

As for the **Supervisory Control and Data Acquisition/Advanced Distribution Management System**, SCADA communicates with 175 RTUs installed at MV Level equipment. The ADMS shall provide, among other FUNCTIONALITIES, applications for Power Flow, Switching Order Management, Short Circuit Analysis, Short-Term Load and Generation Forecasting, RES Management and Curtailment, Emergency Load Shedding and Restoration, Cyclic Load Shedding and Restoration, Outage Management System and Power Quality Monitoring.

Decarbonization
• Utilization of wind parks in operation • Utilization of photovoltaic parks in operation • Energy Efficiency • Roof insulation in the building stock • Deployment of photovoltaic panels • Deployment of heat pumps for heating • Utilization of biomass boilers • Promotion and utilization of high efficiency air conditioning units
Energy Security
• Optimization and control of the distribution system • Load and generation forecasting • Supervisory Control and Data Acquisition of PV systems
Internal Energy Market
• Load profile management through demand response • Increased distribution system observability • Direct participation of customers in all market stages, through aggregation

Regulatory/ legislation steps contributing to the realization of the NECP priorities Cyprus

The most indicative regulatory/ legislation steps that Cyprus should undertake, in order to fulfill and accomplish the NECP priorities, are summarized as follows:

- Achieve the fulfillment of the climate neutrality objective, maintaining the consistency with all relevant EU and national policies
- Deploy policies promoting the penetration of RES in electricity generation, in heating, cooling and in transport
- Deploy strategies for the renovation of the building stock (both residential and governmental)
- Increase diversification of energy sources and import routes
- Promote flexibility, storage and response systems, ensuring Cyprus's power adequacy
- Strengthen electricity and gas interconnectivity with neighboring countries and upgrade the existing ones

8.1.5 Estonia

<u>Current Situation Estonia</u>

Regarding the **dimension of decarbonization**, between 1990 and 2017, GHG emissions decreased by 48.4% (see Figure 20). The main reasons for the decline were the transition from a centrally planned economy to a market economy and successful implementation of the associated reforms.

The energy sector is indisputably the largest source of GHG emissions in Estonia. It accounted for 88.76% of Estonia's total GHG emissions in 2017. The second biggest source of emissions is the agricultural sector, which accounted for 6.61% of total emissions in 2017. Emissions from industrial processes and product use and waste accounted for 3.06% and 1.57% of total emissions respectively. The share of emissions of total emissions from the energy sector accounted for by emissions from heat and electricity production covered by the EU ETS was 70.26% in 2017.

According to the Eurostat SHARES model, the share of gross energy consumption accounted for by renewables was 29.29% in 2017, including 17.33% of gross electricity consumption, 51.64% of gross heat consumption and 0.40% of gross consumption by the transport sector.

In line with current projections, the estimated share of renewable energy in gross final consumption totaled at 32.3% by the end of 2019, including 17.76% of gross final consumption of electricity, 53.92% of gross final consumption of heat and 8.2% of gross final consumption by the transport sector.

As for the **energy efficiency dimension**, in comparison to 2004, when Estonia joined the European Union, energy consumption in the services and transport sectors and transport has grown by a quarter. Household energy consumption has not significantly changed in comparison to 2004, whereas industrial energy consumption has reached the same level. At the same time, the added value of the manufacturing industry has increased more than twofold but its share of total added value has declined by 1.6%. To create added value (in current prices), manufacturing used less than half the energy in 2018 than it did in 2004.

In terms of the **dimension of energy security**, the vast majority of Estonia's primary energy needs are satisfied by domestic sources of energy. Thanks to oil shale, renewable energy sources and peat, Estonia is the least dependent country in the EU on imports via energy carriers; these accounted for 6.8% in 2016183. This share will probably decrease in the coming years as generating electricity from oil shale becomes less competitive.

Despite the good overall picture, all liquid motor fuels and natural gas consumed in Estonia is imported. For fuel deliveries, natural gas represents a higher risk, as most of the gas consumed in the entire region is imported from Russia. However, the situation is expected to improve in the near future, due to the completion of the GIPL gas pipeline connecting Poland and the Baltic States in 2023.

As regards to the **internal energy markets dimension**, in 2017, the level of interconnection of Estonia's electricity grids with neighboring countries (Latvia, Finland) was at 63%. The interconnection capacity between EE and LV was 900-1,000 MW, and 1016 MW from EE to FI. Two 330 kV lines connect Estonia with Latvia's electricity system (one connects Tartu to Valmiera, and the other between Tsirguliina and Valmiera). Two DC cable lines connect Finland and Estonia (EstLink 1 and EstLink 2). According to data from 2017, the peak capacity of the interconnection in the direction of Latvia was 816 MVA and 1048 MVA in the direction of Finland. The transmission capacity between Estonia and Latvia may vary depending on repair works taking place in the electricity network, and on the external air temperature.

It is estimated that capacity in the direction from EE to LV will increase to 1379 MW by 2030, as a result of the completion of the third Estonia-Latvia interconnection.

According to the Natural Gas Act, Estonia's gas transmission system has one transmission operator, which is also the system operator. The gas transmission system and the electricity system have the same system operator - Elering AS. Estonian gas transmission system is interconnected with Latvia and Russia. The interconnection with Latvia passes via Karksi and with Russia via Narva and Värska. Estonia's gas transmission network comprises 885 km of gas pipeline, three gas metering stations and 36 gas distribution stations. Estonia's gas transmission system is also interconnected with Lithuania's gas transmission system via Latvia.

Also, since the 1st of January of 2017, all Estonian electricity customers have had smart readers that record and transmit at least the hourly data to the central database (data storage - e.elering.ee).

Consumers have free access to their data. They may also enable data access for the selected service provider.

Estonia shows the largest share of investments associated mostly with the Smart Network Management technologies, focusing on increasing the observability and controllability of the distribution network.

Also, a significant share of investments is associated with Integration of DG and Storage (in order to ensure the stability of the network) and Demand Side Management Technologies (mainly through energy efficiency technologies in the building sector), with the deployment of smart readers.

Future Targets and Objectives Estonia

In terms of **decarbonization**, the main objective is to reduce GHG emissions by 40% compared to the 1990 level by 2030. To achieve the overall target, all sectors falling under the EU emissions trading system (EU ETS) will have to reduce their emissions by 43% compared to 2005 by 2030. Emissions from the sectors that fall outside the emissions trading scheme (transport, agriculture, waste management and industrial processes and small-scale energy production where energy is produced by equipment with a rated output less than 20 MW), must be reduced by 30% compared to the 2005 level by 2030. The objective also concerns the land use, changes in land use change and forestry (so-called LULUCF) sector, which should contribute towards achieving the EU's GHG reduction target. The EU Member States reached a detailed agreement on how to meet the target of the Paris Agreement in early 2018, and EU internal legislation was adopted on reduction of GHG emissions. Agreement was reached on reform of the EU ETS reform, objectives of emissions reduction in sectors not covered by EU ETS and details of how the LULUCF sector relates to the EU climate and energy framework.

In the scope of renewables, Estonia's renewable energy trajectory is based on the national renewable energy targets that comply with the agreed EU targets laid down in Directives (EU) 2018/2001 and (EU) 2018/1999), including milestones (at least 18% of the general target must be achieved by 2022, at least 43% by 2025 and at least 65% of the general target by 2027). The target levels of the trajectories are based on projections that take into account current renewable energy generation and consumption trends Estonian renewable energy target for 2020 is 25%. This will remain Estonia's baseline.

Regarding the penetration of renewable energy in electricity supply, wind energy will have the highest growth potential (from both on-shore as well as off-shore wind farms), as will solar energy. In the heating sector, as indicated in the Estonian NECP, heat pumps have the highest growth potential in heating and cooling energy. As for the transport sector, an increase in the share of second-generation biofuels and electrical energy is expected in the next decade. The reduction of the share of first-generation biofuels in transport to a minimum is a priority. Also, the need to meet as much as possible of the consumption demand for second generation fuels with domestically produced fuel is indicated. Production of domestic biomethane and its use in transport have the highest potential.

The role of electricity consumption in the transport sector will grow sharply after 2025. Consumption will rise significantly due to amendments to the Clean Vehicles Directive, lower prices of electric vehicles and their resulting rise in popularity, as well as the electrification of railways and the completion of Rail Baltic.

As regards the **energy efficiency dimension**, Article 7 of the Energy Efficiency Directive requires Member States to achieve energy savings in final consumption Average final energy consumption forms the basis for determining the savings required. The period 2021-2030 requires annual energy savings equivalent to 0.8% of the average final energy consumption in the period 2016-2018.

According to Section 5 of the Energy Sector Organisation Act, 3% of the total useful floor area of buildings occupied by the central government where the central government uses more than 250 m2 and that do not comply with the minimum energy efficiency requirements are to be brought into conformity with the requirements each year. As of 1 January 2018, the total useful floor area of public buildings with more than 250 m^2 of useful floor area based on the ownership or contracting lease in the territory of the Republic of Estonia was 1,354,752.1 m^2 of which 572,260.5 m^2 met the requirements. Hence to comply with the Energy Sector Organisation Act, it must be ensured that the buildings that are used by public bodies that comply with the minimum energy efficiency requirements enforced in 2013 have a total useful floor area of at least 812, 000 m^2 by 2030. This means that **a total of 170,000 m^2 of building space must be renovated in the period 2021-2030 to achieve that target** .

In the housing sector, housing and energy management are closely related. Energy demand for buildings forms an important part of the energy balance in Estonia. At the same time, both have high potential for energy savings - the energy costs of buildings account for some 40% of the EU's total energy consumption. In Estonia, the energy consumption of the households forms 42.7% of the total energy balance. The main types of energy consumed are electrical energy, gas and heating, of which the last accounts for the greatest share of consumption. State-applied policies to improve energy efficiency **are increasingly focused on energy-efficient buildings and renovating buildings to make them more energy-efficient**, thereby **reducing energy dependency and GHG emissions from the building stock**.

As for the **dimension of energy security**, the sectoral targets in different energy systems are presented as follows:

Flexibility of the energy system

The adequacy and flexibility of the electrical system (and the increase thereof) is ensured by the Electrical Market Act and harmonization with the legislation laid down pursuant to it. According to the current Electrical Market Act, the system operator (including the transmission system operator) in Estonia develops the system in their service area in a way that ensures provision of consistent network service that is based on the legislation and an operating license to consumers, producers, transmission line owners and other system operators who are connected to the system considering their justified needs and to connect to the electrical installation of the market operator in their service area. By developing the grid, the system operator will follow the need for ensuring the security of supply, efficiency and market integration considering the results of the studies carried out in these areas.

Developing the electrical energy production, with an increase of more than 25% in the share of fuel-free energy sources (solar, wind, hydro energy) in final power consumption, is considered as a key target.

Investments made within the framework of the synchronization project of the Baltic States that help eliminate bottlenecks and increase the readiness of external connections and flexibility of the electrical system for fast changes in the power generation also contribute to the resilience of the electrical system. When the production of electricity from oil shale is reduced (phasing out of direct combustion), new production capacities and interconnections with neighboring countries will ensure the security of the electricity supply.

Gas system

According to the Natural Gas Act, the system operator is responsible for ensuring the security of the natural gas supply. The system operator is obliged to ensure the security of supply and balance of the gas system at any time according to the agreements in force. The system operator develops the system on the basis of known and projected demand, including new known connectees. Therefore, the N-1 criterion of the infrastructure standard must be met at any time (The N-1 criterion indicates the assessment of a situation where one of the biggest gas supply connections is interrupted. If, upon interruption, it is possible to reorganise the supply so that there will be no disturbances in the supply, the N-1 criterion is met).

Estonia used to have one of the lowest rates of dependency on imported energy in the EU but largely depends on imports for natural gas and motor fuels. While it is possible to use different supply channels, for motor fuels, opportunities are more limited for natural gas supplies.

Estonia’s natural gas consumption accounts for some 5% of the energy balance. As part of the diversification of the energy sources, Estonia has started to produce biomethane from local raw material. In 2018 Estonia produced 40 GWh of biomethane. The country has set a target of increasing biomethane production volumes to 380 GWh per year by 2030.

Regarding **the internal energy market dimension**, the target level of the electrical interconnectivity of the EU Member States is at least 10% by 2020 and at least 15% by 2030. The Estonian electrical interconnectivity level is 63%, thereby exceeding the EU target level.

However, the network of Estonia and in general, of the Baltic States have not been fully interconnected to the EU electricity grids; the Baltic States are not located in the synchronous area subject to EU law The electricity systems of Estonia, Latvia and Lithuania operate synchronously with the Russian Unified Energy System (IPS/UPS). Synchronization of the electrical system of the Baltic States with the synchronous area subject to EU law around 2025 is one of the most important energy policy targets for Estonia and other Baltic States and will significantly affect the long-term development of the electricity network.

The main target for the Estonian electricity system in the near future (until 2030) is to synchronize the electrical system with the Continental European frequency band, subject to EU law. The Estonian electricity system must also prepare for strengthening the connections between West Estonia and its islands in connection with added major capacity from the development of the off-shore and on-shore wind farms. Looking to the future, it is expedient for local governments to add the guideline to their comprehensive planning using for planning infrastructure sites (e.g. cable connections of wind farms) related to off-shore activities via public procedure on land.

Summary of the future targets and objectives of Estonia (Per Dimension)

Decarbonization
Increase in RES power generation (On-shore and off-shore Wind Farms, Solar Energy)
Increase in the penetration of RES in transport (2nd generation of biofuels, electricity)
Increase in the penetration of RES to cover heating and cooling needs (Heat pumps)
Electrification of railways and completion of Rail Baltic
Increase in the production of biomethane and penetration in the transport sector

Increase of popularity and utilization of electric vehicles (Clean Vehicles Directive)
Energy Efficiency
Renovation of public sector and commercial buildings
Renovation of private residences and apartment buildings
Establishment of minimum requirements for energy efficient buildings
Energy Security
Increase of more than 25% in the share of fuel-free energy sources (solar, wind, hydro energy) in final power consumption
Reduction in production of electricity from oil shale (phasing out of direct combustion)
Development of interconnections with neighboring countries to ensure the security of the electricity supply
Internal Energy Market
Synchronization of the electrical system with the Continental European frequency band
Strengthening the connections between West Estonia and its islands in connection with added major capacity from the development of the off-shore and on-shore wind farms
Comprehensive planning for the development of infrastructure sites (cable connections of wind farms)
Research, innovation and competitiveness
Development of the “Green technology investment programme”, to boost start-up and scale-up companies to bring in the market new products, services and technologies for reducing or capturing greenhouse gas emissions
“Green technology investment programme” to bring additional private equity to the field of green technology via investments with state equity capital

On the **Research, innovation and competitiveness dimension**, the current national development documents in Estonia have not set independent research and development targets related to the energy sector.

Research and development and innovation for increasing competitiveness are governed by the following current sectoral development plans:

- Estonian Rural Development Plan 2014-2020
- Competitiveness Plan ‘Estonia 2020’
- National Waste Plan 2014-2020
- Estonian Forestry Development Plan 2020
- Transport Development Plan 2014-2020

An agriculture and fishery sector development plan until 2030, a forestry development plan for the period 2021-2030 and an infrastructure and mobility development plan for the period 2021-2030 are being drafted.

The overall objective of the ***NDPES 2030*** (National Development Plan of the Energy Sector) is to ensure, among other things, the growth in the competitiveness of the economy: to ensure that customers have an energy supply with market-based prices and availability that meets the European Union's long-term energy and climate policy targets and at the same time contributes to the improvement of Estonia's economic climate and environmental status.

The long-term vision for Estonian climate policy and sectoral and cross-cutting policies to set a clear path towards alleviating climate change were agreed upon at national level in the development document 'General Principles of Climate Policy until 2050'. Estonia aims to have a competitive low-carbon economy by 2050. This will ensure that the country is ready and able to minimize the negative consequences of climate change and make optimal use of the positive effects. In accordance with the first policy document covering the entire economy, Estonia's main priority is to be transformed into an environment that will primarily be attractive for the **development of innovative technologies, products and services that reduce GHG emissions**. The export of these technologies, products and services and their global implementation in solving global problems connected with climate change will also be promoted.

The introduction of low-carbon emission technologies and the efficient use of resources in industrial processes will be promoted. Legislation will be used to motivate industry to employ predominantly low-carbon fuels and production inputs. In seeking to limit the GHG emissions of energy and industry, preference will be given to directions in research, development and innovation that promote the **development of efficient energy technologies, valorize domestic renewable energy resources, increase primary energy savings and reduce GHG emissions**.

Estonia joined the **Hydrogen Initiative** at the informal meeting of EU energy ministers in Linz, Austria on 17 and 18 September 2018. The public meeting of the ministers of energy in Brussels on 19 December 2018 discussed follow-up measures connected with the Hydrogen Initiative. The use of hydrogen in different sectors of the economy offers the most efficient possibility for moving towards a low-carbon economy.

As related to the **dimensions of energy efficiency and energy security**, specific activities of the Estonian research and innovation system are focused on the development of the "smart house" concept, with the deployment of IT solutions (controlling the house electronically, incl. with mobile devices), using more efficient materials and use of more efficient energy solutions. This trend is also gaining more attention in Europe, i.e. the Smart City initiative of the European Commission is likely to push this area further into the spotlight.

These activities aim at the creation of an innovation environment for the development of smart services, leading eventually to the optimization of network usage and improved transmission network observability.

Towards the **dimension of internal energy market**, there are no specific research and innovation activities mentioned in the Estonian NECP.

Decarbonization
• Introduction of low-carbon emission technologies and the efficient use of resources in industrial processes • Motivation of industry to employ predominantly low-carbon fuels and production inputs • Increase in hydrogen production
Energy Efficiency
• Development of "Smart House" concept • Deployment of IT solutions towards energy efficiency
Energy Security

- Optimization of network usage
- Transmission network improved observability

Regulatory/ legislation steps contributing to the realization of the NECP priorities Estonia

The most indicative regulatory/ legislation steps that Estonia should undertake, in order to fulfill and accomplish the NECP priorities, are summarized as follows:

- Promoting RES in Estonia's energy mix and enhancing the interconnections of the autonomous island systems (Interconnection of Estonia with its islands in the west border, development of on-shore and off-shore wind farms)
- Deployment of strategies for the renovation of the governmental and residential building stock
- Promote flexibility and storage systems, ensuring Estonia's power adequacy
- Increase diversification of energy sources and ensure the reduction in energy dependency
- Strengthening of electricity and gas interconnectivity with neighboring countries

8.1.6 Greece

Current Situation

The **total greenhouse gas emissions** experienced a decline of 30% in 2017 in comparison with 2005, while in absolute figures they were found to be at a lower level than those of 1990. The greenhouse gas intensity indicator decreased during the period 2005-2017 (decline of 7 %) mainly because of high RES penetration and reduced energy consumption both due to the implementation of energy efficiency improvement measures, but also due to the economic downturn. In 2017, there was a slight increase of 4.1% in total GHG emissions compared to the total emissions for 2016, mainly due to the higher share of fossil fuels in gross domestic consumption.

