PANTERA

Pan European Technology Energy Research Approach

Work Package WP4 "Key Topics and Content Management"

Deliverable D4.3

The Final Report on Identification of gaps and missing subjects

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All Authors/Partners	**IERC (Task Lead) – Shafi Khadem, Mohamed Bahloul, Lorena Sanchez** **SINTEF (WP Lead) – Andrei Morch, Kyrre Kirkbakk Fjær** **FOSS – Venizelos Efthymiou** **DERlab – Yaksh Kumar** **RSE – Mattia Cabiati** **IPE – Anna Mutule** **UCD – Alireza Nouri** **TUS RDS – Rad Stanev**
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Table of Contents

Abbreviations

Acronym	Meaning
AI	Artificial Intelligence
CEC	Citizens Energy Community
CSA	Coordination and Support Action
CSCC	Cross Sectoral Coordination Centre
CSP	Concentrated Solar Power
CYBAN	Cyprus Business Angels Network
DE	Distributed Energy
DER	Distributed Energy Resources
DG RI	Directorate for Research and Innovation
DN	Distribution Network
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EI	Enterprise Ireland
ENTSO-E	European Network of Transmission System Operators for Electricity
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ES	Energy Storage
ETIP-SNET	European Technology and Innovation Platform Smart Networks for Energy Transition
EV	Electric Vehicle
FACTS	Flexible Alternating Current Transmission System
HEA	Higher Education Authority
HV	High Voltage
HVDC	High-voltage Direct Current
ICT	Information and Communication Technology
IDEK	The Research and Innovation Foundation of Cyprus
IES	Integrated Energy Systems
IoT	Internet of Things
IRC	Irish Research Council
IRP	Integrated Research Program
LEN	Local Energy Network
LES	Local Energy Systems
LTS	Long-term Strategy
LV	Low Voltage
MNEs	Multi-National Enterprises
MV	Medium Voltage
NECP	National Energy and Climate Plan
NRA	National Regulating Authority
PHEV	Plug-in Hybrid Electrical Vehicle

PV	Photovoltaics
R&D	Research and Development
R&I	Research and Innovation
RCS	Regulations, Codes and Standards
RD	Regional Desk
RE	Renewable Energy
RES	Renewable Energy Sources
RICAP	R&I status and Continuous gAP analysis
SEAI	Sustainable Energy Authority of Ireland
SME	Small and medium-sized enterprises
SRA	Administration of Studies and Research
TN	Transmission Network
TRL	Technology Readiness Level
TSO	Transmission System Operator
TYND	Ten-year Network Development Plan
WP	Work Package
WT	Working Team
EIRIE	European Interconnection for Research Innovation & Entrepreneurship platform

Executive Summary

This deliverable is the **fourth in the series of five project reports** in activity "Key topics and content management" (WP4), seeking to carry out the following analysis:

- The initial definition of the content for dissemination and networking activities (D4.1) [2]
- 1st Report on Identification of Gaps and Missing Subjects (D4.2) [3]
- 2nd Report on Identification of Gaps and Missing Subjects (D4.2.2) [4]
- Final Report on Identification of Gaps and Missing Subjects (D4.3) – this report

Additional evaluation of learnings from the R&I status identification and gaps analysis process, as discussed in this deliverable, while as a further elaboration of the topics of content, will be discussed in the final WP4 deliverable.

This deliverable builds on the previous ones, but updating objectives based on the revised EU policies because of the emergence of RepowerEU needs and requirements. These therefore affect the content and strategic objectives of the National NECPs, and this is specifically indicated in this deliverable.

Based on this required updating, this deliverable presents the key findings of the RICAP outcomes for all 15 countries. As indicated PANTERA CSA has divided the 15 low-active countries into six regions and thus created the regional desks (RD) that actively support the RICAP process to identify the R&I status and needs of these countries. Figure 2 shows the list of RDs and the 15 countries. Details of these RD activities can be found in [12]. The summary outcomes for one selected country from each RD are presented in Section 3.