Over the entire energy system, gross domestic energy consumption declined significantly by 21% over the period 2006-2017. Compared to the previous year (2016) there is an increase of 3.3%. The **increase in RES penetration into gross energy consumption** continues and almost doubles in 2017 compared to 2006. At the same time, the share of solid fuels decreased by 43% over the period 2006-2017.

During the period 2006-2017, a decrease in final energy consumption is recorded for all end-use sectors. The greatest decline was in the industrial sector (27% decrease), followed by the residential and transport sector, with a respective 21% and 20% decrease in final consumption compared to 2006. The tertiary sector shows a lower, 6% decrease over the same period.

However, during the period 2013-2017 almost all end-use sectors showed an increase of the final consumption of energy. The greatest increase was found in the residential and the industrial sector (increase of 16% and 9%, respectively), while the increase in the transport and the tertiary sector was 8%.

For 2017, the transport sector has the largest contribution as a share to the final consumption of energy (41%), while the participation of both the residential and the industrial sector (shares of 26% and 18%, respectively) is also significant.

The greatest share in the end-use sectors corresponds to the consumption of oil products (56% for 2017), followed by electricity, RES and gas at 28%, 8% and 7%, respectively. Consumption of solid fuels and oil products in the end-use sectors decreased significantly in 2017 compared to consumption levels in 2006 (by 53% and 37% respectively). This decrease is largely offset by the dramatic increase in gas consumption (72%) from RES and electricity consumption, which increased by 24% and 3% over the period 2006-2017.

The **contribution of RES** in the consumption of energy in the territory of Greece shows a significant increase in the period 2006-2017, since the total contribution for 2017 as a share in gross final consumption of energy is 17%, more than doubling the relative share corresponding to RES in 2006.

The share of RES to the gross consumption of electricity in 2017 reached 24.5% by producing a tremendous growth compared to 2006, when the corresponding share was 9%. In particular, with regard to the electricity generation from RES with characteristics of non-controlled generation, i.e. electricity generation from photovoltaic and wind power stations, the percentage of this share is already more than 15% in gross final consumption of electricity and is significantly higher than the corresponding market share at the level of the European Union.

Greece shows the largest share of investment associated mostly with the **Smart Network Management technologies** and the integration of DG and Storage, focusing on increasing the observability and controllability of the distribution network, while ensuring the stability of the network.

Also, emphasis is put on Demand Side Management technologies, mainly through demand response technologies and energy efficiency technologies in the building sector. Over the next years, the investments on Demand Side Management technologies are expected to be increased, due a revised and updated Regulatory Framework.

<u>Future Targets and Objectives</u>

The main objective of the NECP is to provide a roadmap for a substantial reduction in GHG emissions compared to specific reference years, thus demonstrating Greece's commitment to comply with the core EU targets for protecting the environment and addressing climate change for the benefit of people and of the society in general.

In terms of **decarbonisation**, a core objective is set for **a total 40% reduction in GHG emissions** in Greece in 2030 compared to 1990, whereas the reduction objective compared to 2005, which is more comparable on the basis of the Greek economy levels and the related emissions at European level, exceeds 55%.

Moreover, regarding the non-ETS sectors, the reduction in GHG emissions exceeds 35.4% compared to the corresponding emission levels of 2005, thus the reduction rate being double that of the national commitment, which was least 16%. As for the ETS sectors, the estimated rate of reduction in GHG emissions under the NECP is over 70% compared to 2005, while it is much higher compared to the overall EU objective for reducing GHG emissions (almost 43% compared to the corresponding emission levels of 2005).

In addition to that, the NECP integrates and adopts the quantitative targets set in the context of the implementation of Directive 2016/2284/EC on the reduction of national emissions of certain air pollutants for the period 2020-2029 and for 2030 compared to 2005, which also requires the development, establishment and implementation of national air pollution control programmes, as well as the monitoring and reporting of the emission levels for relevant pollutants.

As regards the **energy efficiency dimension**, the objective is to improve energy efficiency in final energy consumption by at least 38% in relation to the foreseen evolution of final energy consumption by 2030, as estimated in 2007 in the context of the EU energy policies, thus resulting in final energy consumption levels of not more than 16.5 Mtoe in 2030.

In addition to that, an objective is set for the annual energy renovation of a total floor area of the thermal zone of central public administration buildings equal to 5.400 square meters, representing 3% of the total floor area. The need to renovate the existing building stock is indisputable, as this will result in significant energy savings and in cost savings for citizens, and will also improve the comfort, safety and health conditions in the use of these buildings.

It is also identified as a necessity the definition of a central quantitative objective for the renovation and replacement of residential buildings with new nearly zero-energy buildings, which could in aggregate amount to 12-15% of all residential buildings by 2030. The annual objective is to have an average of 60 000 buildings or building units upgraded in terms of energy and/or replaced with new more energy-efficient ones.

With regard to **the dimension of energy security**, the qualitative objectives developed in the context of the NECP are broken down into the following main categories:

- *Increasing the diversification of energy sources and suppliers from third countries:*

Strengthening the diversification of energy sources and of fuel supplying countries, to prevent dependence on just one fuel or just one country, is a key objective for the following period. This diversification also increases competitiveness between fuels and suppliers from third countries for the benefit of Greek consumers and makes a substantial contribution towards establishing the security of supply.

- *Optimal utilisation and use of domestic energy sources:*

The recognition of potential and the most cost-effective utilisation of domestic energy sources are a key objective and aim for the development of the national energy system.

- *Highlighting Greece's profile as a regional energy hub:*

Strengthening and utilising the geopolitical role of Greece is a national objective. Therefore, there is an urgent need to complete the existing interconnections and to design new international interconnections with pipelines from third countries.

- *Ensuring adequate system capacity:*

The objective is for Greece to ensure adequate system capacity in order to attain a minimum level of reliability for covering the demand for electricity in the system, in conjunction with Greece's objective for shutting down all lignite-fired plants by 2028.

In terms with the **internal energy market dimension**, the qualitative objectives are broken down into the following main categories:

<u>Market integration and competitive energy markets</u>

A key reform in restructuring the internal market in electricity consists in **reducing domestic lignite-fuelled power generation** through the scheduled shutdown of all lignite-fired plants by 2028. The foreseen coupling of the markets between Greece and Italy and between Greece and Bulgaria will, due to improved energy flows via the interconnections, increase the liquidity of the interconnected markets and enable the participation of RES in the cross-border trade in electricity. Greece's objective is also to strengthen the role of electricity market consumers **by increasing demand-side participation in the electricity market** and to promote the deployment of storage systems that will ensure lower electricity and gas prices and will strengthen RES penetration in the system and provide adequate system capacity.

<u>Electricity interconnectivity</u>

- Increasing cross-border transmission capacity is necessary which contributes significantly to the security of supply;
- Constitutes a key factor in the integration of national electricity markets
- Allows for the desired high RES penetration in Europe.

Energy transmission infrastructure

Greece aims to become an energy hub for both the market in electricity and natural gas. Therefore, Greece is promoting projects, which will be implemented in the following decade, to strengthen its electricity interconnection with neighboring countries and, at the same time, to connect most of the non-interconnected islands with the mainland system, thus contributing significantly to the integration of the electricity market. Moreover, the interconnection of most of the non-interconnected islands with the system aims at:

- Increasing reliability in covering the demand for electricity on the interconnected islands at an interconnected system level
- Substituting diesel with other energy
- Utilising RES potential on the islands in a more cost-effective way.

Digitalisation of the energy system

The digitalisation of the energy system is a prerequisite for the development of properly functioning and competitive domestic energy markets and for the optimal implementation and use of all technological applications and market mechanisms that can be developed in the context of the energy markets. Emphasis will be placed, through the operators' development programmes, on planning and implementing the relevant infrastructure projects, information systems, control centres and metering devices that will allow for the complete transition from the current energy system to a fully digitalised one, also ensuring secure handling of consumer data.

Net metering and active consumer schemes

The contribution of net metering and energy community schemes is twofold, as they will contribute both to the implementation of RES and energy saving investments and to the more active participation of the local community and ultimately to the strengthening of the role of people in energy activities.

Table 8.1 Summary of the future targets and objectives of Greece (Per Dimension)

Decarbonisation (GHG, Emission Reduction and RES Integration)
• Development, establishment and implementation of national air pollution control programmes; monitoring and reporting of the emission levels for relevant pollutants (Sulphur Dioxide (SO2) , Nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), ammonia (NH3) and fine particulate matter (PM2.5)] and other pollutants (CO, heavy metals, POPs, BC). • Increase in RES power generation (Wind Farms, Photovoltaics as the most mature applications) • Increase in the penetration of RES in transport (Biofuels) • Increase in the penetration of RES to cover heating and cooling needs (Biomass boilers, heat pumps) • Electrification of the transport sector, with the penetration of electric vehicles in the market • Hydrogen or Methane produced from RES, to be fed into the natural gas network
Energy Efficiency

• Renovation of the building stock in the residential sector • Renovation of the building stock in the tertiary sector • Increase in the use of natural gas in final consumption
Energy Security
• Utilisation and use of RES potential, both for power generation and for immediate supply and use in final consumption • Highlight Greece's profile as a regional energy hub with the second Greece – Bulgaria interconnection; interconnection of Crete in the context of Greece – Cyprus – Israel (EuroAsia interconnector) interconnection; upgrade of Greece – North Macedonia interconnection • Develop demand response systems and operators to increase the system capacity and decrease energy dependency
Internal Energy Market
• Reduction of domestic lignite-fueled power generation • Setup of storage systems with RES plants on smaller islands • Digitalisation of the energy system, enabling the dynamic pricing of energy supply and demand through the processing and exploitation of consumer data, also ensuring secure handling of consumer data • Development of interconnections of non-interconnected islands to the mainland system
Research, innovation and competitiveness
• Gradual decoupling of economic growth from energy consumption and GHG emissions • Promote innovative applications and services in the energy sector with high domestic added value, in order to ensure the sustainability of the energy sector

Concerning the **Research, innovation and competitiveness dimension**, the Greek Research and Innovation System is considered as one of the strengths of the Greek economy. Promoting research and innovation will continue to be a priority in the period 2020-2030, by strengthening important technologies which will contribute to the attainment of all energy objectives.

In terms of **decarbonization**, achieving the goal of reducing greenhouse gas emissions in all sectors of economic activity is the main priority of Research and Innovation System in Greece. The development and utilisation of innovative RES technologies, which can contribute to the further exploitation of the domestic potential, is expected to play an important role. In this regard, new applications and technologies for renewable electricity generation, as well as other applications enabling them to expand their use and utilise existing energy infrastructure, are already being evaluated and promoted.

In the coming period, priority will be given to utilising the geothermal potential for electricity generation, to developing a viable market for small wind turbines contributing to both scattered production and increased domestic value added as well as marine wind parks with corresponding multiple combining benefits for the energy system, the grids and the national economy. Similarly, initially mainly through pilot applications, the development of projects for the energy utilisation of wave energy and of RES hydrogen production will be promoted.

As for the **energy efficiency dimension**, a key priority is to step up research into new materials and innovative applications of heating and cooling systems, with an emphasis on improving their reliability and automated operation. At the same time, the maturation and integration of innovative energy-saving technologies that contribute significantly to improving energy efficiency, will be facilitated.

In particular, research and innovation activities related to improving the energy efficiency of buildings will include:

- New building materials: Innovative materials and building technologies that will support a recycling process, innovative thermal insulation building systems with improved thermal performance, innovative thermal insulation system without materials derived from mineral sources.
- Prefabricated active roof and facade elements: Standard panels for ventilated facades or roofs combining photovoltaic and thermal solar systems, thermal insulation, phase change materials, batteries.
- Cost-effective, intelligent, flexible heat pumps and high-temperature heat pumps: Intelligent heat pump adjustable to provide additional services to the grid, versatile heat pump to provide a wider operating range and operation control equipment, further development & deployment of absorption technologies and heat pump absorption systems.
- Digital programming and operational optimization: Automated fault detection and diagnosis, combining statistics and technical data to improve energy demand forecasts and updating-upgrading building assessment methods

Regarding the **energy security and the internal energy market dimensions**, the main research and innovation actions to be strengthened are: i) the creation of an innovation environment for the development of smart services and ii) the development of an optimized energy network.

These actions will facilitate the increased observability and controllability of medium and low voltage networks with high penetration of distributed energy resources, smart-flexible design, programming and operation of the network based on improved transmission network observability; the development and implementation of solutions and tools for load profile management through demand response and control in order to optimize network usage.

Table 8.2 R&I Priorities in Greece NECP

Decarbonisation
• Utilization of geothermal potential for electricity generation • Development and deployment of marine wind parks (use of small wind turbines) • Wave energy utilization • Increase in RES hydrogen production
Energy Efficiency
• Thermal insulation building systems with increased thermal performance • Ventilated facades or roofs with PV and solar systems, thermal insulation, batteries • Deployment of flexible and high-temperature heat pumps • Improve on energy demand forecasts, via the combination of statistics and technical data, as a result from the digital programming and operational optimization of the energy system
Energy Security
• Load profile management through demand response • Observability and controllability of medium and low voltage networks with high penetration of DER • Transmission network improved observability
Internal Energy Market
• Load profile management through demand response • Observability and controllability of medium and low voltage networks with high penetration of DER • Transmission network improved observability

Regulatory/ legislation steps contributing to the realization of the NECP priorities Greece

The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities, are summarized as follows:

- Attain a climate neutral economy, through lignite phase-out, while also promoting RES in Greece's energy mix and enhancing the interconnections of the autonomous island systems
- Deploy strategies for the renovation of the building stock in the residential and tertiary sector
- Increase diversification of energy sources and import routes
- Promote flexibility, storage and response systems and ensuring Greece's power adequacy
- Strengthen electricity and gas interconnectivity with neighboring countries and upgrade the existing ones
- Encourage the digitization of energy networks
- Increase in the penetration of RES to ensure the reduction in energy dependency
- Development of interconnections of non-interconnected islands to the mainland system
- Maintenance of social tariff scheme

8.1.7 **Ireland**

Current Situation Ireland

For 2016, total national greenhouse gas (GHG) emissions were estimated to be 61.55 million tonnes carbon dioxide equivalent (Mt CO2 eq) which is 3.6 % higher (or 2.12 Mt CO2 eq) than emissions in 2015 (59.43 Mt CO2 eq) and follows the 3.7% increase in emissions reported for 2015. Emission reductions were recorded from 2007 to 2014, however since 2015, this trend experienced a change in line with economic and employment growth, particularly in the Energy Industries, Agriculture and Transport sectors. Between 2015 and 2017, national total emissions increased by 7.4% in Ireland, this is 4.23 Mt CO_2eq. In the same period, emissions in the ETS (Energy Trading Scheme) sector grew by 11.2% or 1.78 Mt CO_2eq, whereas in the non-ETS sector, there was a boost by 5.9% or 2.45 Mt CO_2eq.

Agriculture and transport sectors accounted for 73.2% of total non-ETS emissions in 2016. With regard to the former, emissions increased by 2.7% or 0.53 Mt CO2eq, following an increment in 2015 of 1.5%. The most significant drivers for the enlarged emissions in 2016 were higher dairy cow numbers (+6.2%), with a growth in milk production of 4.0%. During the 5-year period 2012-2016, dairy cow numbers rose by 22% and their corresponding milk production by 27%, as a result of the national plans to expand this activity. On the other hand, other cattle and pig numbers increased by 3.0% and 3.7%, respectively. The rest of the emissions increments in 2016 within this sector were due mainly to liming (+8.4%) and urea (+26.5%) applications, as well as the fossil fuel consumption in agriculture and forestry activities (+5.0%).

Concerning the transport sector, GHG emissions increased by 4.1% or 0.48 Mt CO_2 eq in 2016. This is the fourth successive year of growing in transport emissions following five consecutive years of decreases since 2007. In road transport, gasoline and biofuels use continued to reduce by 6.7% and 8.0%, respectively, while diesel use increased by 8.0%.

The energy industries sector show an increase in its emissions of 6.0% or 0.71 Mt CO_2eq in 2016, which is attributable to an increment in natural gas use for electricity generation at power plants by 27.7% and reductions of 6.5% and 15.6%, respectively, for electricity generated from wind and hydro renewables. This is reflected in a 3.3% rise in the emissions intensity of power generation in 2016 (480 g CO_2/kWh) compared with 2015 (465 g CO_2/kWh).

It is important to highlight that renewables accounted for 25.5% of electricity generated in this year (down from 27.3% in 2015). Moreover, Ireland exported 2.4% of electricity generated in 2016, when the final consumption of electricity also increased by 2%.

Regarding other industries such as the manufacturing combustion sector, its emissions rose by 0.07 Mt CO_2 eq or 1.6% in 2016. There were minor decreases in combustion emissions for almost all sub sectors, for instance, non-ferrous metals industry, experienced a reduction of 5.1%. However, increased emissions from companies within the ETS were evident in the food, drink and cement sectors, with emissions increments by 4.5% and 3.5%, respectively.

Emissions from the industrial processes sector continue to increase by 7.1% (0.14 Mt CO_2eq) in 2016 following a 10.3% increment in 2015, mainly from the cement production growth, whose emissions rose by 8.6% in 2016 and by 79% since 2011. Furthermore, total process emissions from the mineral products subsector (including cement) increased by 7.5%, being these emissions included in the ETS sector and contributing significantly to its expansion.

By contrast, GHG emissions in the residential sector are almost unchanged with a small increase of 0.1% or 0.01 Mt of CO_2 eq in 2016. Within the different fuels used in household space and water heating, kerosene use grew by 5.2%, gasoil by 5.0% and natural gas by 1.4%, whereas coal and peat use continued to decline by 13.3% and 1.9%, respectively. In addition, emissions from commercial and public services rose by 2.5% and 2.7%, respectively, with increments in both sectors of 5.2% in natural gas use, 55.4% in biomass and 26.9% in biogas use.

Last but not least, emissions from the waste sector increased by 0.9% or 0.01 Mt CO_2 eq in 2016 with decreases in the sub-category of incineration and open burning (-42.8%).

Future Targets and Objectives Ireland

The European Union energy policy is currently defined by a framework called the “Energy Union”. The European Commission’s strategy as set out in the Energy Union package is about achieving an energy resilient union with a forward-looking climate policy. The strategy seeks to ensure secure, affordable, and climate-friendly energy for citizens and businesses and to allow a free flow of energy across borders with a secure supply in every EU state.

The Energy Union has established five mutually reinforcing and closely interrelated dimensions that have followed the different countries to elaborate their NECPs:

i. Decarbonising the economy
ii. Energy efficiency contributing to moderation of energy demand
iii. Energy security based on solidarity and trust
iv. A fully integrated European energy market
v. Research, Innovation and Competitiveness

1. Decarbonisation

The Effort Sharing Regulation (ESR), which set out the binding emissions reductions for energy, industrial processes and product use, transport, agriculture and waste has established a **greenhouse gas emissions reduction target for Ireland in 2030 of 39% above 1990 levels, reduced to 30% to reflect the cost effectiveness of measures.** There are no individual targets for each sector in the ESR, this 30% reduction target set for Ireland will cover all non-ETS sectors, including transport, buildings, agriculture and waste management.

Nevertheless, Ireland will be able to avail of a transfer of 4% of its 2005 emissions to be used for compliance under the ESR, for every year in the 2021-2030 period. All Member States are eligible to make use of this flexibility, while access is higher for Member States with a larger share of emissions from agriculture, being Ireland the EU country with the highest.

In line with EU leaders' guidance, this recognises that there is a lower mitigation potential for emissions from the agriculture sector. Ireland's agriculture accounts for 33% of national emissions whereas agriculture in the EU-28 represents only 10% of emissions. As a portion of the non-ETS sector (for which the State is responsible under EU law), agriculture represents over 45% of non-ETS GHGs in Ireland, but only 18% of EU-28 non-ETS emissions. Recognition of the unusually large contribution of agriculture to our national emissions is vitally important to Ireland. The EU has already recognised (including in European Council conclusions) the multiple objectives of the agriculture and land use sector with their lower mitigation potential.

Furthermore, the Ireland National Policy Position envisages that policy development will be guided by a long-term vision based on an **aggregate reduction in carbon dioxide (CO_2) emissions of at least 80% (compared to 1990 levels) by 2050** across the electricity generation, built environment and transport sectors and, in parallel, an approach to carbon neutrality in the agriculture and land-use sector, including forestry, which does not compromise capacity for sustainable food production.

2. Energy Efficiency

Apart from the elements set out in the point (b) of Article 4 of *RES* Directive 2001/77/EC, the Ireland NECP also includes in the energy efficiency dimension objectives the indicative milestones for 2030, 2040 and 2050, the domestically established measurable progress indicators and their contributions to the Union's energy efficiency targets. These are set out in the long-term renovation strategies roadmap for the national stock of residential and non-residential buildings, both public and private, in accordance with Article 2a of Directive 2010/31/EU. This relates to a new requirement for the Long-Term Renovation Strategy under the revised Energy Performance of Buildings Directive (EU) 2018/844.

What is more, national objectives in other energy efficiency areas such as the transport sector or the heating and cooling are also contemplated by this NECP.

3. Energy Security

Concerning the energy security dimension, the Ireland NECP classifies the objectives in four different categories given the profile of the country and taking into consideration the most cost-effective way.

I. *National objectives set out in the Article 4* of *RES* Directive 2001/77/EC.
   - To maintain and, where necessary, facilitate the enhancement of resilience of the gas and electricity networks.
   - To improve diversity of the gas and electricity supply and import routes, including exploring the potential for LNG and gas storage.
   - To increase indigenous production of clean energy sources.
   - To facilitate, as a preference, commercial investment through policy and regulatory certainty.
   - To ensure close cooperation on security of supply at EU and regional level, in particular with the UK.
   - Continue to examine how emissions from the energy mix can be reduced, including the potential role that Carbon Capture and Storage technology could have facilitating the high level of natural gas in the energy mix.

Moreover, in this category, there are also some established goals regarding the **oil** sector:

- To provide a policy and regulatory framework to facilitate the commercial oil companies in their supplying of product to the domestic market.
- To facilitate the continued operation of sufficient infrastructure to import and supply oil to the marketplace.
- Support for renewable and sustainable alternatives to petroleum products, including electric vehicles, biofuels and CNG in transport.

II. National objectives with regard to increasing the diversification of energy sources and supply from third countries with the purpose of increasing the resilience of regional and national energy systems.

- To ensure that there is sufficient flexibility in the energy system to maintain energy security of supply and facilitate the integration and transition to clean energy sources in the most cost-effective way.
- To support further electricity interconnection to improve the functioning and flexibility of the national energy system.

III. National objectives with regard to reducing energy import dependency from third countries, with the purpose of increasing the resilience of regional and national energy systems.

- To ensure the resilience of the gas network to a long-duration supply disruption, in the context of EU and national climate objectives.
- If deemed necessary, to identify options needed to enhance our security, including examining the potential role of LNG and gas storage.
- To actively participate in EU and regional initiatives to maintain and enhance security of supply including national, regional and EU cooperation on emergency planning and response for gas and electricity networks, including risk assessments, preventative plans and emergency plans.
- Continued strong regional cooperation between Ireland and the UK on matters related to gas and electricity security of supply, including emergency preparedness and response and solidarity in an emergency situation.

IV. National objectives with regard to increasing the flexibility of the national energy system, in particular by means of deploying domestic energy sources, demand response and energy storage.

- To ensure that there is sufficient flexibility in the energy system to maintain energy security of supply and facilitate the integration and transition to clean energy sources.
- Support further electricity interconnection to improve the functioning and flexibility of the national energy system.

4. Internal Energy Market

The way electricity is traded in the all-island Single Electricity Market (SEM) changed the 1st October 2018 with the introduction of the new Irish wholesale electricity market, which is now coupled with other EU markets, involving the creation of new day ahead and intra-day markets.

In relation to this dimension targets, it is necessary to distinguish among four different parameters:

I. Electricity interconnectivity. Ireland's level of interconnection is currently reported by the European Commission as 7.4%. When the UK leaves the EU, Ireland will have no direct electrical interconnection with the rest of the EU. The target of electricity interconnection for 2030 is at least 15%, taking into account the 2020 interconnection objective of 10% and the following indicators of the urgency of action:

- Price differential in the wholesale market exceeding an indicative threshold of 2 €/MWh between Member States, regions or bidding zones.
- Nominal transmission capacity of interconnectors below 30 % of peak load.
- Nominal transmission capacity of interconnectors below 30 % of installed renewable generation.

In addition, each new interconnector shall be subject to a socioeconomic and environmental cost-benefit analysis and implemented only if the potential benefits outweigh the costs.

II. Energy transmission infrastructure. The main goal in this category is to carry out key electricity and gas transmission infrastructure projects, and, where relevant, modernisation projects, that are necessary for the achievement of objectives and targets under the five dimensions of the Energy Union Strategy.

III. Market integration. The main targets of market integration in the Ireland NECP can be summarised as the following:

- To increment system flexibility, in particular related to the promotion of competitively determined electricity prices in line with relevant sectoral law, market integration and coupling, aimed at increasing the tradeable capacity of existing interconnectors, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment and real-time price signals.
- The non-discriminatory participation of renewable energy, demand response and storage, including via aggregation, in all energy markets.
- To ensure that consumers participate in the energy system and benefit from self-generation and new technologies, including smart meters.
- To ensure electricity system adequacy, as well as for the flexibility of the energy system with regard to renewable energy production.
- To protect energy consumers and improve the competitiveness of the retail energy sector.

IV. Energy poverty. The main target of this parameter is to set up objectives to combat the energy poverty.

5. Research, Innovation and Competitiveness

A key metric for the assessment of innovation activity is R&D intensity, which reflects the extent of research and innovation activities undertaken in a country in terms of resources input. Ireland's intensity rate in 2016 was 1.18 % Gross Expenditure on R&D (GERD) as a percentage of GDP. Nonetheless, in 2016, the estimated EU (28 countries) average for civil GERD as a percentage of GDP was 1.93%, whereas for the total OECD was 2.24%. Therefore, Ireland is below the EU 28 average for this indicator. The Europe 2020 strategy (a 10-year strategy developed by the European Commission in 2010) sets a 3% objective for R&D intensity in EU Countries by 2020.

For this reason, among the national targets of research, innovation and competitiveness are the public and private projects related to the Energy Union and the objectives for 2050 linked to the promotion of clean energy technologies, including not only the decarbonising energy- and carbon-intensive industrial sectors but also the carbon transportation and storage infrastructure.

Summary of the future targets and objectives of Ireland (Per Dimension)

Decarbonization
• To increase RES power generation in wind, hydro, biomass/landfill gas and ocean energy • To increase the use of renewable energy in the heat sector • To increase the use of renewable energy in the transport sector and to provide viable alternative transport infrastructure • To reduce industrial GHG emissions in a cost-effective manner, including a sustainable food production
Energy Efficiency
• Upgrading of the residential buildings, as well as the commercial and public buildings stock • To influence and deliver new best practices in energy efficient design to improve energy management and asset performance in homes, SMEs and the public sector
Energy Security
• To prioritise oil for societal needs, including critical infrastructure and vulnerable users during a prolonged oil emergency • To provide for petroleum products security of supply
Internal Energy Market
• To ensure a secure power system with increasing nonsynchronous renewable generation • To increase the resilience of the gas network • To increase electricity interconnection to Ireland improving sustainability, security of supply and competitiveness • To facilitate efficient and transparent pricing in the electricity market • Strategy to help combat energy poverty
Research, Innovation and Competitiveness
• To support research, development, demonstration & innovation in low carbon technology / energy sector • To support research into climate science

The Energy Research Strategy published by DCCAE recognises Ireland's reputation as a world class location for research across a several sectors, including Life Sciences and ICT, with many global companies actively engaged in research activities in Ireland. The strategy states that the Irish energy research system should:

1) Develop new technologies for the harnessing and integration of indigenous renewable resources (e.g. wind energy, ocean energy and bioenergy).

2) Identify and develop products and services that will radically transform the efficient utilisation of energy across all sectors of the economy, with consequent benefits for economic growth, development of new Irish businesses and job creation.

3) Undertake basic research in such areas as material sciences and bio-sciences, to expand the knowledge base on which breakthrough innovations in energy supply and utilisation can be made.

4) Take innovative ideas and concepts developed elsewhere, and examine how they might usefully be adapted, further developed, demonstrated and deployed by Irish companies both in Ireland and abroad.

5) Help Irish companies in the energy sector to develop and grow at national and international level.

6) Seek to collaborate and attract investment from indigenous and foreign businesses in order

to enhance the benefits of energy research.

7) Contribute to effective policy making, through the development and maintenance of an energy

system modelling capability.

8) Investigate and address the various technological and behavioural barriers to the uptake of new energy efficient and low carbon technologies.

Decarbonisation
• Research on the integration of renewable electricity systems on the grid, on carbon sequestration, on bioenergy emissions and on the environmental impacts of renewable technologies. • Suggestion of a collaborative approach to research between Government, academia, research bodies and industry, including the development of a costed model setting out the least coast pathway to decarbonisation
Energy Efficiency
• Increased energy efficiency and competitiveness utilising existing infrastructure
Energy Security
• Increased security of supply (including LNG) • Research on demand side management, energy storage, floating wind, hybrid technologies and on making biofuels economically viable
Internal Energy Market
• Focus on areas specific to Ireland such as agriculture and non-synchronous generation • Focus on integration of renewable electricity onto a power system • High energy volume storage and power-to-gas technologies research

8.1.8 **Italy**

Current Situation Italy

Regarding the **dimension of decarbonization**, the last few decades have seen profound changes being made to the Italian energy system, in which natural gas first of all established itself, followed by (from 2005 onwards) a marked rise in renewable energy sources, in particular in the electricity sector, and a steady reduction, on the other hand, of petroleum products. These developments have been imposed both by policies aimed at significantly reducing greenhouse gas emissions and thus combating the risks associated with climate change, and by the need to guarantee greater security and diversification in energy supplies.

Gross inland consumption and final consumption levels fell dramatically in the 2005-2014 period. The decrease in the consumption of petroleum products, natural gas and (albeit at an inconsistent rate) coal have been particularly marked. Over the last few decades, renewable energy sources, also thanks to the deployment of a incentivisation scheme, have played a leading role in a period of significant development in Italy.

The trend in final consumption levels shows that the energy mix has remained substantially the same in recent years. As can be seen, gas and electricity sources are predominant in the industrial sector (around 70% of total consumption) and the civil sector (85%), while oil covers virtually all the requirements of the transport sector, although it is worth pointing out an increase in RES in relation to the use of biofuels.

As for the **energy efficiency dimension,** the use of heat pumps for air conditioning (heating and cooling) and ACS (full electric building) is the optimal result only for newly constructed buildings of single-family residence and office type. In the other cases, the selected installation solution is always based on the integration of heat pumps, gas boilers (three-star condensing) and multi-split systems.

The installation of solar panels, which always features amongst the work identified for all types of buildings (these panels having an installed power of between 20 and 26 W/m2), has made it possible to achieve coverage levels of 50% to 70% for newly constructed residential buildings, and of 10% to 30% for existing ones. The coverage level for offices is not so high, amounting to between 40% and 50% for new buildings and between 15% and 20% for existing ones.

It is important to underline that, in order to fit solar panels on the various reference buildings in question, it has always been assumed that optimal levels of space and orientation will be available, with no consideration being given to any possible constraints or obstructions that are often actually present.

School buildings, which have a significantly different use profile compared with the other types, are the only types of building for which no provision has been made for the use of heat pumps, owing to the absence of any summer air-conditioning system. The heating and ACS system is in fact fully integrated within the single condensing boiler. For this type of building, the coverage of renewables, via solar power, is lower (around 20% of the total) and relates to around half of the energy requirements for lighting.

In terms of the **dimension of energy security**, in 2016, the national production of energy sources recorded a decrease of a total of 6.5% compared to 2015, with zero generation of solids, a reduction of 30% from petroleum sources and a 15% decrease in natural gas.

The indicator of the country's degree of dependence on imports of commodities from abroad has increased slightly (from 77.1% in 2015 to 77.7% in 2016) but is still below the above 80% values that have been recorded in the past. In recent years, the increasing penetration of RES and the reduction in energy intensity have contributed to a reduction in Italy's dependence on foreign supply sources

As regards to the **internal energy markets dimension**, interconnection capacity is currently primarily located at the country's northern border (4 lines with France, 12 with Switzerland, 2 with Austria, 2 with Slovenia). In total, there are 7 circuits at 380 kV, 9 circuits at 220 kV and 3 circuits at 150/132 kV on the northern border. There is also a direct current connection with Greece and one that connects Sardinia and the peninsula with Corsica (SACOI2). Sardinia is also connected to Corsica by an alternating current cable. A 220 kV double circuit cable connects Sicily with Malta.

The interconnection projects currently underway are the Italy-France and Italy-Montenegro (first centre) connections, which will be up and running by 2020 and will contribute to the achievement of the target of 10% by 2020. 40 With reference to national network development plans and TSOs' regional investment plans. In addition to a new project with Austria, which is at an advanced stage of the authorisation process, the complete overhaul of the Sardinia-Corsica-Mainland Italy connection to replace SACOI 2 and the underwater link between Italy and Tunisia are at the design stage.

Furthermore, the interconnectors (pursuant to Law 99/2009) with Switzerland, Slovenia and Austria, which are at the authorisation stage, should also be taken into account. These are complemented by the merchant lines at the initiative of private parties (Reg. 14/2009), which must be taken into account by Terna so as to avoid overestimating the interconnections and overburdening the country. Compared with the number of authorisations granted, however, few merchant lines have been put in place; this therefore represents an uncertainty factor. Among these, therefore, are connections that would open up new borders (with Croatia and with Albania) or that would push the connection with Tunisia further north, towards Lazio.

The list below shows the development projects for the overseas interconnection; these were identified by Terna in the Development Plan 2017.

At the design stage:

- HVDC connection between Italy and France (Piossasco – Grand'Ile): high-voltage direct current (HVDC) terrestrial cable, of nominal power 2x600 MW, between the two electrical stations in Piossasco (Piemonte) and Grand'Ile (Savoia);
- HVDC connection between Italy and Montenegro (Villanova – Tivat): two pole lines at ±500 kVcc partly in terrestrial cable and partly in marine cable, with transmission capacity of 2X600 MW, between the two Converter Stations in Cepagatti (Abruzzo) and Kotor (Montenegro);
- 132 kV connection between Prati di Vizze/Brennero (IT) and Steinach (AT), in conjunction with the local Distributor.
- 400 kV power line Interconnection between Italy and Austria, in two stages: i) removal of the restrictions on the current 220 kV connection between Italy and Austria; ii) new 400 kV connection;
- connection between Italy and France, SACOI 3 'Sardinia-Corsica-Mainland Italy': replacement of the existing SACOI 2, which has now reached the end of its useful life;
- connection between Italy and Tunisia; work of strategic importance for the electrical transmission system in the Mediterranean basin, which will provide an additional tool to optimise the use of energy resources between Europe and north Africa.

Regarding the **Research, innovation and competitiveness dimension**, in recent years, there has been a strong focus on more extensive use of alternative sources, partly driven by environmental obligations that have provided impetus for new technological demand. The positive results recorded in recent decades in the field of thermo-electromechanics do not currently appear to be capable of overcoming the limits of a weak specialisation, contrasted by much greater strengths at a European level. The greatest difficulties include the lack of presence among technologies using renewable sources, with the exception of some strong points in solar power (CSP), geothermal and bioenergy.

Following a period of high levels of fragmentation, in recent years Italy's research into energy technologies is evolving into a more coordinated framework of initiatives; this has also been boosted by the alignment of the key actions in the SET Plan and participation in the Horizon 2020 Programme and Mission Innovation. The Italian research system is well positioned internationally, demonstrating a willingness to seize all the most innovative ideas appearing on an international level.

Italy shows a great share of investment associated mostly with the Demand Side Management technologies, mainly through demand response technologies and energy efficiency technologies in the building sector, and the integration of DG and Storage, focusing on ensuring the stability of the network.

Also, a significant share of investments is associated with e-mobility technologies. This share of investments is expected to be increased over the next years.

The largest share of investments in Italy, is associated with the Smart Network Management technologies, through which it is prioritized the increased observability and controllability of the distribution network.

Future Targets and Objectives Italy

Regarding **decarbonization**, the target of reducing greenhouse gas emissions by at least 40% at

European level by 2030 compared with 1990 is shared amongst the ETS sectors (energy industries, energy-intensive industrial sectors and aviation) and non-ETS sectors (transport, residential, tertiary, industry not included in the ETS sector, agriculture and waste), which will need to record a -43% and -30% decrease, respectively, compared with 2005.