Through the RICAP process, for each country, the PANTERA team has collected the smart grid projects' data and information that are available in different open sources. Most of these are EU collaborative projects, and some are national funding projects. The outcomes of these projects have been analysed to identify the “present R&I status” which mainly shows the “smart grid technologies/systems” that have already been highly focused on. For a high-level indication, we have considered the term “highly focused” as to where at least 20% of the analysed projects have considered these technologies/systems in their R&I activities.

This "R&I status" study is followed by analysing the NECPs. The NECPs 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. The PANTERA team has gone through the details of these national plans and strategies for 2020 - 2030. It identifies the “R&I priorities” and their link to “smart grid technologies/systems” in relation to the integrated energy systems. These are presented in detail in this deliverable in Section 3.

All EU countries have prepared their 10-year NECPs for the period from 2021 to 2030 based on the framework given by the EC [13]. The NECPs reflect the objectives, policy, and measurable plan to achieve their national target. This will help EC to analyse the national progress on achieving their targets by 2030. At a very high level, the R&I dimension and plan to support in achieving the national target are also a part of these NECPs.

PANTERA team has taken the initiative to understand the R&I activities as outlined in the NECPs, and an attempt has been made in this deliverable in Section 3.2, to link the R&I priorities to the smart grid

technologies/systems.

It is to be noted that the R&I dimension, as outlined in the NECPs, is linked to the overall national energy and climate plan. In contrast, based on our understanding, we have extracted the key points/terms in the R&I priorities that are directly linked with the smart grid technologies/systems.

It is expected that countries will develop a more detailed specification of their R&I plans in their NECPs that will define their future involvement in smart grid projects. This will further help to fine-tune the R&I priorities and their link with smart grid technologies/systems. In tables 18 to 33 show the R&I priorities outlined in the national NECPs and the corresponding technologies that will be focused on as future R&I activities.

Considerable variations are occurring among countries in terms of the number of analysed projects, as shown in Figure 4 in this deliverable. In total, 409 projects have been analysed in this report, and around 30% of these projects have at least two of these countries in collaboration. In most cases, the contribution from each participating partner/country in a specific technology/system is not available; thus, it is very difficult to identify the individual contribution. Nevertheless, based on the available information, this study is a very high-level indication of the R&I status, priorities and gaps in smart grid technologies/systems.

Particular attention was given in this deliverable, to show the outcome of project analysis where gaps have been identified for each country and the technologies/systems in general. This “group of technologies/systems” study (a combined effort from these selected countries) also suggests that there are considerable gaps present at the country level where each country should focus more on these technologies/systems in the future. Based on the “R&I status” and “R&I priorities” studies, section 4 briefly discuss the gaps in “technologies/systems” that countries may consider in their future NECPs. As the regional desk (RD) approach is strongly focused on the PANTERA activities and the EIRIE platform for developing future collaboration to accelerate the R&I activities within the regional countries, the analyses in the referred sub-sections are presented through this RD approach.

Based on all this high-level information on R&I dimensions and our mapping with smart grid technologies, it appears that most of the countries still have big gaps in R&I status and specially in the technologies under the “integrated grid” and “customers and market” technologies. It is expected and reasonable that all countries will focus more on all these technologies considered under the “Integrated Grid” and “Customers and Market” groups. These are very much aligned with their 2030 target and adequate to the present energy sector situation. One of the core parts of the advancement and development of the smart grid electricity grid and active customers' participation in the electricity market is to develop the digitalisation infrastructure, including advances in communication, big data analysis and cybersecurity systems. Thus, the technologies/systems under the “digitalisation, communication and data” group are equally important for all countries. Thus, we expect that all countries will focus on these technologies more in their R&I priorities and will also participate in projects accordingly. Depending on the geographical locations and resource availability, the technologies under the “generation” and “storage” groups can differ.
Section 4, briefly outline these technological gaps in the current R&I status and R&I priorities. The green dots indicate that the countries are somehow considering the technologies in their R&I priorities. The red dots indicate a clear gap in their existing R&I priorities as planned in the current NECPs.

Finally, this deliverable, gives evidence of the contribution of stakeholders through targeted interviews by

the PANTERA consortium. Section 5 presents the main part of the feedback from stakeholders which was received during interviews and surveys with the stakeholders. Following the description of work and feedback from the stakeholders, the project group recognised the necessity to establish a direct interaction with various groups of stakeholders to obtain interdisciplinary feedback allowing to uncover gaps, barriers and in some cases best local practices. The interaction started at the first workshop in Sofia in 2019, when the first interviews were conducted. Introduction of COVID restrictions limited the possibility of physical interviews, therefore the project group continued with web-based interviews, which proved to function even better than physical interviews. All interviews were carried out according to GDPR requirements and organised as semi-structured interviews with rather qualitative results.

1 Introduction

The work in this report is carried out under the activity "Key topics and content management" (WP4) 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 (R&I) stakeholders active in the fields of smart grids, storage and local energy systems, including policymakers, standardisation bodies and experts in both research and academia, representing the EU energy system (for details see [1]).

According to the project's description of work, the main intention of this sub-activity is to maintain throughout the project the significance and value of the operational topics of PANTERA through regular interaction with the stakeholders, following the legislative and political changes related to the EU energy transition (at national or EU level) and herewith to point out the gaps (in terms of technology, regulations, policy, national funding mechanism) and provide directions on missing subjects or aspects that are hindering the energy transition. Interaction with stakeholders through surveys and individual interviews is used as further validation of the work.

This deliverable is the **fourth in the series of five project reports** in activity "Key topics and content management" (WP4), seeking to carry out the following analysis:

- The initial definition of the content for dissemination and networking activities (D4.1) [2]
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- Final Report on Identification of Gaps and Missing Subjects (D4.3) – this report

Additional evaluation of learnings from the R&I status identification and gaps analysis process, as discussed in this deliverable, as well as a further elaboration of the topics of content, will be discussed in the final WP4 deliverable:

Assessment of the defined topics, relevance, driving forces and trends (D4.4)

2 Process of identification of gaps and barriers

The work in this document is carried out under the "Key topics and content management" activity 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 policymakers, standardisation bodies and experts in both research and academia, representing the EU energy system.

2.1 Overall process

The process of identification of gaps and barriers includes two parallel work streams (see Figure 1). It starts with a reference to the Pan-European Political landscape, defining the main R&I priorities and political targets for the Member States. The Pan-European regulatory landscape has constantly been changing in recent years, focusing on the long-term goals of decarbonising the power sector.

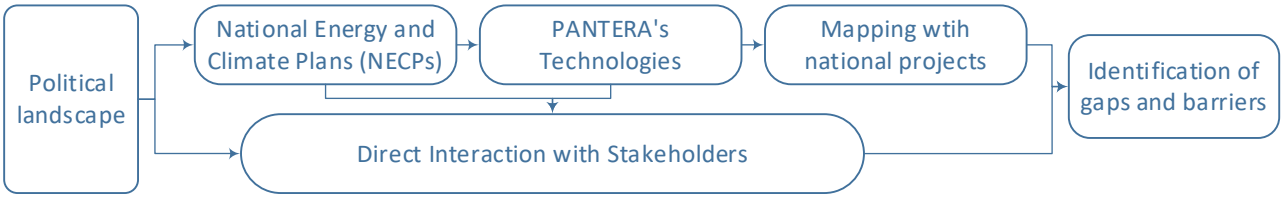


Figure 1 Two work streams in the activity

The project is further divided into two parallel streams:

- The upper stream is essentially dedicated to the technical domain of Smart Grids, storage and distributed generation. This process starts with an assessment of the National Energy and Climate Plans (NECPs) in the target countries, based on the PANTERA's taxonomy of technologies, in order to identify national R&I technical priorities. This is done through mapping technologies toward national projects in the target countries. Finally, the outcomes are used for the identification of the R&I gaps.
- The lower stream has a broader holistic nature based on direct interaction with stakeholders around technical and non-technical areas. The exchanges are made as semi-formal interviews, where the topics are modified according to any changes in the technical stream. This stream results in the definition of the main barriers and gaps whenever it is possible. These conclusions are deliberately not country-specific. This has been done to meet the requirements of GDPR and avoid tracing the answers. More importantly, the information about gaps and barriers has been used as input to the main outcome of the PANTERA project - the European Interconnection for Research Innovation & Entrepreneurship platform (EIRIE).

2.2 Changes in the Pan-European legislative and regulatory landscape

This section intends to briefly update the recent changes in the Pan-European regulatory landscape rather than providing a deep and exhaustive description. The focus is on the changes which may directly influence the relevant R&I activities in the targeted countries.

The previous deliverable [3] in this activity outlined the following key documents and strategies:

- The European long-term decarbonisation strategy (LTS) "A Clean Planet for all" aims to make Europe climate-neutral by 2050, with net-zero greenhouse gas emissions. The strategy shows how Europe can find a way to achieve climate neutrality by investing in realistic technological solutions,

empowering citizens, and aligning action in key areas such as industrial policy, finance or research.

- The Strategic Energy Technology (SET) plan defines the main priorities for the European energy ambitions of the energy transition according to the defined 10 Key actions. Several national case studies pointed out that national R&I strategies in the energy field are following the road paved by SET-plan.
- The New Circular Economy strategy is one of the main drivers behind the most recent Green Deal Initiative and is defined as Europe's new agenda for sustainable growth.
- "Clean Energy for All Europeans" package comprises several important documents and, in particular, EC Directive (EU) 2019/944 on common rules for the internal electricity market (IEM) [4] and the corresponding IEM Regulation 2019/943 [5].

After that, on 2019-12-11, the European Commission presented a Communication for the EU's green growth strategy - the European Green Deal. The document introduced a visionary and holistic approach to the EU's climate and environmental policy that cuts across policy areas and safeguards and integrates sustainability in further policy design and in the implementation and revision of existing regulations. The Communication aims to ensure a more sustainable and circular economic development with less pollution, lower greenhouse gas emissions, better health, increased quality of life, and new jobs. The action point “Clean, affordable and safe energy” was stated as second in the list and included:

- Assessment of the final national energy and climate plans (June 2020)
- A strategy for smart sector integration (2020)
- An initiative for a "Renovation wave" in the construction sector (2020)
- Evaluation and revision of the trans-European network - Energy Regulation (2020)
- A Strategy for Offshore Wind Energy (2020)

For the scope of the present project, it is relevant to mention the EC’s intentions to assess all member states' National Energy and Climate Plans (NECPs) that were completed in 2019. The European Commission decided to assess the level of ambition in the individual plans and the need for further measures if the level of ambition was not sufficient. Furthermore, the Commission announced a Greed Deal Call with a one billion Euro budget, which materialised in several ambitious European projects e.g., Green Airport and Green Harbours. Green airports and ports as hubs for sustainable and smart mobility.

The last year (2022) unfortunately brought an unexpected political and economic turmoil caused by the outbreak of the war in Ukraine, which resulted in unprecedented energy crises with extremely high prices for electricity in Europe. Furthermore, dry summers in Central and Southern Europe worsened the situation, limiting output from the nuclear power plants. The severity of the situation called for several immediate actions from the European Commission, which issued a Communication (2022/230) REPowerEU Plan [6]. The initiative resides on three main pillars, as shown in Figure 2.