Greenhouse gas emissions (GHG) from energy uses represent 81% of the national total. The remaining share of emissions derives from non-energy sources, which are mainly associated with industrial processes, fluorinated gases, agriculture and waste.

Italy plans to pursue the target of obtaining 30% of gross final consumption of energy from renewable sources in 2030 by defining a pathway of sustainable growth for renewable sources and the full integration thereof into the system. In particular, the target for 2030 projects a gross final consumption of energy of 111 Mtoe, with approximately 33 Mtoe of that coming from renewable sources.

According to the objectives of the NECP, electricity production facilities are undergoing a major transformation thanks to the target of phasing out coal-fired generation by as early as 2025 and the promotion of the widespread use of renewable energy sources. The significant penetration of technologies for renewable electricity production, primarily photovoltaics and wind power technology, will enable the sector to cover 55.0% of gross final electricity consumption with renewable energy, compared with 34.1% in 2017. The significant technically and economically feasible growth potential of photovoltaic installations and wind parks, thanks also to the reduction in costs associated therewith, points to a major development of these technologies, the production of which should triple and more than double, respectively, by 2030.

Also, the promotion of investments in repowering existing wind power plants with more developed and efficient machines, by exploiting the excellent wind conditions at well-known sites that are already being used, will also help to limit the impact of soil consumption.

In the heating sector, the installation of new biomass-fired heating systems will be targeted towards promoting high-efficiency systems meeting high environmental quality standards, with consideration also being given to the possibility of introducing restrictions on new systems in areas characterised by critical air quality conditions. In order to stimulate the renewal of old systems using efficient, low-emission technologies, more stringent performance requirements on accessing incentives for biomass-fired heat generators will be introduced in the short term.

The recast Renewable Energy Directive (RED II) identifies a specific target for the transport sector of 14% for 2030 (obligation for suppliers of fuels and electricity). In order to contribute to the challenging general target of 30% total gross final consumption met by RES, it is expected that the transport sector will surpass the value of 14% by increasing the obligation imposed on suppliers of fuels and electricity for the transport sector up to a renewables share of 22.0%.

In terms of the **energy efficiency dimension**, a long-term strategy for the renovation of the building stock will be prepared, setting intermediate and final targets, in accordance with the provisions of Directive (EU) 2018/844 on energy performance in buildings.

The plan is to focus the **Conto Termico** scheme on energy-efficient retrofitting and restoration of non-residential buildings, in the public and private tertiary sector. The intention is to continue the task of simplifying access to the scheme for public bodies, also through promotion of the ESCo model and the use of energy performance contracts (EPCs). In addition, the possibility of extending the admissibility of interventions, including measures to connect to efficient district heating systems, will be explored.

With regard to the **dimension of energy security**, the qualitative objectives developed in the context of the NECP are broken down into the following main categories:

- *Increasing the diversification of energy sources and supply thereof from third countries, with a view to reducing energy import dependency:* optimising the use of existing infrastructure and developing the LNG market and increasing the growing share of renewable gas (biomethane, synthetic methane and, eventually, hydrogen) in the network.
- *Increasing the flexibility of the national energy system:* with respect to sources of supply by means of updating the gas transport network, including for the purpose of increasing its security and control standards, in accordance with the provisions of the 10-year development plans for transport companies
- *Addressing constrained or interrupted supply of an energy source, for the purpose of improving the resilience of regional and national energy systems:* improving the security margin in the event of large peaks in demand, while also, coordinating the national emergency plans with those of the other countries along the same physical supply corridors, as provided for by European Regulation 2017/1938 on the security of the gas system

The national objectives in the context of energy security for the electricity sector are broken down into infrastructure objectives, which aim to increase the security of supply in various projected situations, in line with the ENTSO-E scenarios and with the projections of the TSO.

The development of interconnections with other networks and solutions designed to create synergies with the gas sector (sector coupling), in a context involving far-reaching changes to the European market, addresses the need to better tackle the issues of system reliability in terms of suitability and flexibility, as well as the need to widen the dimension of the market itself and reduce the price gap.

Today, Italy's interconnection capacity is primarily concentrated on the north-west and north-east borders of the country, complemented by additional connections with Greece and, since November 2019, with Montenegro.

The interconnections along these borders will be further enhanced in order to contribute towards the attainment of the targets identified by the Energy Union, in line with a cost-benefit approach and with priority being given to connections with systems having highly developed renewable energies and/or able to contribute towards reducing domestic prices.

An increased flexibility of the system is undoubtedly one of the national objectives relating to the **internal energy market dimension**. This objective will be achieved through increased flexibility of existing thermoelectric production facilities and, above all, by increased market participation of new flexible resources. These new flexible resources include aggregation and demand response, a greater participation of distributed generation and non-programmable renewables in services markets, and the development of new storage systems.

In particular, flexibility requires a strong push for new storage systems that give benefits not just in terms of shifting production from the peak of non-programmable renewables (photovoltaics and wind power in particular) towards hours of increased consumption, but also in terms of providing the system with the actual services needed for security, including as a replacement for thermoelectric production units. Still on the issue of flexibility, the active participation of demand on the markets makes a significant contribution; this kind of contribution will be encouraged by building on the experience gained from the pilot projects launched by Terna, which can undoubtedly be of benefit to technological development by enabling the spread of demand response configurations, as well as the evolution of new players, such as aggregators and energy communities.

Summary of the future targets and objectives of Italy (Per Dimension)

Decarbonization
• Phasing out coal-fired generation in electricity production facilities • Increased penetration of RES in electricity production (Wind Parks, Photovoltaic Installations) • Repowering of wind power plants with more efficient machines, exploiting Wind energy • Biomass-fired heating systems deployed in the heating sector • Increase of RES and electricity in the transport sector
Energy Efficiency
• Deployment of a long-term strategy towards the renovation of the building stock • Energy efficient retrofitting and restoration of non-residential buildings, focusing on the Conto Termico scheme, in the public tertiary sector • Energy efficient retrofitting and restoration of non-residential buildings, focusing on the Conto Termico scheme, in the private tertiary sector • Use of energy performance contracts (EPCs)
Energy Security
• Increase in the diversification of energy sources, by optimising the use of existing infrastructure and developing the LNG market and increasing the growing share of renewable gas (biomethane, synthetic methane and, eventually, hydrogen) in the network • Increase in the flexibility of the national energy system, by updating the gas transport network, including for the purpose of increasing its security and control standards • Improving the security margin in the event of large peaks in demand, while also, coordinating the national emergency plans with those of the other countries along the same physical supply corridors
Internal Energy Market
• Development of new storage systems • Increased flexibility through existing thermoelectric production facilities • Increase of demand response configuration • Evolution and introduction of aggregators and energy communities, in the energy market
Research, innovation and competitiveness
• Monitor and develop product and process technologies vital to the energy transition • Promote the introduction of technologies, organisational and operational models and systems used for the energy transition and for safety

On the **Research, innovation and competitiveness dimension**, during the COP 21 in Paris, Italy signed up to the multilateral initiative which aims to promote an acceleration of technological innovation to support the energy transition by means of a significant increase in public funding dedicated to cleantech research. The initiative comprises a series of 'Innovation Challenges'.

Italy views the Strategic Energy Technology (SET) Plan as a fundamental instrument for meeting the new challenges posed by decarbonization and agrees with the role the Commission has assigned to it in setting the objectives of the present Plan. Since the SET Plan was first introduced, Italy has progressively aligned its objectives and priorities for public investment in research and innovation in the energy sector with those of the SET Plan. As confirmation of this commitment, Italy follows all of the key actions of the SET Plan with its own experts, who have set up standing consultation groups with businesses and national research bodies, and engages in collaboration with other Member States that has often translated into joint participation in Horizon projects.

In addition, the conception and construction of the Innovation Challenges envisaged by Mission Innovation to a large extent reflect the SET Plan methodology and there are significant synergies between the two. Italy therefore considers the systematic and integrated management of research in the energy sector to be necessary, both for the SET Plan and for Mission Innovation, in order to improve efficiency and the effectiveness of the allocated resources.

The objective is to create the conditions for a system where the participation of industry and public and private Italian research centres in future research programmes provided either by the SET Plan/Horizon Europe or Mission Innovation is broader and less fragmented, effectively offers the opportunity to play a more decisive role and which has better success than has been achieved in the past. The principal objectives aim to:

- monitor and develop product and process technologies vital to the energy transition;
- promote the introduction of technologies, organisational and operational models and systems used for the energy transition and for safety.

Following the intense work carried out by the Italian Delegation as part of the working groups set up by the SET Plan for the implementation of the Key Actions, it is considered that renewable sources – among them solar PV and CSP in particular, and, in the longer term, sea energy (wave, tidal and current energy), storage systems (including hydrogen and power-to-gas and, more generally, the integration between the electricity system and other systems), system devices for safety of the electricity system, electric mobility, biorefineries, materials, processes and systems for **energy efficiency of the industry and of buildings** represent the subjects that have, concurrently, sufficient focus among research bodies, a considerable industrial basis and are of significant interest to the system, not only for the 2030 objectives but also and especially in the longer term view, looking ahead to 2050.

Moreover, **the development of smart grids** will also be a dominant theme over the coming decades in Italy. It will benefit not only small producers but also large companies, insofar as the availability of a network in which all devices communicate among themselves will channel a quantity of information able to appropriately **predict energy demand to software equipped with artificial intelligence**.

Also, the modernization of electricity networks, poses as a priority for the R&I community, with a view to smart grids. The **increase in generation of distributed energy resources** in fact requires real transformation of the **distribution networks and of the related operational modes**, with modernisation both of the hardware component (e.g. to also make distribution networks also bi-directional) and of the software component (e.g. to enable demand response management initiatives).

The field of cybersecurity is one where large spaces and opportunities, therefore, the cyber research plan in the electricity sector in Italy will also have to address, in the next few years, the issue of innovation of energy infrastructure from a long-term perspective, by means of **modelling and simulation activities, experimental activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector**.

In this same context, it must be considered that **the evolution of the energy mix and of the set-up of the markets** will increasingly involve, in an active role, new parties and new resources, at several voltage levels. This creates requirements for research and innovation in technologies to **make the system more 'readable' and the networks smarter**, and to maintain development of the necessary instruments for **safely managing the networks and the energy system**.

Lastly it is considered to be of interest to encourage research into the potential benefits **of integration of the electricity and gas systems through the development of pilot power-to-gas, power-to-hydrogen and gas-to-power projects;** an integration that sees the gas network as a useful tool for development of an ever greater quantity of intermittent renewables, itself a carrier of renewable gases, and – through conversions of electrical energy carriers into gas and vice versa – a pillar of an integrated energy infrastructure, which enables the full potential of renewable sources to be exploited, also guaranteeing the storage of energy in the medium to long-term.

The evolution and development of the technologies previously cited would allow the **storage of excess energy produced by non-programmable renewable energy sources (RES) into renewable energy carriers (biomethane, hydrogen, heat)** increasing the overall efficiency of the energy system and initiating a synergic course between the two systems towards a possible fusion of the gas and electricity sectors into a single energy sector.

Decarbonization
• Further exploitation of solar PV and CSP renewable sources • Utilization of wave / tidal energy • Development of power-to-gas storage systems
Energy Efficiency
• Development of Smart Grids • Energy demand forecasting via software equipped with artificial intelligence • Storage of excess energy produced by non-programmable renewable energy sources (RES) into renewable energy carriers (biomethane, hydrogen, heat) • Make the system more 'readable' and the networks smarter
Energy Security
• Evolution of the energy mix • Modelling and simulation activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector • Experimental activities for verifying preventative and reactive safety measures used in communication systems in the electricity sector • Management of the distribution network and the energy system
Internal Energy Market
• Increase in generation of distributed energy resources • Load profile management through demand response

Regulatory/ legislation steps contributing to the realization of the NECP priorities Italy

The most indicative regulatory/ legislation steps that Italy should undertake, in order to fulfill and accomplish the NECP priorities, are summarized as follows:

- Accelerate the decarbonisation process by setting 2030 as an interim milestone for achieving full decarbonisation of the energy sector by 2050

- Place a central emphasis on citizens and businesses (in particular SMEs), in such a way that they become key players and beneficiaries of the energy transition and not just the financiers of active policies. This requires the promotion of self-consumption and renewable energy communities
- Foster the evolution of the energy system, particularly in the electricity sector, from a centralised structure to a distribution predominantly reliant on renewable sources,
- Adopt measures to improve the capacity of renewables to contribute to security while at the same time promoting frameworks, infrastructure and market rules which, in turn, contribute to the integration of renewables.
- Continue to ensure adequate supplies from conventional sources, by pursuing security and continuity of supply, with the understanding that the demand for these conventional sources is in progressive decline as a result of both the increase in renewables and energy efficiency.
- Promote energy efficiency across all sectors as an instrument for protecting the environment, improving energy security and reducing energy costs for families and businesses.
- Promote electrification of consumption, in particular in the civil and transport sectors, as an instrument for additionally improving air and environmental quality.
- Guide the evolution of the energy system through research and innovation activities to develop, in line with European guidelines and the requirements for full decarbonisation, solutions able to achieve sustainability, security, continuity and cost effectiveness of supply based increasingly on renewable energy in all usage sectors.
- Adopt, taking into account the conclusions of the strategic environmental assessment (sea) and related environmental monitoring, measures and expedients to reduce the potential negative impacts of energy transition on other equally relevant objectives, such as the quality of air and bodies of water, the limitation of soil consumption and landscape protection.

8.1.9 Lithuania

Current situation Lithuania:

The National Energy and Climate Action Plan of Lithuania for the period 2021-2030 has been drawn up in accordance with the requirements of the Energy Union Regulation. The national plan presents the provisions, objectives, targets and measures implemented and planned in Lithuanian national legislation and international commitments.

Lithuania has decreased its greenhouse gas emissions with 57% compared with 1990 figures, which is the largest reduction in the EU-28. In terms of per capita GHG emissions, Lithuania had the ninth lowest result in the EU in 2017. It should be noted that this remarkable progress in the area of environmental protection has been achieved despite the country’s economic growth. The positive downward trends are expected to continue.

Lithuania is among the leading European countries in terms of its share of GHG removals in its forests. In 2017, removals in forests accounted for 7.8 million tons of CO2eq, which is one third of Lithuania's total GHG emissions.

In the area of tax policy, Lithuania is behind the EU countries. Its environmental taxes are considerably lower (1.9% of GDP) than the EU average (2.4% of GDP in 2017). Lithuania’s transport fleet consists of 1.5 million passenger cars, 69% of which are diesel cars with an average age of 15 years and with high CO2 emissions (an average of 160-170 g/km). Transport taxes are the lowest in the EU and the environmental performance of the vehicle is not taken into account. Incentives for choosing lower CO2 emission cars in the form of compensation for the purchase of low-emission cars only started in 2019.

In 2018, 28% of the Lithuanian population believes their homes are under-heated, which means that energy poverty reached 28%. Lithuania is one of the most affected by energy poverty countries in the EU.

Over the last ten years, Lithuania has radically restructured its energy sector in order to reduce its energy dependence on Russia. This resulted in unreasonably high resource prices and the use of energy as a political lever. The implementation of the National Energy Independence Strategy (NEIS) increased energy supply's diversity and reduced the energy cost to consumers.

In 2018, the share of RES in total final energy consumption was 24.21% (including the statistical transfer of energy to Luxembourg). The share of RES in the heat sector was 46.50%, the share of RES in electricity production was 18.41% and in transport 4.33%.

Lithuania reached and exceeded the 2020 EU RES target of 23% as early as 2014 (RES share was 23.66% of the gross final consumption of energy). Thus, in October 2017 Lithuania transferred part of the generated surplus to Luxembourg and became the first EU country to sign a cooperation agreement on the transfer of statistical quotas for renewable energy sources.

In terms of energy efficiency, Lithuania's energy productivity indicator has been improving (overall energy efficiency indicator). In 2017, Lithuania had the best performance among the Baltic countries, reaching EUR 4.8/kgoe (EU average energy productivity stood at EUR 8.3/kgoe).

Fuel and energy consumption in the transport sector increased by 42.4% between 2010 and 2018. Diesel consumption increased by 11% between 2010 and 2018 and it accounts for 74% of the fuel consumption in the transport sector. Diesel vehicles dominate public transport fleets and freight transport. 90% of the total fuel consumption in the transport sector comes from the road transport.

The increased energy consumption in transport resulted in a decrease of the share of RES in the sector. It fell from 4.6% in 2015 to 3.7% in 2017. The RES in transport consist mainly of biofuels and only a small part comes from electricity consumed in railways and trolleybuses.

Energy and energy resources constitute a significant share of industrial costs and household budgets in Lithuania. In industry, the cost of energy is 20% higher than the EU average. A better import-export balance of energy resources and technologies will increase the competitiveness of Lithuania's economy.

The increase of national GDP and the reduction of GHG emissions resulted in the growth of the economy. The GDP increased by 36% and the GHG emissions from all sectors decreased by 9.8% between 2005 and 2017.

Since 1990, there was a transformation of the country's economic activity. The industrial sector was contracted, the services sector was developed, there were changes in the used energy resources, etc. This transformation, along with the measures taken to reduce GHG emissions, resulted in the change of the structure of GHG emissions.

Funds for energy and climate projects and measure implementation come from national and local budgets. EU funds (EU Structural and Investment Funds, Connecting Europe Facility, etc.) and funds from the National Climate Change Programme constitute a significant share of energy and climate investment. Revenues from the statistical transfer of RES to Luxembourg are invested in RES research and development.

The European Commission's report on Lithuania's National Plan from February 2019 recommended that Lithuania focuses on innovation, energy and resource efficiency, sustainable transport and energy interconnections in 2019 and 2020.

Future Targets and Objectives Lithuania

In terms of **decarbonisation**, Lithuania has a target of reducing GHG emissions from all sectors of its economy by at least 40% by 2030, compared to 1990. The ambitious long-term goal is to neutralize the impact of GHG by 2050.

In the EU ETS sectors, emissions must be decreased by 43% compared to the 2005 levels. Non-ETS sectors have an objective of achieving at least a 9% reduction in 2030 compared to 2005.

At least 0.9% of Lithuania's GDP has to be allocated to the implementation of short-term climate change mitigation targets in 2030. The share of the population contributing to environmental protection is set to be at least 50% in 2030.

In the waste sector, the GHG emissions have to be reduced by at least 40% compared to 2005. In the sector of non-centralised energy production and use, the GHG emission decrease is set to be at least 15% compared to 2005. For other sectors, the GHG reduction target is 9%. Transport and industry will have the most difficulties in meeting the GHG removals objectives since they have to decrease their GHG emissions by more than a third.