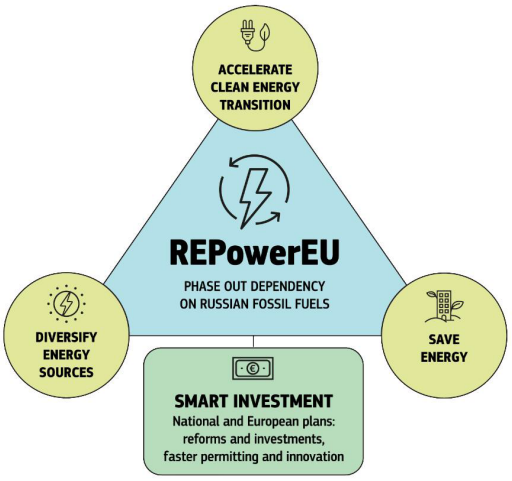


Figure 2 Main pillars of the REPowerEU Plan [6]

It was emphasised that the document complies with and further elaborates on the defining principles of the European Green Deal: fairness and solidarity. The European Commission proposes amendments or additions to three Directives: The Renewable Energy Directive (REDII) (2018/2001) [7], the Energy Performance for Buildings (2018/844) [8] and the Energy Efficiency Directives (2018/2002) [9].

For the scope of the present project, it is specifically relevant to mention that the Communication also includes very specific and ambitious targets related to renewable electricity generation and technology:

- Increase the target in the 'Renewable Energy Directive' (RED) to 45% by 2030, up from 40% under the Fit for 55 Package.
- Target 320 Gigawatts (GW) of solar photovoltaic (PV) capacity installed by 2025, rising to 600 GW by 2030.
- Double the number of heat pumps in use to 10 million over the next 5 years, including corresponding measures to utilise waste heat from industry and engage in community heating projects.
- Enhance the regulatory framework and life-cycle sustainability of solar PV by tabling eco-design and energy labelling requirements in Q1 2023 and revising existing heat pump requirements by the same date.

Among the most recent changes is a revision of the Renewable Energy Directive (REDII), which was proposed in July 2021, where the overall increase in the use of energy from renewable sources by 2030 target was increased to 40% and in May 2022, this target was further lifted up to 45% as a part REPower EU Communication. The overall intention of the revision is to foster better energy system integration and contribute to climate and environmental objectives, including biodiversity protection, thereby addressing the intergenerational concerns associated with global warming and biodiversity loss.

The above-mentioned changes in the Pan-European regulatory landscape reaffirm the previously committed decarbonisation targets and indicate that we are stepping into a decisive phase of energy transition in Europe. Furthermore, the outlined actions will inevitably strengthen the necessity for implementing Smart Grid technology and make the outcomes of the PANTERA project more relevant and timely.

2.3 Technological Gap Identification Process

PANTERA has developed a universal methodology for evaluating the national and EU projects and their contribution to analysing the maturity of PANTERA-defined "Smart Grid technologies/systems" and the ETIP SNET-defined "FUNCTIONALITIES" to achieve the decarbonisation of integrated energy system target as outlined by the ETIP SNET Vision 2050 [10]. The evaluation methodology is known as PANTERA proposed RICAP (R&I status and Continuous gAP analysis) process, and the details of this can be obtained in [11]. This evaluation process helps to identify the R&I status at the EU and national levels. Considering the ETIP SNET implementation plan (at the EU level) and the present R&I status (at the EU and national level), the PANTERA team identifies the R&I priorities for 2020 – 2030 as defined in the NECPs (at the national level) and its link with the "Smart Grid technologies/systems" and "FUNCTIONALITIES". This further helps to identify the R&I needs at the national and EU level. The list of PANTERA-defined "Smart Grid technologies/systems" is given in Table 1.