In regard of renewable energy targets, the share of RES in gross final consumption of energy to be achieved by 2030 is 45%. The objective for 2030 in the electricity sector is to increase the share of RES in gross final electricity consumption to 45%. Wind energy will account for 70%, solar energy will constitute 3%, biofuels 9%, hydropower 8% and biogas 2%. In the transport sector, the goal is to achieve a 10% RES share by 2020 and a 15% share by 2030. The 2020 target will most likely not be achieved (RES share expected to be around 5%). As for the heating and cooling sector, the aim is to reach a 67.2% RES share, making the largest contribution to gross energy consumption.

In terms of **energy efficiency**, the targets are to reduce primary and final energy intensity 1.5 times by 2030, compared to 2017, and to reduce primary and final energy intensity 2.4 times by 2050, compared to 2017. In order to achieve these goals, Lithuania will: promote integrated renovation of multi-apartment and public buildings, rapidly develop energy-efficient industries, increase energy efficiency in the transport sector (renovation of vehicle fleet, modernization of public transport, etc.).

Regarding the **energy security** dimension, the main priorities are energy independence, competitiveness and sustainable development. Lithuania is connected to the Russian energy system. After the closure of Unit 2 of Ignalina Nuclear Power Plant, Lithuania's dependence on a single external energy supplier has been reinforced. Thus, the main goal is to interconnect the Lithuanian and EU energy systems.

In terms of electricity security, the Lithuanian-Latvian-Estonian-Belarussian electricity systems are currently part of the IPS/UPS system operated by the Russian electricity operator. The Synchronization Project has for objective to synchronize the Baltic States' electricity systems with the continental European network. The future targets in the electricity sector are the following: electricity generation in Lithuania will account for 35% of total final electricity consumption in 2020 (65% will be imported), 70% in 2030 (30% imported) and 100% in 2050.

In terms of natural gas security, all natural gas consumed in Lithuania is imported since the country does not have its own natural gas resources. Sources of gas supply have diversified thanks to the construction of the Klaipėda Liquefied Natural Gas (LNG) terminal in 2014, which insures the import of 50% of the natural gas consumed in Lithuania each year. The main objective in the gas sector is to complete the Gas Interconnection Poland-Lithuania (GIPL) project, which will enable Lithuania, Latvia, Estonia and Finland with the gas networks of continental Europe.

Concerning the **internal energy market** dimension, the main goals are broken down into the following categories:

Electricity interconnectivity:

The EU objectives are that the nominal interconnection capacity of the lines are 30% at peak load, and the nominal interconnection capacity of the lines are at least 30% of the installed renewable energy capacity. These two targets are achieved in Lithuania (more than 60% for the two indicators).

It is important that the average final electricity price for business and industrial consumers is lower compared to other Scandinavian, central and eastern European countries, in order to insure the competitiveness of the Lithuanian economy and to attract foreign investment. In 2017, Lithuania had the 9th position in this ranking. The target is to reach the top three positions.

Market integration:

The national targets for the development of electricity markets for the period 2021-2030 are to:

Adapt the electricity system to variable and distributed generation from RES

Establish an electricity market that rewards flexibility and innovation

Set measures that encourage investment in the development of secure and competitive local energy production

Promote competitive price formation by letting consumers choose dynamic price agreements

Coordinate national energy policies with neighboring EU countries and integrate balancing markets and cross-border energy trading

Promote fair competition and easy access for energy suppliers

Energy poverty:

The share of population unable to keep their home adequately warm was 28% in 2018 (while the EU average was 7.4%). The target is to reduce this value to 17% in 2030.

The share of households spending a large share of their income on energy was 17.1% in 2016. The goal is to reduce it to 10% in 2030.

Summary of the future targets and objectives of Lithuania (Per Dimension)

Decarbonization
• Reduction of GHG emissions in all sectors • Use of a part of the GDP to implement short-term climate change mitigation targets in 2030 • Increase in the share of RES in gross final energy consumption (wind, solar, biofuels, hydropower) • Increase in the share of RES in transport (biofuels) • Increase in the share of RES in heating and cooling (solar energy, heat pumps, biofuel boilers)

Energy Efficiency
• Renovation of multi-apartment and public buildings • Development of energy-efficient industries • Increase in energy efficiency in transport (renovation of vehicle fleet, modernization of public transport, electrification and optimization of transport, use of alternative fuels)
Energy Security
• Prioritization of energy independence, competitiveness and sustainable development • Decrease in the dependence to Russian energy system • Interconnection of the Lithuanian electricity system to the EU system (Synchronization Project) • Increase in the electricity generated in Lithuania and decrease in the imported electricity • Completion of the Gas Interconnection Poland-Lithuania
Internal Energy Market
• Reduction of the average final electricity price for business and industrial consumers • Development of electricity markets (adaptation of the electricity system to variable generation from RES, stimulation of flexibility and innovation, investment in secure and competitive local energy production, competitive price formation, integration of balancing markets and cross-border energy trading, fair competition and easy access for energy suppliers) • Reduction of the energy poverty among the population
Research, innovation and competitiveness
• Evolve from a country importing energy technologies to a country creating and exporting energy technologies • Become a centre of research and innovation developing RES technologies, information technologies and energy markets

Concerning the **Research, innovation and competitiveness** dimension, the main objective for Lithuania is to evolve from a country importing energy technologies to a country creating and exporting energy technologies. Lithuania aims at becoming a center of information technology and cybersecurity solutions for energy, solar and wind energy technologies, biomass and biofuel technologies, geothermal technologies, energy market development and creation of new electricity system management approaches. Synergies between scientific and academic institutions, energy companies and engineering industry companies will be enhanced by promoting different forms of cooperation.

In terms of **decarbonization**, research and innovation are focused on the development and network integration of new technologies for low greenhouse gas and ambient air emissions. The development of power generation technologies from renewable energy sources will also be a priority. In this context, the possibilities for offshore wind energy production will be explored, production of solar technologies will be encouraged by establishing Lithuania as the largest exporter of solar technologies in the Baltic region. The use of biomass and the recycling of waste for energy recovery will be increased. The modernization of 9 biomass power plants will take place. Lithuania will also focus on research on the use of hydrogen in energy, industry and transport.

The introduction of clean environmentally friendly transport technologies is expected to reduce the negative impact of the transport sector on climate and nature (air pollution, noise). Thus, research and development of intelligent transport systems will be encouraged. Developing the market for advanced biofuels, electrifying the transport and integrating the use of biomethane gas in the transport sector are all part of the R&I objectives for the decarbonization of transport.

As for the **energy efficiency** dimension, the priority areas of research and innovation are the following:

Modernization of existing energy production technologies

Development of technologies for distributed energy production, smart grids, and production and use of new viable forms of energy

Development and application of digital energy innovation

Development of alternative fuels and energy-savings technologies (it will increase energy efficiency in end-use and will boost Lithuania's competitiveness in clean energy technologies)

Development of new production processes, materials and technologies: energy efficiency, safety, durability and other requirements for materials are constantly increasing the R&I activities, resulting in important international competitiveness

Renovation of inefficient residential and public buildings

Increase in the energy performance of buildings and businesses

Conversion of all public and private residential and non-residential buildings to near zero-energy buildings by 2050

Development of new technologies for the heating and cooling sector (heat pumps, modern biofuel boilers, high-efficiency cogeneration plants)

Regarding the **energy security** dimension, research and innovation are focused on ensuring security and quality of electricity supply, vulnerability of electricity systems and optimization of operating modes. Other important aims are energy and cyber security, reliability of energy equipment and systems, and resistance to cyber-attacks. The development of electricity storage technologies will be encouraged by attracting investment for their production in Lithuania. A capacity mechanism is currently being developed in order to ensure the adequacy of the Lithuanian electricity system and to reduce the likelihood of loss of load. This capacity mechanism will ensure reliable operation and high level of security of electricity supply after 2025. As for gas supply security, the development of liquefied natural gas technologies will be encouraged.

In terms of the **internal energy market** dimension, main priorities of research and innovation are the functioning of electricity markets and power mechanisms, and the involvement of consumers in the electricity system and markets. Another priority area is the improvement of electrical system management. Lithuania has to ensure optimal energy pricing and promote liquidity in the energy trade market.

• Development and network integration of new technologies for low GHG emissions • Offshore wind energy production • Development of solar technologies production • Increase in biomass use • Development of the use of hydrogen in energy, industry and transport • Intelligent transport systems • Increase in RES in transport (advanced biofuels, biomethane)
Energy Efficiency
• Modernization of existing energy production technologies • Development of smart grids, production and use of new viable forms of energy • Development of new production processes, materials and technologies • Renovation of residential and public buildings • Increase in energy performance of buildings and businesses • Development of new technologies for the heating and cooling sector
Energy Security
• Security and quality of the electricity supply, optimization of operating modes • Energy and cyber security, reliability of energy equipment, and resistance to cyber-attacks • Development of electricity storage technologies • Development of a capacity mechanism ensuring the adequacy of the electricity system • Development of liquefied natural gas technologies
Internal Energy Market
• Functioning of electricity markets and power mechanisms • Involvement of consumers in the electricity system and markets • Improvement of electrical system management • Optimal energy pricing and promotion of liquidity in the energy trade market

Regulatory/ legislation steps contributing to the realization of the NECP priorities Lithuania

The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities, are summarized as follows:

- Achieve climate neutral economy and ensure the resilience of the sectors to the environmental changes brought by climate change
- Develop a competitive low-carbon economy through sustainable financing and investment
- Overcome energy poverty and create new green jobs
- Increase the use of RES in all economy sectors
- Increase diversification of energy sources and import routes
- Promote innovation in the energy sector
- Increase the number of RES installations owned by private consumers and communities
- Reduce energy cost and increase the competitiveness of Lithuanian business
- Improve conditions for energy supply by integration into the EU's internal energy market

8.1.10 **Malta**

Current Situation Malta

Regarding the dimension of **decarbonization**, Malta's GHG emission trends, in terms of the overall profile of total national emissions (ETS and non-ETS) spanning the period 1990 - 2017 show an increase in total emissions up until 2012, followed by a rapid decrease over a period of just four years, with emissions in 2017 being even lower than the emissions in 1990. The peak of GHG emissions was recorded in 2012, where such emissions were 51% higher than in 1990. In contrast, the lowest level of emissions was recorded in 2016, where in total national GHG emissions were around 10% lower than in 1990. The 2017 total national emissions are almost 41% lower than 2012 emissions. The drop in the total amount of emissions registered from 2012 and onwards is related to the energy sector, with the onset of the electricity interconnection with Sicily and the subsequent shift from heavy fuel oil to natural gas in local power generation.

As of 2017, the share of renewable energy in relation to gross final energy consumption is estimated to have reached 7.3%, increasing from 6.4% reached in the previous year. Since 2010, there is a continuous increase in the share of renewable energy in total gross energy consumption at an average 32% per year. The highest relative share of renewable energy was achieved in the heating and cooling sector.

The largest contribution of renewable energy is provided by solar PVs, contributing to around 36% of renewable energy in 2017, followed by heat pumps with 25%, the use of biofuels in the transport sector at 19% and solar water heaters, contributing with 13%. While there has been a continued increase in the use of heat pumps for heating and cooling, and biofuels used in the transport sector, the installation of new solar water heaters in recent years has slowed down. Other sources of RES include electricity and heat produced by waste-to-energy plants, biomass imports and the electricity consumed by electric and plug-in-hybrid electric vehicles.

In the terms of the **energy efficiency dimension**, the residential and services sectors make up 87% of the total estimated heating and cooling demand. Local climatic conditions impose a much higher summer cooling demand than the winter heating requirements. Since Malta has no public district heating and cooling network, the main solution, in order to tackle the cooling demand, is through air-to-air heat pumps, widely used in both households and commercial buildings. These heat pumps are also being used in reverse mode for spatial heating purposes.

The main consumer of fuel-based spatial heating technologies is the hotel sector. In an effort to incentivise the uptake of highly efficient CHP units, the Maltese government released a scheme whereby enterprises are eligible for aid through tax credits. However, to date the uptake is not positive, mainly due to spatial requirements for on-site fuel storage (mainly LPG) and applicable international standards.

The diversification of energy sources and suppliers achieved over the last years constitutes an important milestone for Malta, in the **dimension of energy security**. As a country lacking indigenous energy sources aside from renewable energy, in 2015 the Maltese national grid was connected to the European energy network through a 200MW Malta-Italy HVAC cable; this was an important milestone which ended Malta's isolation from the European electricity network, and provided increased security of supply and flexibility of electricity services.

The high dependency on oil and petroleum products decreased from 79% in 2016 to 55% in 2017, whereby the share of natural gas now amounts to 31% of the energy mix. The share of renewable energy is also increasing on an annual basis. The share of electricity imported over the interconnector in the energy mix in 2017 was 9%. In 2017, net import dependency in Malta reached 95.8% as all energy sources, apart from renewables imported.

In terms of the **Internal Energy market dimension**, at the end of 2017, Malta had an interconnection level of 31%, well above the 2030 interconnection target of 15%. Import interconnection capacity amounted to 200MW, while Malta's net nominal generation capacity in 2017 was 650MW. Malta aligned its methodology for the calculation of the current interconnection level with the European

Commission's approach, as included in the country factsheets of the Third State of the Energy Union report, through which, the interconnection level is calculated as a ratio between import interconnection capacity and net installed generation capacity.

Malta's electricity interconnection level is well above the 15% EU interconnection target for 2030 required by the Governance regulation. Currently, there are no plans for a second interconnector, although this is subject to the outcome of the in-depth study on power generation covering the period 2019-2040 commissioned by the Government. However, a Malta-Sicily gas pipeline project is planned for the years to come, in order to provide access on the European gas grid, making it possible for Malta to replace the LNG supply, that is currently present in the energy market.

Malta is considered as a Moderate Innovator and has shown a performance increase over the years, despite the underemphasis shown towards the **dimension of Research, Innovation and Competitiveness**. This is made clear by the fact that the public R&I funding is at the 0.01% of the GDP in 2016, when the funding of both private and education sectors is at 0.35% and 0.21% respectively. However, Malta has an Innovation-friendly environment and strong employment impacts with respect to knowledge-intensive activities and fast-growing enterprises. This has resulted in Malta ranking as the highest EU Member State when it comes to intellectual assets, with special focus on trademark and design applications.

Malta shows the largest share of investment associated mostly with the Demand side Managememt technologies (mainly through the deployment of smart meters and the adoption of a tariff system that promotes the prudent use of energy) and the integration of DG and Storage, aiming to secure the stability of the network.

Also, emphasis is put on Smart Network Management technologies, focusing on increasing the observability and controllability of the distribution network.

Future Targets and Objectives Malta

Towards the **decarbonization dimension**, Malta reaffirmed its commitment to address climate issues to their fullest potential and to contribute towards the European Union's collective target of 40% reduction of its GHG emissions by 2030 compared to 1990 levels, through the ratification of the Paris Agreement. Furthermore, Malta's Sustainable Development Vision for 2050 sets out aspirations and priorities towards a low-carbon economy, sustainable mobility, transition towards low-carbon energy and sustainable buildings and urban development, amongst others. It also sets a precedence for mainstreaming sustainable development up till the year 2050 and is set to become Malta's main guiding principle for developing policies when planning and implementing projects.

Malta has initiated the process of developing **a national Low Carbon Development Strategy** in accordance with requirements under the UNFCCC, European Union legislation, the Climate Action Act 2015 (CAP543), and in line with the decarbonisation ambitions of the Energy Union. In relation to this, the Maltese Government published a Vision Document, in 2017, highlighting its aspirations for socio-economic development in a low-carbon and climate resilient manner. As such the Maltese Government is committed to:

- Uphold national GHG emission reduction commitments in the EU up to 2020;
- Move towards a reduction of national GHG emissions as opposed to pursing a continued limited increase in emission level post-2020;
- Progress in reducing national GHG emissions post-2030 in full cognisance of Malta's economic development and priorities of the time;

- Set sector-specific GHG emission reduction targets post-2020 to contribute to meeting reduction commitments made at the national level; and
- Identify and implement opportunities to enhance climate resilience in Malta.

Malta's potential for renewable energy deployment is mainly affected by physical and spatial limitations, technological advancement and resource potential, with resource availability and cost of land being the predominant barriers for further deployment. Solar energy is, so far, the predominant viable renewable energy source in Malta, and this led to efforts aimed at increasing the local RES-share to focus on the deployment of photovoltaic systems.

On the **energy efficiency dimension**, Malta remains commited to develop a long-term renovation strategy to support **the renovation of the national stock of residential and non-residential buildings**, both public and private, in accordance with Article 2a of Directive 2010/31/EU. Malta does not have other national objectives in areas such as energy efficiency in transport and heating & cooling.

Regarding the **Energy Security dimension**, Malta's National Energy Policy (2012) underlined the Government's commitment to the diversification of energy sources and contingency planning in the case of supply disruption, in order to achieve greater security of supply. The emphasis on diversification seeks to ensure diversification in terms of energy sources, procurement sources, exporting country and supplier.

Natural gas, which is used as fuel in the power generation sector is currently imported in the form of LNG. There are currently no gas pipeline interconnections, however a Final Investment Decision on the **construction of the Melita Trans Gas Pipeline project (MTGP) between Malta and Sicily** is expected to be taken by 2020 subject to financing. LNG is imported via marine carriers and held in a Floating Storage Unit (FSU) supplying LNG to a regasification plant and to Delimara 3 and Delimara 4 power plants. LNG is procured on the international market, which provides flexibility in terms of sources of origin. In 2017 and 2018 LNG was delivered from 8 different countries of origin.

A physical connection to the European gas network would result in a more reliable, secure and energy efficient form of transport of natural gas as it will replace the LNG supply chain, which has both a limit in its technical capacity and its susceptibility to adverse weather conditions.

Malta's high-level objectives in the area of energy security as set out in the NECP can be summarized into the following:

- Continued diversification of energy sources and suppliers;
- Reduction of import dependency through the deployment of indigenous sources of renewable energy whilst taking into account the specificities of Malta's energy system;
- Increasing the flexibility of the national energy system, including through the roll-out of cost-effective, innovative solutions such as storage;
- Periodic contingency planning in the case of supply disruption for the electricity, gas and oil sectors;
- Energy security in the context of the long-term objective of decarbonisation of the energy system and increased deployment of RES

In the dimension of **Internal Energy market**, Malta's electricity interconnectivity level is projected to be at 24% by 2030, remaining well above the EU 15% interconnectivity target. The Government is currently undertaking an assessment to determine which infrastructure requirements are required in the mid-term (until 2035) to ensure the desired level of generation adequacy is maintained. In the area of electricity interconnectivity, Malta's objective until 2030 in the area of interconnectivity is therefore to remain above the 15% EU target.