Table 1 PANTERA defined "Smart Grid technologies/systems"

Group of Technologies	Technology/Systems	№
Integrated Grid	Flexible ac transmission systems (FACTS)	IG1
	Models, Tools, Systems for the operation analysis, control and development of the integrated grid, including cost elements	IG2
	HVDC	IG3
	Forecasting (RES)	IG4
	Asset management	IG5
	Outage management, fault finding and associated equipment (including protection)	IG6
	Equipment and apparatus of the integrated grid	IG7
	Equipment, sensing, monitoring, measuring for analysis and solutions and control	IG8
	Advance distributed control	IG9
	Feeder auto-restoration / self-healing	IG10
	Smart metering infrastructure	IG11
Customers and Market	Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems	CM12
	Smart appliances	CM13
	Building control, automation and energy management systems	CM14
	Electric vehicles	CM15
	Energy communities	CM16
	Lighting	CM17
	Electricity market	CM18
Storage	Electric Storage	St19
	Thermal Storage	St20
	Power to X	St21
	Pumped storage	St22
	Other Storage	St23
Generation	Flexible generation	Ge24
	Solar, including PV & Concentrated Solar Power	Ge25
	Wind	Ge26

	Hydropower	Ge27
	Hydrogen & sustainable gases	Ge28
	Other generation	Ge29
Digitalisation, Communication and Data	Communication networks, including devices and systems for signals and data connectivity and solutions	DCD30
	Digital Twins	DCD31
	Artificial intelligence	DCD32
	Data and cyber security, including repositories	DCD33

2.4 Limitations of the approach

In general, evaluating the outcomes of R&I projects is highly demanding and time-consuming. Considering the purpose of this activity, a number of the projects to be assessed and resources available in the PANTERA project in-depth and exhausting evaluation is neither doable nor necessary. Therefore, the selected approach presents somewhat more indicative than precise results, showing the most obvious gaps and shortages.

The project groups acknowledge that the interviewed and surveyed stakeholder represent different actors belonging to the Smart Grid domain, and their views and opinions vary accordingly. In addition, there is a certain level of personal opinions presented at the interviews. Since the number of interviews is limited, applying statistical methods for data analysis is impossible.

3 Country-specific analysis

This section presents the key findings of the RICAP outcomes for all 15 countries. PANTERA CSA has divided the 15 low-active countries into six regions and thus created the regional desks (RD) that actively support the RICAP process to identify the R&I status and needs of these countries. Figure 3 shows the list of RDs and the 15 countries. Details of these RD activities can be found in [12]. The summary outcomes for one selected country from each RD are presented below.

Through the RICAP process, for each country, the PANTERA team has collected the smart grid projects' data and information that are available in different open sources. Most of these are EU collaborative projects, and some are national funding projects. The outcomes of these projects have been analysed to identify the “present R&I status” which mainly shows the “smart grid technologies/systems” that have already been highly focused on. For a high-level indication, we have considered the term “highly focused” as to where at least 20% of the analysed projects have considered these technologies/systems in their R&I activities. Again, the detailed contribution to improving the technologies within the projects is beyond this study.

It should be noted that the outcomes of this study are only an indication at a very high level and based on the available information for the selected projects and mainly at the Pan-European level. The PANTERA team has limited resources for collecting data and analysing the national projects in detail; thus, the more accurate information from the national project contributions is mostly unknown at this stage.

This "R&I status" study is followed by analysing the NECPs. The NECPs 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. The PANTERA team has gone through the details of these national plans and strategies for 2020 - 2030. It identifies the "R&I priorities" and their link to "smart grid technologies/systems" in relation to the integrated energy systems.

These "R&I status" and "R&I priorities" studies then further help to identify the gaps in terms of "smart grid technologies/systems" which give again a high-level indication of where the low active countries may need to lay an extra effort in their future NECPs.

Figure 3 List of RDs and involved 15 countries.

3.1 Present R&I status

It is already mentioned that the "R&I status" study is based on the evaluation of the smart grid projects only. The projects started and completed between 2015 – 2020 are considered for this study. For most collaborative projects, multiple countries and partners are involved; thus, it is difficult to identify individual contributions. So, we have analysed the projects using the publicly available deliverables/documents/websites and have tried to identify the "smart grid technologies" complying with the list defined by the PANTERA project that has been considered in these projects. The outcomes, then, have been linked to the countries that were involved in these projects. The assessment did not differentiate the level of engagement into different technical topics according to the roles or responsibilities within the projects i.e. participation in a project means equal involvement in specific technical topics for all partners. Thus, we expect each participating country to be equally involved in the considered smart grid technologies and benefit from the project outcomes through project collaboration. The list of analysed projects for the selected countries is given in the Annex.