In line with its programme to ensure an efficient distribution system, Enemalta has equipped 99.6% of its consumers with **smart meters and has adopted a tariff system** that favors the prudent use of energy. The expected increased share of renewable self-consumption by consumers with an installed PV system would provide additional benefits in the form of reduced stress on the electricity grid, in particular during peak hours in the summer months. Additionally, a second generation of smart meters are being installed which will allow the consumer to be more aware of his energy consumption. This will be done through the consumer energy management system where in-house display systems, smart phones and other devices will provide the consumer with real-time information on their consumption. Through this readily accessible information, the consumer has the opportunity to better understand his consumption patterns, resulting in increased energy conservation.

Summary of the future targets and objectives of Malta (Per Dimension)

Decarbonization
• Increase in RES power generation (Photovoltaics) • Development of a holistic strategy to promote the importance of the Internal Combustion Engine (ICE) passenger vehicles transition • Energy Efficiency • Development and deployment of strategies for the renovation of the national residential building stock • Development and deployment of strategies for the renovation of the national non-residential building stock
Energy Security
• Construction and delivery of the Melita Trans Gas Pipeline project (MGTP) between Malta and Sicily, resulting in a more reliable, secure and energy efficient form of transport of natural gas, in order to replace the LNG supply chain • Launch of new initiatives tailored to local specificities, to ensure the exploitation of the most technically and economically viable indigenous sources of renewable energy (Solar PV, Wind Energy, Hydro Energy)
Internal Energy Market
• Deployment of the second generation of smart meters, to ensure energy conservation • Development of incentive-based strategies, promoting renewable self-consumption by consumers with the adoption of a tariff system that favors the prudent use of energy
Research, innovation and competitiveness
• Strengthen and increase coordination and cooperation on R&I projects between the public sector, research institutions and business enterprises • Development of the RINEW (Research and Innovation in Energy and Water) national strategy, prioritizing the support of research activities from domestic business enterprises.

On the **Research, innovation and competitiveness dimension**, Malta will seek to support and bolster R&I initiatives relating to the dimensions of Energy Union, specifically those which address national policy priorities and challenges, and those which contribute to national competitiveness and economic growth. The Draft National Strategy for R&I in Energy and Water 2021-2030 aims to strengthen and increase coordination and cooperation on R&I projects between the public sector, research institutions and business enterprises.

The high-level objectives under the dimension of Research, innovation and competitiveness dimension, are presented as follows:

- renewable solutions for islands
- integration of RES electricity
- energy efficient solutions for industry and services

In support of **decarbonisation** through cleaner power generation, the main priority of the Research and Innovation System in Malta is to focus on RES innovative technologies and energy efficiency projects mainly by further exploiting solar energy (photovoltaic and solar water heaters), heat pumps, biofuels, and energy recovery from waste.

During the past years Malta has embarked upon a wholesome reform of the energy sector. This has resulted in improved policy making, more focused economic and environmental regulation as well as a reformed operational landscape. Substantial progress has been made in recent years in **diversifying the energy mix**. Significant efforts have been targeted at upgrading the energy infrastructure, including switching **electricity production from oil to natural gas**. Important measures in this area include the **gasification of the Maltese power plants** and the **completion of the electricity interconnector with Italy**. The Maltese Government also introduced several programmes to incentivise **energy performance improvements in buildings, through grant schemes or soft loans for energy saving solutions**. These solutions include **energy efficient appliances**, **energy-saving lighting systems**, **thermal insulation**, **double-glazing**, **solar heating**, **photovoltaic panels**, **solar water heaters** and **wind energy resources**.

In terms of **Energy Security**, the development of the **energy storage market** is considered essential for further deployment of photovoltaic capacity and for optimization of the power system by providing for demand management and peak demand shaving. Cost-effective, technically viable options to increase the flexibility of Malta's power system are being assessed, whilst ensuring the desired level of security of supply and further integration of low carbon technologies.

The **deployment of new smart meters** and replacement of old inefficient smart meters will continue post-2020 in line with the requirements of Articles 19 and 20 of Directive (EU) 2019/944 on common rules for the **internal market** for electricity. Smart metering systems will have to comply with the minimum functional and technical requirements and provide final customers with information on actual time of use and real-time consumption data in order to support energy efficiency programmes as well as demand response.

Decarbonization
• Wind energy resources utilization • Solar Energy exploitation (PV panels, solar water heaters)
Energy Efficiency
• Thermal insulation building systems • Deployment of energy-saving lighting systems • Deployment of energy efficient appliances • Double-glazing utilization (Double Glazed Windows) • Deployment of heat pumps

Energy Security
• Development of energy storage market, leading to increased photovoltaic capacity and optimization of the power system
Internal Energy Market
• Load profile management through demand response

Regulatory/ legislation steps contributing to the realization of the NECP priorities Malta

The most indicative regulatory/ legislation steps that Malta should undertake, in order to fulfill and accomplish the NECP priorities, are summarized as follows:

- Deployment of sets of measures for the exploitation of all indigenous RES sources
- Extension of the current policy framework in the area of RES, providing new initiatives tailored to local specificities
- Enhancement of funding schemes for R&I projects
- Encouragement of public-private partnerships in energy R&I

8.1.11 Poland

Current Situation Poland

The Polish energy system is one of the largest within the European Union. It places in the top ten in terms of key macro-energy indicators. Responding to this is the potential of the Polish economy, which ranks seventh in the European Union GDP (in 2018 - EUR 496.4 billion in current prices), sixth in number population (37.9 million). In the category of gross primary and final energy consumption in 2018. Poland ranks sixth in the EU. Total global energy consumption in 2018 was 4,490.7 PJ. Direct energy consumption in 2018 was 3551.8 PJ. The industry has the largest share in direct energy consumption (34.5%). The second sector in terms of the volume of consumption was the transport sector, its share has been systematically increasing in recent years and in the 2018 was 27%. Households consumed 23% of energy in 2018, agriculture 4.6%, and the rest recipients 9%

Primary and final energy intensity of GDP decreased in 2017 compared to 1990 by 61.5% and 57.3%, respectively. The decrease in energy intensity in Poland is systematic, with periods in which it occurred a slight increase in energy intensity in 2010, 2016 and 2017. Decreasing energy intensity, primary and final is a result of implementing energy efficiency measures, increasing efficiency of industrial processes and faster GDP growth than the rate of energy consumption.

Changes in the national power sector result in an increase in the share of renewable energy sources in the capacity structure installed in the KSE and in the production of electricity. In 2018, the share of renewable energy in energy production electricity amounted to 12.7%. Over the years 2010-2018, there was a 4 times increase in RES installed capacity and double electricity production from these sources. The share of these sources in gross final energy consumption amounted to around 11% in 2018, with the national target for 2020 being 15%.

Due to the large share of domestic energy resources in the national balance sheet Poland is one of the most energy-independent EU countries. The Indicator for energy dependence in 2017 for Poland was 38%, with the EU average 55%.

The data show that despite of the continuing upward trend in electricity production in Poland, starting from 2011, this does not correspond to an increase in CO_2 emissions from this sector. On the contrary, emissions from the abovementioned sector were reduced by approx. 7% in the years 2011-

2018.

Future Targets and Objectives Poland

Decarbonization

In the dimension of decarbonisation, there are issues related to both the emission and absorption of greenhouse gases and air pollution, as well as concerning the use of renewable energy sources. The issue of adaptation to climate change has also been taken into account.

The reduction target for Poland in terms of greenhouse gas emissions in sectors not covered by the ETS system was set at -7% in 2030 compared to the level in 2005. The stated target is to be achieved by reducing emissions in transport, construction and agriculture, taking into account the beneficial effects of CO2 absorption by ecosystems and the flexibility associated with land use, land use change and forestry (LULUCF). In this aspect, it is also important to improve the quality of life of the inhabitants of Poland, especially to protect their health and living conditions, including environmental protection. This applies in particular to solve the problem of air quality associated with emissions of pollutants in transport and by individual heat sources.

As part of the EU-wide 2030 target, Poland declares to achieve 21-23% of RES share in gross final energy consumption by 2030 (total consumption in electricity, heating and cooling as well as for transport purposes). It is estimated that in the perspective of 2030 the share of renewable energy sources in heating and cooling will increase by an average of 1.1 percentage point per year. In transport, a 14% share of renewable energy is expected to be achieved by 2030. The RES share in electricity production will increase to approx. 32% in 2030. To enable the achievement of the above-mentioned targets, it is planned to support renewable energy sources in the form of continuation of existing and creation of new support and promotion mechanisms. It is also planned to increase the use of advanced biofuels, introduce offshore wind energy and increase the dynamics of development of renewable energy micro installations.

Energy efficiency

The national target for improving energy efficiency by 2030 was set at the level of 23% reduction of primary energy consumption comparing to the PRIMES 2007 forecast. Actions aimed at reducing energy consumption are treated in a special way, as they simultaneously lead to strengthening energy safety, sustainable usage of energy resources and further reduction of emissions, affecting the achievement of energy and climate goals. In this context, the development of ecological and effective heating systems, the production of heat in cogeneration, intelligent networks and the functioning of mechanisms that stimulate the saving of energy end-use and pro-saving behaviour are particularly important. Both in terms of energy efficiency and the improvement of housing conditions, it is important to develop a long-term strategy for the renovation of domestic stocks of residential and non-residential buildings, public and private, in accordance with the amended Directive 2010/31/EU. Actions are also planned to increase energy efficiency in transport by promoting more sustainable methods of transporting goods (e.g. intermodal transport, rail transport) and societies (e.g. public transport). The document provides for increasing energy efficiency through a creation of a coherent, sustainable, innovative and user-friendly transport system at national, European and global level.

Market integration and competitive energy markets

As part of the development of the internal energy market, Poland will strive to increase the availability and capacity of current cross-border interconnections and to integrate the national natural gas transmission system with the systems of Central and Eastern Europe and the countries of the Baltic Sea region. In this context, 4 further investments in internal gas and electricity networks that will ensure security of energy supply will also be necessary. With regard to the production of energy from renewable sources, measures will be taken to guarantee an appropriate level of flexibility of the energy system.

To enable the development of a competitive market, the objective is to increase consumers' knowledge and to encourage them to play a more active role in the energy market, while limiting the energy poverty, taking into account the protection of vulnerable social groups.

Research, innovation and competitiveness

Research, implementation of innovations and activities related to the development of competitiveness of the economy will be of significant importance for realization of the objectives and policies mapped in the NECP PL. This dimension is particularly interwoven with other pillars of energy union, providing new technologies and solutions supporting energy transformation. The main objective of this dimension is to reduce the civilization gap between Poland and economically highly developed countries, and to improve the quality of life of Polish society. Poland also plans to increase the competitiveness of the economy through a more complete use of social and territorial resources as well as automation, robotization and digitization of enterprises. By supporting the development of energy innovations, it is planned to increase the competitiveness of the Polish energy sector, and thus maximize the benefits for the Polish economy. Another goal is the acceleration of technology sales by Polish companies on foreign markets, combined with the growing importance and competitiveness of Polish science on the international stage. The foundation for the realization of the objectives in this area are: an increase in expenditure on research and development in Poland (from 0.75% of GDP in 2011 to 2.5% of GDP in 2030) and the establishment of new, better suited to today's conditions, rules for using this inputs.

Electricity interconnectivity

Concerning the interconnectivity the target of Poland is increasing the availability of current cross-border interconnections and cross-border capacity by:

- changing the principles of providing access to transmission capacities
- between EU Member States,
- constructing missing lines within national systems,
- optimizing the methods of providing market participants with access to those capacities (the introduction of the FBA),
- installing phase shifters or other devices optimizing transmission where necessary.

Energy transmission infrastructure

The key national objectives concerning electricity transmission infrastructure are as follows:

- to safeguard the security of electricity supplies – understood as the capacity of the electricity system to ensure the security of operation of the electricity grid and to balance electricity supply with demand;
- to ensure the long-term capacity of the electricity system with a view to meeting reasonable transmission needs relating to domestic and cross-border trading in electricity, including the needs relating to the expansion of the transmission network, and, where appropriate, the expansion of interconnections with other electricity grids.
- Construction, expansion and modernization of an internal gas transmission network

Digitization of the energy system

An important energy efficiency and digitalization project for the next years in Poland is the program of building a smart electricity grid. It encompasses works on organizational and legal solutions which will enable the application of new technologies such as the introduction of smart metering. Only then it will be possible to implement electricity demand management mechanisms and, as a result, to use electricity in a more sustainable manner. This will be possible by making up for the gap in knowledge about measures and preferences that exists between energy consumers and its producers and suppliers.

Summary of the future targets and objectives of Poland (Per Dimension)

Decarbonization
• Greenhouse gas emissions in sectors not covered by the ETS system was set at -7% in 2030 compared to the level in 2005 • Solve the problem of air quality associated with emissions of pollutants in transport and by individual heat sources • Poland declares to achieve 21-23% of RES share in gross final energy consumption by 2030 (total consumption in electricity, heating and cooling as well as for transport purposes). • The share of renewable energy sources in heating and cooling will increase by an average of 1.1 percentage point per year. • A 14% share of renewable energy is expected to be achieved by 2030 • The RES share in electricity production will increase to approx. 32% in 2030 • Increase the use of advanced biofuels, introduce offshore wind energy and increase the dynamics of development of renewable energy micro installations • It is planned to support renewable energy sources in the form of continuation of existing and creation of new support and promotion mechanisms
Energy Efficiency
• The national target for improving energy efficiency by 2030 was set at the level of 23% reduction of primary energy consumption comparing to the PRIMES 2007 forecast • The development of ecological and effective heating systems, the production of heat in cogeneration, intelligent networks and the functioning of mechanisms that stimulate the saving of energy end use and pro-saving behavior • Development a long-term strategy for the renovation of domestic stocks of residential and non-residential buildings, public and private, in accordance with the amended Directive 2010/31/EU • Increase energy efficiency in transport by promoting more sustainable methods of transporting goods (e.g. intermodal transport, rail transport) and societies (e.g. public transport).
Energy Security

• Covering the growing demand for fuels and energy in connection with the forecasted economic growth, while ensuring uninterrupted energy supplies • Increase of diversification of the energy mix and diversification of directions of supplies of imported fuels • Increase of electricity generation capacity, especially based on RES • Coal generation will be important to guarantee stable and reliable electricity supply but the share of coal in electricity generation will be systematically reduced. In 2030 it will reach the level of 56-60%. • The implementation of nuclear energy in Poland is indicated in the national plan as important from the point of view of ensuring stable and zero-emission electricity supply, as well as diversifying energy sources. The commissioning of the first nuclear power unit (with a capacity of about 1-1.5 GW) of the first nuclear power plant is planned for 2033. In the next years, it is planned to launch another five such units every 2-3 years (with a total capacity of approx. 6-9 GW
Internal Energy Market
• Increase the availability and capacity of current cross-border interconnections and to integrate the national natural gas transmission system with the systems of Central and Eastern Europe and the countries of the Baltic Sea region. In this context, 4 further investments in internal gas and electricity networks that will ensure security of energy supply will also be necessary. • Measures will be taken to guarantee an appropriate level of flexibility of the energy system. • Increase consumers' knowledge and to encourage them to play a more active role in the energy market, while limiting the energy poverty, taking into account the protection of vulnerable social groups.
Research, innovation and competitiveness
• Increase the competitiveness of the economy through a more complete use of social and territorial resources as well as automation, robotization and digitization of enterprises. By supporting the development of energy innovations. • Increase the competitiveness of the Polish energy sector • The acceleration of technology sales by Polish companies on foreign markets, combined with the growing importance and competitiveness of Polish science on the international stage • An increase in expenditure on research and development in Poland (from 0.75% of GDP in 2011 to 2.5% of GDP in 2030) and the establishment of new, better suited to today's conditions, rules for using this inputs

National objectives and budgetary funding targets for research and innovation, including with regard to the Energy Union, are carried out within the framework of the state science, technology and innovation policy.

The main criteria applied in the NRP to choose strategic directions for research and development include the long-term needs of the economy, the high level of research in national centers – the competitiveness at the global level, the micro-, small- and medium-sized-scale development of business sectors based on new Polish technologies or the priority directions in research development defined in European research programs and strategies (e.g. the SET-Plan and Horizon 2020 which constitutes the main source of funding for the measures defined in the SET-Plan and the EU energy and climate policy).

Strategic directions for research and development work defined in the NRP are as follows:

1. New energy technologies,
2. Diseases of affluence, new medicines and regenerative medicine,
3. Advanced information, telecommunications and mechatronic technologies,
4. Modern materials technologies,
5. Natural environment, agriculture and forestry,
6. Social and economic development of Poland in the conditions of increasingly global markets,
7. State security and defense.

In the scope of **decarburization** the activities are in supporting the scientific research to decarbonize the energy sector with co-financing and providing incentives for private investment in new technologies and research and development in the field of high-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems; smart and energy-efficient building technologies and environment-friendly transport solutions

In the terms of **energy efficiency** the key priority steps are in the fields of developing of environment-friendly and efficient district heating systems and development of heat production in cogeneration processes.

Regarding the **energy security and the internal energy market dimensions** R&D activities will be concentrated on developing of resources for integrated and interconnected energy system assigning a central role to energy user, efficient and flexible energy generation and the use of raw materials combining the reduction of impact on the environment with energy security, diversification of energy generation and use technologies, implementation of competitive organizational and business models, green and energy-efficient city.

Decarbonisation
• Determination of the potential of forest areas for carbon dioxide sinking and the launching of research aimed at developing better methods of carbon dioxide balance calculation • Developing better methods of carbon dioxide balance calculation • Environment-friendly transport solutions • Minimization of waste generation, including waste unfit for processing, and the use of waste for materials production and energy generation purposes(recycling and other forms of recovery)
Energy Efficiency
• Smart and energy-efficient building technologies; • High-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems
Energy Security
• Efficient and flexible energy generation and the use of raw materials combining the • reduction of impact on the environment with energy security • Diversification of energy generation and use technologies,
Internal Energy Market
• Continuous enhancement of technological advancement and the quality of operation; • Implementation of competitive organizational and business models; • Optimization of capital use. • Support for building close relations between business entities and public institutions and the science sector.

Regulatory/ legislation steps contributing to the realization of the NECP priorities Poland

The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities, are summarized as follows:

- Meeting the non-ETS (ESR) 2030 reduction target.
- CO2 emission reduction in the energy sector
- Ensuring maximum availability (high efficiency and coefficient utilization, controllability, energy storage utilization), with relatively the lowest at the expense of producing energy
- Satisfying local energy needs (heat, electricity, transport), but also related to waste management (in accordance with the waste hierarchy) and using local potential.
- Increase the role of individual renewable energy technologies in the energy mix by source controllable and non-controllable (including solar, wind, biomass, bio-gas, geothermal and heat pumps)
- Transfer and implementation of joint renewable energy projects
- Support for the production of electricity and heat from renewable energy sources and biofuel production support
- Support for innovative solutions in the production of second generation bio-components
- and other renewable fuels
- Distributed energy development
- The development of stabilizing technologies (manufacturing and storage) non-controllable renewable energy sources
- Development of installations for generating heat from renewable energy sources
- Development of offshore wind energy
- Improving the service of electricity producers included in the auction
- Renewable energy support system

8.1.12 **Romania**

Current Situation Romania

National policies and action plans to reduce GHG emissions are a key element in limiting the effects of climate change on the environment, the economy and society. In order to support green growth for the reduction of carbon content, the EU has introduced ambitious climate and energy targets by 2030.

Decarbonisation and GHG

The absolutely figures show that Romania decrease the GHG (including international aviation, indirect Co2 and excluding LULUCF) from 248,9 million tons of CO2 equivalent to 151,7 million tons in 2005 and to 114,8 million tons in 2017. This figures shows the decrease of about 24% of the GHG in 2017 comparing to 2005 and approximately 2% decrease of GHG comparing to 2015.

Energy is the most important sector in Romania; in 2015, this sector had a share of approximately 81.59 % from total GHG emissions (without LULUCF), accounting for 80,098.16 Gg CO2 eq. Compared to the base year, GHG emissions in 2015 decreased by 63.07%. The main reason for this trend is the process of transition to a market economy that has led to a sudden decrease in the demand for electricity produced by power plants.

In 2015, the total GHG emissions related to the Energy Industries category had the highest share (37.11%), followed by Transport category (19.64%) and Manufacturing industries and construction category (15.55%). Also, CO2 emissions in the Energy sector accounted for 58.48% of total national GHG emissions (without LULUCF), CH4 emissions (calculated as CO2 eq) represent 9.88 % and

N2O (calculated as CO2 eq) represent 0.44%. Compared to 2014, in 2015 GHG emissions from the Energy sector increased by 0.33%.

Energy consumption

Comparing to 2005 the final energy consumption has less than 10% decrease in 2017 and has approximate stable average value of 22 Mtoe per year for the period between 2009 and 2016. In 2017 and 2018 there is a slight increase to the values of 23.5 Mtoe in 2018.

In 2015, Romania's gross inland consumption was of 32.4 Mtoe. The highest shares of primary products in the energy mix were taken by petroleum products (27.6%) and gas (27.1%), followed by renewables (18.1%), solid fuels (17.9%)and nuclear (9.1%). In comparison to the average energy mix in the EU, Romania's energy mix has a higher share of renewable energy (18.1% vs 13%) and natural gas (27.1% vs 22%) and a lower share of nuclear energy (9.1% vs 13.6%) and oil (27.6% vs 34.4%).

The share of RES in final energy consumption in 2017 is 24,47 distributed by sectors as follows: Transport (1,512%), Heating and Cooling(14,296%) and Electricity (9,008%).

Romania traditionally had the third lowest energy dependency rate in the EU, due to natural gas and oil reserves and to an oversized electricity production system. Romania's electricity mix is one of the most balanced in the European Union, with coal, hydropower, natural gas, nuclear energy and wind power having comparable shares of capacity and power generation. The yearly electricity production mix of Romania for 2018 consists Coal(23,1%), Gas & Fuel(16,9%), Wind (10,3%), Solar(2,9%), Nuclear(17,2%) and Hydro (29,1%).

Future Targets and Objectives Romania

The implementation of the EU ETS scheme and compliance with the annual emission targets for non-ETS sectors are the key commitments to achieving the targets. For the sectors that are included in the EU-ETS scheme, Romania's emissions reduction target is about 43% by 2030 compared to 2005. As a result of the proposed policies and measures, the GHG emissions from the in 2030 indicate a level of 39 mil. t. CO2 equivalent.

Considering that the overall share of renewable energy in gross final energy consumption of 24% for 2020 was exceeded (25% in 2016, according to Eurostat) and its evolution (estimated at 26.2% in 2020), the projections based on the assumptions used to implement this Plan, indicate a global share of renewable energy in the gross final energy consumption of 27.9% for 2030.

The gross final consumption of energy from renewable sources used in the H&C sector is projected to increase by 33% between 2021 and 2030, given the availability of biomass sources (mainly firewood and agricultural waste) in compliance with the sustainability criteria. Another alternative valid for 2030 could be the introduction of heat pumps to meet heating needs (in the context of decreasing costs of heat pumps by at least 25% in 2030 compared to today's values, without taking into account the measures of support at national and European level, which could lead to an even wider decrease of these costs.

Energy efficiency

Through the commitments in this area, Romania must contribute in reaching the target of the Union related to energy efficiency (a primary energy consumption of maximum 1,273 Mtoe or 956 Mtoe of final energy consumption respectively) 13. Therefore, the global target is at least 32.5% at EU level, an objective that can be revised upwards in 2023.

Taking into account the assumptions and projections considered in the calculations, that rely on increase of the industrial production and living standards, the primary energy consumption is estimated to reach 36.7 Mtoe in 2030, compared to a primary energy consumption of 30.3 Mtoe in 2020.

Reported to the forecast for the primary energy consumption for 2030, as calculated in PRIMES 2007 scenario for Romania, respectively 58.7 Mtep, the WPM scenario estimates a 37.5% decrease in 2030.

From this perspective, energy efficiency measures will lead to a decrease in primary energy intensity, from 195 toe / EUR'15 in 2015 to around 150 toe / EUR'15 in 2030. In this context, Romania could use the flexibility mechanism provided by the applicable legislation, to cover up to 35% of the annual amount needed for energy savings with increase of the access of the population to electrical energy, heat and natural gas and applying proper measures for energy efficiency in all sectors: industry, transport, buildings, etc.

Market integration and competitive energy markets

Electricity and natural gas prices are currently set in a competitive manner in the wholesale market of Romania. On the other hand, the regulator currently endorses the prices of last resort suppliers in relation to final customers (domestic and non-household) supplied in the framework of the universal service regime (representing approximately 7.5 million consumption places in Q2 2018), taking into account the wholesale purchase prices, as well as the operational costs of supply. The regulated tariffs for household gas consumers will be maintained according to current policies by July 2021.

On the other hand, the increase in the degree of flexibility is foreseen through the establishment of a short term (quarter, year) capacity market for power reserves, if possible, and if it is economically efficient. In the context of defining and implementing measures for the protection of vulnerable consumers, Romania will include in the relevant legal framework provisions guaranteeing the free formation of delivery prices, as a result of market mechanisms (centralized and transparent trading), while pursuing - through the instruments of regulators - to ensure an increased level of accessibility, correlated with household incomes (projected to sustainably increase by 2030 as a result of expected economic growth).

At regional level, a strategic action for Romania remains the integration into the single coupled markets for the day-ahead and intra-day markets (SDAC and SIDC) as a member state, which derives from the need to comply to European regulations.

One of the objectives will be to increase the marketable capacity of existing interconnections by aligning them to the European / regional targets, depending on the configuration of the regions / supply areas. Another priority objective of Romania should be the early implementation of the Balancing Regulation (including by aligning with the tendencies of unification of the system services markets by participating in pilot projects supported by ENTSO-E (PICASSO, MARI, TERRE, etc.)

Electricity interconnectivity

According to the analysis of the Romanian transport and system operator, Romania fulfills the peak load indicators (between 66% and 75% in terms of the ratio between current interconnection capacities and the peak load according to the forecasting scenario) and the installed power of production of renewable energy (indicator ranging from 30 to 44% depending on the RES scenario). 21 Government Decision 83/2012 on the adoption of safety measures on the electricity market Integrated National Energy and Climate Change Plan 2021-2030 Page 72 of 168 Romania intends to supplement its interconnection capacities by 2030, taking into account socio-economic and environmental cost-benefit analyzes, having the intent to implement projects where the potential benefits are higher than costs. At the same time, through the primary and secondary legislative framework, as well as the projects related to closing the 400kV national ring (internal lines), Romania will also create the conditions for maximizing the offered interconnection capacities.

Energy transmission infrastructure

The national transmission system is made of power lines and substations, most of which were built during the period 1960-1980, with a technological level corresponding to that period.

Due to the maintenance program performed and the implementation of new technology and modernization program, the installations were kept with a proper technical condition until present time.

Natural gas is transported through main pipelines, their total length totaling over 13,350 km (data for reference year 2017), as well as through their related installations, equipment and facilities, the natural gas supply connections having diameters from 50 mm to 1,200 mm at pressures from 6 bar to 63 bar, through which the natural gas extracted from the generation areas or from import is taken-over and transported for the purpose of supply to final customers on the natural gas internal market and external market.

The main aims for improving the transmission systems consists

- Completion of the projects for implementation of new technology and modernization of the installations and equipment that are in progress, but other new projects will be also initiated.
- Digitalization of the electricity network with utilization of smart metering and digital technologies
- Extension of storage capacities for natural gas transmission system
- Ensure the security of the natural gas supply;
- Increase the interconnection of the national network of natural gas transmission to the European network;
- Increase the flexibility of the national network of natural gas transmission;
- Liberalization of the natural gas market;
- Integration of the natural gas market at European Union level.

Digitization of the energy system

Digitization of the national energy system in the transmission, distribution and consumption segments: The digitalization of the Romanian energy system, including of transmission and distribution networks ("smart grids") plays an important role in increasing the energy production from renewable sources and in transforming the Romanian energy market in a "fit-for-RES" market and in increasing the RES integration.

Smart metering

The main objective of smart metering is to streamline meter reading, optimize operating costs, reduce technological losses, reduce interruptions and improve the fixing time in case of interruptions.

Smart grids

Smart grids allow bidirectional communications and real-time monitoring and coordinating systems that lead to a more efficient network operation (for example, for forecasting and identifying congestion, network flexibility) and ultimately a lower cost for distribution.

Smart grids and smart metering will allow by adopting the legalization to encourage domestic, industrial and agricultural prosumers build-up, along with the development of electrical grids and smart meters; to integrate of distributed production systems and prosumers into the power grid system:

Summary of the future targets and objectives of Romania (Per Dimension)

The Romania define 19 operational objectives (OP) related to the 5 dimensions of the in accordance with the Regulation on the Governance of the Energy Union. A summary of them is given in the table below.

Decarbonization
• (Op1) diversified and balanced energy mix • (op8) replace electricity production capacities to be decomissioned by 2030 with new, efficient and low emission capacities • (op12) economic investment policies to stimulate the development of the manufacturing industry, res equipment, energy efficiency and electromobility • (op14) support the sustainable development of the national energy sector, while protecting quality of air, water, soil and biodiversity
Energy Efficiency
• (OP9) INCREASE ENERGY EFFICIENCY IN Energy sector by Reducing losses from electricity grids, natural gas and centralized heat and efficient use of local energy sources including assigned storage • (OP9) INCREASE ENERGY EFFICIENCY IN Manufacturing sector by improving the energy management systems and legalization initiatives • (OP9) INCREASE ENERGY EFFICIENCY IN Buildings by thermal insulation programs, integrated approach for production, transport and efficient heat use, smart cities and green house concepts utilization, legalization procedures like (energy audits, certifications, etc.). • (OP9) INCREASE ENERGY EFFICIENCY IN Transport with utilization of alternative fuels, transport management improvement, etc. • (OP9) INCREASE ENERGY EFFICIENCY IN Cross-sectoral area via funding and regulation frameworks and information activities
Energy Security
• (Op2) valorization of new primary resources pool for a low energy dependence level and national energy system resilience • (op4) ensure energy storage and backup systems capacities • (op6) protect the critical infrastructure against physical , cyber attacks and natural disasters
Internal Energy Market

• (Op3) enhance the interconnections capacity of the energy transmission network • (op5) increase the national energy system flexibility via digitalization, intelligent grids and active consumer (prosumer) development • (op7) romania's proactive participation in the european energy diplomatic initiatives • (op10) increase competition on domestic energy markets • Liberalize energy markets and ensure their regional integration, so the energy consumer may benefit from the best price of energy • (op16) sectorul energetic ensure transparency of the administrative act, simplification of bureaucracy of the energy sector • (op18) increase the access of the population to electrical energy, heat and natural gas • (op19) reduce energy poverty and protect the vulnerable consumer to ensure human rights
Research, innovation and competitiveness
• Develop higher education in the field of energy and align educational programs with the needs of the energy sector; promote partnerships for education and training with the energy industry and encourage gender equality • Support research in basic and applied energy science; developing partnerships with energy industry, as well as research entities in the EU and/or other countries • Develop the capacity to attract European and international funding sources for scientific research, through the participation in international consortia of institutes acting in field of research - development –innovation • Increase the number and quality of human resources in the field of R&D activities in priority areas, through stimulating young independent teams, scholarships for early stage researchers, international mobility projects and reintegration projects addressing researchers from diaspora • Conceptual development, construction and operation of the research infrastructures described in the national road map, aiming at alignment with ESFRI infrastructures and the SET Plan (e.g. ALFRED or CCAP) by providing investment funds and supporting the development of human resources • Develop research partnerships to improve the quality of life between domestic and entities abroad

Concerning the **Research, innovation and competitiveness dimension**, programs for stimulating the research / innovation activities developed at Cabinet level have a general scope, with fundamental research being prioritized across all domains, including Energy. Per existing constraints, the progress of the research sector would continue upon priorities, in order to optimize the capacity of the existing research infrastructure in Romania.

In the scope of **decarbonisation** the activities are in supporting the scientific research to decarbonize the energy sector with co-financing and providing incentives for private investment in new technologies and research and development in the field of low GHG technologies**,** Introduce strong economic incentives for an environmentally friendly transport system through price instruments, Promote more compact, cross-functional, transit-oriented development measures as a way to reduce distances travelled by vehicles, develop infrastructure and reduce maintenance costs, etc.

In the terms of **energy efficiency** the key priority steps are in the fields of developing smart meters and smart grids, Smart medium and low voltage power distribution systems (including smart grids and IT systems) and efficient use of local energy sources including assigned storage, Creation of an energy efficiency investment fund (FIEE), financed by private funds, European funds, state budget.

Regarding the **energy security and the internal energy market dimensions** R&D activities will be concentrated on developing of resources for integration of smart metering, IoT technologies, storage facilities and distributed production systems.

Decarbonisation
• Support scientific research to decarbonize the energy sector • Adopt advanced technologies in the energy sector by attracting private investments, supporting scientific research and developing strategic partnerships • Integration of distributed production systems and prosumers into the power grid system
Energy Efficiency
• Implementation of smart city concept, integrating developed infrastructure; implementation of IoT at residential level • Creation of an energy efficiency investment fund (FIEE), financed by private funds, European funds, state budget, complying with the provisions of Law no. 500/2002 and no.69/2010
Energy Security
• Smart medium and low voltage power distribution systems (including smart grids and IT systems) and efficient use of local energy sources including assigned storage • Digitization of the national energy system in the transmission, distribution and consumption segments and introduction of the IoT and AI in the transport and distribution systems" management.
Internal Energy Market
• Develop capacities and mechanisms to integrate the intermittent RESs in the national energy system and in the electrical accumulators systems, including the small storage capacities at the prosumer premises • Encourage domestic, industrial and agricultural prosumers build-up, along with the development of electrical grids and smart meters • Integration of distributed production systems and prosumers into the power grid system • Develop smart metering and smart grids

Regulatory/ legislation steps contributing to the realization of the NECP priorities Romania

The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities. A set of policies and measures have been developed in order to achieve the overall GHG reduction target and national GHG absorption. These policies and measures are in line with the Operational Objectives of the Energy Strategy of Romania 2019-2030, with perspective of 2050, of the National Strategy for Climate Change and Economic Growth, based on low carbon emissions for the period 2016-2030, of the National Action Plan for the implementation of the national strategy for climate change and economic growth, based on low carbon emissions for the 2016 – 2020, and other strategies and documents that are considered crucial in the energy, climate change or related ETS and non-ETS industries. The regulatory/legalization measures can be summarized as follows:

- Complying the surrent activities and projects of energy companies with environmental legislation and apply best international environmental protection practices; extension of EMAS certification throughout the economy
- Management of the carbon stocks in forests in protected areas, according to forestry legislation and regulations
- Primary and secondary legislation will be amended to offer possibility to the final customers and projects developers to conclude, on centralized markets, according to the regulation project elaborated by NERA, a long-term contract (with the aim of uniformizing revenues and reduce the risk of price volatility), in fact a market instrument (without adjacent support measures), which can also attract private funding.

- through the primary and secondary legislation, but also through the projects related to the closure of the 400 kV national power ring (internal power lines), Romania will create the conditions for maximizing the offered interconnection capacities.

8.1.13 **Slovakia**

Current situation Slovakia

The Slovak Government approved the Energy Policy in November 2014. The policy sets targets and priorities for the energy sector to 2035 with an outlook to 2050. The main objectives of the Energy Policy are to have a competitive low-carbon energy industry and to ensure the efficient supply of all forms of energy at affordable prices while taking customer protection into account.

Improving the air quality, reducing the greenhouse gas emissions and securing the supplies of all energy types are priorities for Slovakia. In 2019, Slovakia set a goal to achieve carbon neutrality by 2050. Nuclear and fossil fuels have balanced shares in domestic consumption. The power industry aims at optimizing the energy mix to reduce greenhouse gas emissions and air pollution while maintaining energy security.

Slovakia’s total GHG emissions were 41037.12 Gg CO_2 (without LULUCF) in 2016, representing a reduction of 44.5% compared to 1990. Emissions increased by 0.3% compared to 2015, which was due to economic growth.

From 2008 to 2016, Slovakia reduced its emissions by 17%. Emissions reductions after 2005 have been completed thanks to the restructuring of the economy in a less energy-intensive direction. The transport sector is problematic since it has ever-increasing emissions.

In 2016, the energy sector, including transport, was the main producer of greenhouse gas emissions with a 67% share. Transport sector GHG emissions constituted 16% of the total emissions and have decreased by 1% compared to 2015. Another significant contributors to GHG emissions were: combustion in stationary pollution sources, pollution from small sources and residential heating systems, emissions of methane from transport, processing and distribution of oil and natural gas.

The Industrial Processes and Product Use (IPPU) sector was the next in order of importance in 2016 creating 23% of total greenhouse gas emissions in the country. Emissions from this sector come from: raw materials processing, chemicals production, steel and iron production. It is very costly to reduce emissions from technological processes due to the existence of specific technical limits. HFCs and SF_6 emissions are the fastest growing in the IPPU sector. These substances are used in construction, insulation, electrical industry and automotive industry.

In 2016, the agricultural sector had a 6% share in the total GHG emissions. Emissions have had a relatively stable trend since 1999. The most significant decrease in agricultural emissions was achieved in the early 1990s due to the reduction in livestock breeding and the reduced use of fertilizers.

As for the waste sector, it contributed to 4% of the total GHG emissions in 2016. Emissions from this sector have increased by more than 100% compared with 1990. In the coming years, a similar trend is anticipated, although the increase should not be so significant. Emissions coming from landfills depend on the applied methodology for landfill assessment, as well as on the extent to which energy recovery from landfill gases is used.

As for renewable energy, the total share of RES in gross final consumption was 12.9% in 2015, 12%

in 2016 and 11.5% in 2017. The share of RES in electricity generation was 21.3% in 2017 (22.5% in 2016 and 22.7% in 2015). The consumption of RES in the heat and cooling sector was 9.8% in 2017 (9.9% in 2016 and 10.8% in 2015). Transport has the lowest share of RES: 7% in 2017 (7.5% in 2016 and 8.5% in 2015).

Primary energy consumption reached 676 PJ in 2017, which was 5.68% (or 36 PJ) more than in 2016. Final energy consumption amounted to 410 PJ in 2017 representing an increase of 7.17% (or 27 PJ) compared to 2016.

The largest energy consumer in Slovakia is the industry sector. Energy consumption in industry had a declining trend until 2009, after which it levelled out, with a moderate increase in 2015 and 2017. Final energy consumption in the industry sector amounted for 144 PJ in 2017, constituting 38% of the final energy consumption in Slovakia.

Final energy consumption in the transport sector was 113 PJ in 2017. The largest year-on-year rise was in 2017, increasing by 13.8%. From 2007 to 2017, consumption increased by up to 33%, which was the largest consumption increase in any sector in the monitored ten-year period.

In 2017, households consumed 88 PJ of energy, with consumption increasing year-on-year by 3.7%. There is a considerable potential for the renovation of buildings (government buildings, public buildings and private sector buildings). There are 1 million apartment buildings and family houses, and over 15 000 public buildings (schools, hospitals and offices). Buildings are estimated to be responsible for approximately 26% of CO_2 emissions.

Agriculture sector does not show such significant fluctuations in energy consumption as in other sectors. In 2017, energy consumption in the agriculture sector was 6 PJ and there was a 4.2% decrease in consumption compared to the previous year.

Slovakia is almost 90% dependent on the import of primary energy sources: nuclear fuel 100%, oil 99%, natural gas 98% and coal 68%. Domestic energy sources are mainly renewables and brown coal. In 2018, total electricity consumption in Slovakia reached 30 947 GWh. Domestic sources produced 27 149 GWh and imports were 3 797 GWh.

Nuclear power plants have the biggest share of electricity generation (55%). In 1998 and 1999, blocks 1 and 2 of the Mochovce power plant were put into operation. Technical modifications have been made in order to increase their output to the current 2x470 MWe. The blocks have an anticipated lifetime of 50 years, but they can theoretically be operated until 2058 or 2059 if all safety conditions are respected.

Future Targets and Objectives Slovakia

In terms of **decarbonisation**, the common target at European Union level is to reduce greenhouse gas emissions by 40% in 2030 and by 80-85% in 2050 compared to 1990. In addition, the ETS sector has to decrease the total GHG emissions by 43% in 2030 and by 90% in 2050 compared to 2005. As for the non-ETS activities, the goal is to reduce the GHG emissions by 30% in 2030 compared to 2005, with country-specific obligations.

The Effort Sharing Regulation (ESR) covers GHG emissions from sectors outside the EU ETS. The regulation covers emissions from all non-ETS sectors, except for emissions from international maritime transport, domestic and international aviation and the LULUCF sector. The ESR includes a wide range of pollution sources within several sectors: transport, buildings, services, small industrial installations, fugitive emissions from the energy sector, fluorinated gas emissions from equipment and other sources, agriculture and waste. These sectors produce 55% of the total EU

GHG emissions.

The ESR distributes the GHG emission reduction target from the non-ETS sector among all EU countries. Under the ESR, national emissions targets for 2030 are set as percentage change from 2005. Slovakia's goal is a 12% reduction compared to 2005.

The Environmental Strategy 2030 sets a more ambitious target for Slovakia: to reduce greenhouse gas emissions from non-ETS sectors by 20% in 2030 compared with 2005.

The linear economy model creates significant amount of GHG emissions from energy-intensive production processes and at the end of product life cycles. Circular economy aims at minimizing and optimizing energy materials and flows. The sectors with the greatest potential for GHG reductions are: materials, agriculture and food production, construction, waste management and automotive industry. Energy generation and use is responsible for around 80% of Europe's GHG emissions and the measures to mitigate climate change focus mainly on improving energy efficiency and using low-carbon energy sources. It is important to note that circular economy implementation can also result in energy savings and in reduction of GHG emissions by optimizing the use of resources, optimizing the use of products and increasing the number of material cycles. The economy is significantly dependent on the energy system because it consumes electricity and fuels during the production and use of materials and products. Thus, the transition to a circular economy also includes a transition to a system based on RES. The Economic Policy Strategy 2030 imposes a measure to adopt a document for the implementation of the circular economy in Slovakia.

As for the renewable energy targets, the EU common goal is to have an at least 32% share of energy from RES in gross final energy consumption by 2030. Slovakia proposes an objective of 19.2% in 2030, which represents an increase of 5.2% compared to the target set for 2020. The indicative targets for 2022, 2025 and 2027 are 14.94%, 16.24% and 17.38% respectively. The total investment costs of achieving the RES targets are approximately EUR 4.3 billion.

Regarding the **energy efficiency** dimension, the target at EU level is to reduce primary energy by at least 32.5% in 2030 compared to 2007. Taking into account current trends in energy consumption in Slovakia and the predicted consumption trends in 2030, the achievement of the 32.5% target by 2030 is very improbable.

The cumulative amount of end-use energy savings to be achieved from 2021 to 2030 is 47 877.5 GWh, or 870.5 GWh per year. This target was calculated in accordance with Article 7(1)(b) of the Energy Efficiency Directive, which states that the energy savings per year should correspond to 0.8% of the annual final energy consumption, to be determined as the average for the three most recent years before 1 January 2019.

Another targets related to the energy efficiency dimension that worth mentioning are: renovation of the national stock of residential and non-residential buildings, both public and private; preparation of legislation to define low-emission zones in cities; implementation of a unified system environment for collecting, processing and sharing traffic information in order to reduce the energy intensity of transport.

In terms of the **energy security** dimension, the main targets are the diversification of energy sources and supply from third countries and the reduction of energy import dependency.

With regard to the diversification of energy sources and supply from third countries, the following projects are of significant importance:

- "Polish-Slovak interconnection of gas networks" project – it is part of the North-South Gas Corridor and is an important element in the transit pipeline chain connecting Eastern Europe from the Polish LNG terminal at Świnoujście to the planned Croatian LNG terminal on the island of Krk.
- The "Eastring" project – the pipeline will pass through Slovakia, Hungary, Romania and Bulgaria, connecting Western European markets with South-Eastern Europe.
- Trading Region Upgrade (TRU) service – it connects the Austrian and Czech gas markets through the existing Eustream transmission infrastructure.

As for the reduction of energy import dependency, it should be mentioned that Slovakia's domestic gas extraction provides 2% of its total gas consumption. The discovery of new sources might increase this share but the financial aspect of extraction from such deposits should be considered. The company NAFTA, a.s. is drilling exploration wells in various parts of Slovakia. An important tool for reducing energy import dependency is the use of underground gas storage facilities. Slovakia has several suitable geological structures that are used or can be used for such purposes. The NAFTA a.s. is planning to build the Veľké Kapušany Underground Gas Storage which will ensure the security of natural gas supply in the region and will contribute to the integration of the markets of Slovakia, Poland and Hungary.

Regarding the **internal energy market** dimension, the main objectives are broken down into the following categories:

Electricity interconnectivity:

The EU legislation sets the target for infrastructure connectivity in the electricity market for 2030 at 15%. Slovakia's interconnectivity level reached 43% in 2017, and is estimated to increase up to 52% in 2030. Therefore, Slovakia will fulfil the common EU target for electricity interconnectivity in 2030.

Energy transmission infrastructure:

In the period until 2030, the completion of the following projects has been set as the goal for improvement of the electricity transmission infrastructure:

- Slovak-Hungarian cross-border interconnections (2x400 kV Gabčíkovo (Slovakia) – Gönyű (Hungary) – Veľký Ďur (Slovakia) and 2x400 kV R.Sobota (Slovakia) – Sajóivánka (Hungary)) – the project aims at increasing the transmission capacity between Slovakia and Hungary and at increasing the security and reliability of the operation of the Slovak transmission system.
- ACON smart grid project (Again COnnected Network) – this is a cross-border project between Slovakia and the Czech Republic which aims at strengthening the integration of the two countries' electricity markets. The new power station in Borský Svätý Jur and the digitization of over 200 kilometers of 22 kV lines are examples of the ACON projects. The project covers the Trenčín and Trnava regions.
- Danube InGrid smart grid project – this cross-border project between Slovakia and Hungary aims at increasing the integration of RES into the grid through the use of intelligent technologies at transmission and distribution level, including their smart management. The project covers the Nitra region and part of the Trnava region.

As for the natural gas sector, the main gas infrastructure projects aiming at developing the gas market are the previously mentioned "Polish-Slovak interconnection of gas networks" and the "Eastring" project.

Market integration:

In terms of the market integration, the main national objectives are the following: increasing system flexibility; market coupling; increasing the tradable capacity of existing interconnectors; developing smart grids, storage systems, distributed generation systems and mechanisms for dispatching.

Another priority is to ensure the participation of consumers in the energy system who will benefit from self-generation of energy and from new technologies, including smart meters. The advantages of smart meters are higher operational safety, higher efficiency, lower losses and lower operating costs of the network.

Energy poverty:

In order to decrease energy poverty the following objectives have been set: create conditions to improve electricity and gas supply security; ensure appropriate pricing for all customers; optimize support for electricity generation from RES and high-efficiency cogeneration; achieve a proper perception of regulation.

Summary of the future targets and objectives of Slovakia (Per Dimension)

Decarbonisation
• Reduction of GHG emissions in all sectors • Implementation of the circular economy model • Increase in the share of RES in gross final energy consumption (electricity, heating and cooling, transport)
Energy Efficiency
• Decrease in primary energy consumption and in final energy consumption • Increase in cumulative end-use energy savings • Renovation of residential and non-residential buildings, both public and private • Preparation of legislation to define low-emission zones in cities • Implementation of a unified system environment for collecting, processing and sharing traffic information in order to reduce the energy intensity of transport
Energy Security
• Diversification of energy sources and supply from third countries • Reduction of energy import dependency (development of underground gas storage facilities)
Internal Energy Market
• Increase in electricity interconnectivity • Completion of cross-border electricity interconnections (Slovak-Hungarian interconnection, ACON project, Danube InGrid project) • Completion of cross-border gas interconnections (Polish-Slovak interconnection, Eastring project) • Market integration and coupling • Participation of consumers in the energy system • Smart metering
Research, innovation and competitiveness
• Use of innovative technologies in order to ensure the sustainability of the energy sector • Increased cooperation between research institutions and the business sector

Concerning the **Research, innovation and competitiveness** dimension, Slovakia's main priority is to ensure sustainable energy. Key areas for R&I funding are: improving the transmission capabilities and security of the Slovak electricity network; developing smart grids and renewable energy sources; developing nuclear energy. The estimated total investments for these areas for the 2020-2024 period amount for EUR 112.8 million. Extra-budgetary resources coming from private sector R&D investments amount for approximately EUR 28.8 million.

In 2018, the Slovak Research and Development Agency (SRDA) launched a public call for applicants to address R&D projects in the science and technology fields. The SRDA's main objective is to improve the quality of R&D through competition. The total funding for the entire period of projects supported under this call is EUR 33 million. These funds were distributed according to the requirements of the individual groups. The total amount of funds provided by the SRDA to address any of the projects is limited to EUR 250 000.

Research and development incentives have for objective to support the growth of R&D in the business sector in Slovakia, as well as to increase its cooperation with the academic sector (universities, Slovak Academy of Science) and cooperation between business sectors in Slovakia and in the EU. R&D incentives increase the leading-edge nature and excellence of the R&D. In the upcoming years, the Ministry of Education, Science, Research and Sport of Slovakia will focus, through R&D incentives, on: research and development into highly efficient energy sources and technologies for transport systems; research and development into biodegradable plastics, including composite materials; the use of RES for the automotive industry.

Slovakia is involved in international activities in research and innovation through bilateral agreements on scientific cooperation with EU countries and outside the EU. Slovakia is a member of the IEA and participates in scientific cooperation within the EU through the 7th EU Framework Programme and EURATOM (European Atomic Energy Community). Slovakia is also involved in the Allegro project, which is a cooperation project in nuclear energy between Slovakia, Hungary, the Czech Republic and France.

In terms of **decarbonisation**, research and innovation are focused on the development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy). In the field of RES innovation there is the National Centre for Research and Applications of RES at the Slovak Technical University (STU). Four STU faculties are engaged in RES research and innovation: the Faculty of Chemical and Food Technology, the Faculty of Electrical Engineering and Informatics, the Faculty of Mechanical Engineering and the Faculty of Civil Engineering. Their main areas of research are biomass, solar energy and hydropower.

Slovakia participates in the EURATOM programme which is focused on nuclear research and its role is to contribute to the long-term plan for decarbonising the energy system. Priorities of the programme are: scientific excellence, industrial leadership and changes in society. There are two main areas of research and innovation in the EURATOM programme: nuclear fission and radiation protection, and the development of magnetic nuclear fusion as an energy source.

As for the **energy efficiency** dimension, the priority areas of research and innovation are the following:

- Development of new network, consumption, production and interoperability technologies
- Development of technologies to increase energy efficiency and decrease energy intensity
- Development of new energy transmission systems (power cables without dispersive electrical and magnetic fields)
- Development of energy conversion technologies
- Development of the efficient use of domestic deposits of energy raw materials and geothermal energy
- Development of high-efficiency cogeneration in district heating systems
- Construction, reconstruction and modernisation of heat distribution systems

Regarding the **energy security** dimension, research and innovation are mainly focused on the development of energy storage technologies. The possibilities of energy storage in the form of mixture of natural gas and hydrogen are being explored. This type of storage can accelerate the use of RES because it eliminates the disadvantages of these energy sources (volatility of the amount of energy obtained). The development of RES and nuclear technologies will contribute to the increase of energy security. The creation of new energy transmission systems is also a priority.

In terms of the **internal energy market** dimension, main priority of research and innovation is the development of circular economy model. Local power consumption management concepts are also being developed so that electricity is not transformed to a higher voltage at the generation site and then back to a lower voltage at a remote location. Research on the involvement of consumers in the electricity system and markets is of significant importance for the internal energy market dimension.

Decarbonisation
• Development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy) • Development of nuclear technologies (participation in the EURATOM programme)
Energy Efficiency
• Development of new network, consumption, production and interoperability technologies • Development of technologies to increase energy efficiency and decrease energy intensity • Development of new energy transmission systems (power cables without dispersive electrical and magnetic fields) • Development of energy conversion technologies • Development of the efficient use of domestic deposits of energy raw materials and geothermal energy • Development of high-efficiency cogeneration in district heating systems • Construction, reconstruction and modernisation of heat distribution systems
Energy Security
• Development of energy storage technologies (possibilities of energy storage in the form of mixture of natural gas and hydrogen) • Development of RES and nuclear technologies (will increase energy security) • Creation of new energy transmission systems
Internal Energy Market
• Development of circular economy model • Development of local power consumption management concepts • Research on the involvement of consumers in the electricity system and markets

Regulatory/ legislation steps contributing to the realization of the NECP priorities Slovakia

The regulatory/ legislation measures that have to be considered as crucial for the realization of the NECP priorities, are summarized as follows:

- Achieve economic growth based on a low carbon, circular and a less energy- and material-intensive economy
- Intensify activities to reduce CO_2 emissions, particularly in the transport sector
- Optimise the RES share, especially in heat generation
- Implement a more harmonised tax regime in heating and energy use in industrial processes
- Increase the use of natural gas and, in the long term, decarbonised gases and hydrogen
- Use waste-to-energy
- Promote self-generation and self-consumption of energy

- Improve the thermal and technical characteristics of buildings
- Provide financial support for research and innovation
- Raise public awareness

8.2 Considered Projects for the ETIP SNET Analysis

Bulgaria	Croatia	Cyprus	Ireland	Latvia	Slovakia
GARPUR GridTech NIGHT WIND SOLID-DER SUSPLAN ZAS CROSSBOW 3e-Houses BECA CORE GRID DEHEMS DERRI ENER-SUPPLY EnVision 2020 ICE-WISH iUrban Project M2RES PV Grid SOLID-DER CryoHub INVADE	PEGASE SIREN CROSSBOW FLEXITRANSTORE ENER-SUPPLY EnVision 2020 E-price EV BASS iUrban Project OS4ES RE-SEEties STORIES SUNSHINE COMPILE UGRIP	FLEXITRANSTORE BestRES CORE GRID EU-DEEP Grasp GROW-DERS PV-NET SINFONIA SINGULAR STORIES VIMSEN GOFLEX inteGRIDy MERLON SMARTPV STORES InforPV	AFTER EWIS GridTech REserviceS SafeWind SGIH TWENTIES Electrical Network Efficiency Improvement Phase 2: Support Scheme for PV Solar PROMOTioN EU-SysFlex FLEXITRANSTORE CITIES COOPERaTE CRISTAL Distributed Connected Wind-Farms ELSA (ETIP-SNET project) Encourage EvolvDSO FINESCE FINSENY GREAT GREENCOM GrowSmarter Mas2tering ModeSto PlanGridEV (ETIP-SNET project) RealValue (ETIP-SNET project) Smart Green	Arrowhead ELECTRA ELECTRA top up EU-DEEP ICOEUR PEGASE RealValue EU-SysFlex INTERRFACE "Arrowhead EU-DEEP "Promoting Energy Efficiency in Households" "RealValue SmartGen Urb.Energy "ITCITY	SOLID-DER "EU-SysFlex E2SG e-DASH ENER-SUPPLY ENERGOZ Flex4Grid INERTIA PV Grid RE-SEEties SOLID-DER

			Circuits SmartGridEnable SmartRuralGrid SPARKS VIMSEN Trinity Smart Grid "Dundalk Virtual Energy Microgrid (DVEM)" "Electrical Network Efficiency Improvement - Phase 1: Loss reduction potential assessment" "Smart Grid demonstration site utilising PV and battery storage" Flexigrid - Solo Energy Ltd eStore Smartblocks GOFLEX RE-SERVE REACT		