So, the findings are based on only these projects. It is also to be noted that for most countries, the PANTERA team has limited information on the number of national projects completed and detailed information on the considered technologies. In general, it is common that the level of involvement in international R&I projects corresponds to the existing national R&I expertise. These findings may change with the increase in the

number of projects assessed and detailed information on the considered technologies. Thus, it is imperative to get the national expert/resources/sources to be involved in the PANTERA-developed RICAP process to fine-tune the "R&I status" of the countries. Smart grid stakeholders at the national level joining PANTERA regional desks and working teams could effectively support these activities.

RICAP is an ongoing process that the PANTERA team has developed. This study presents an example. Figure 4 shows the number of projects in which the countries have participated and that have been considered for this study. It is expected that more project information will be available on the EIRIE platform through the involvement of national experts in the regional desks (RDs) and working teams (WTs). Thus, progressing with time, new project information will be added, and new findings (R&I status) will be visible on the EIRIE platform at the national and EU level.

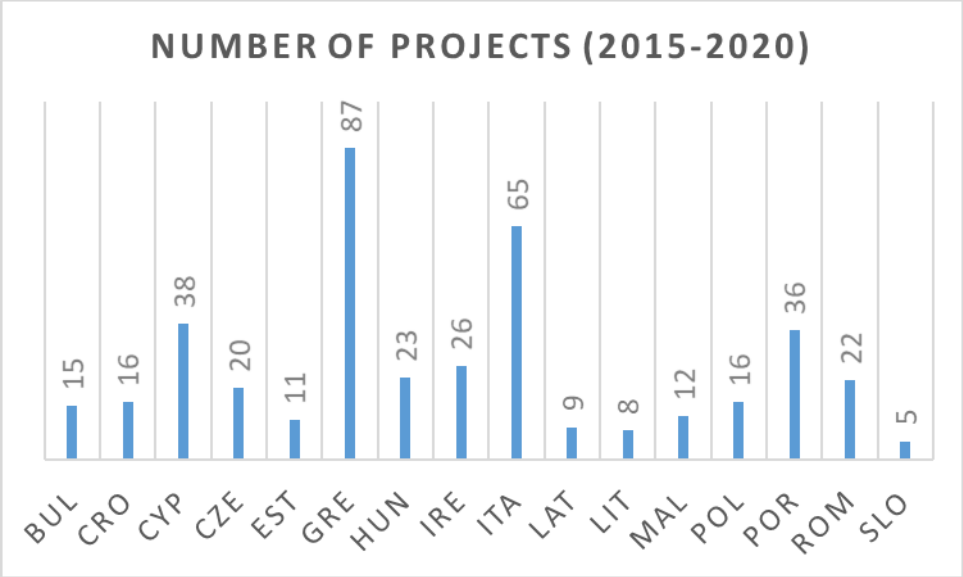
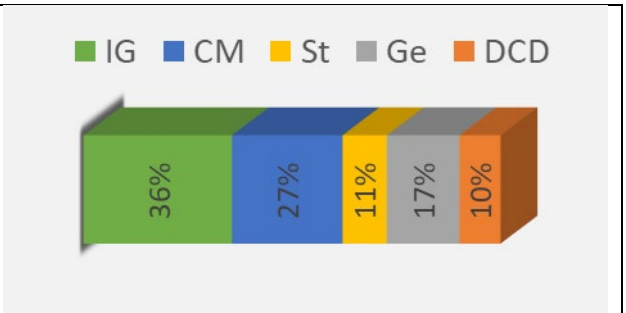


Figure 4 Number of Projects

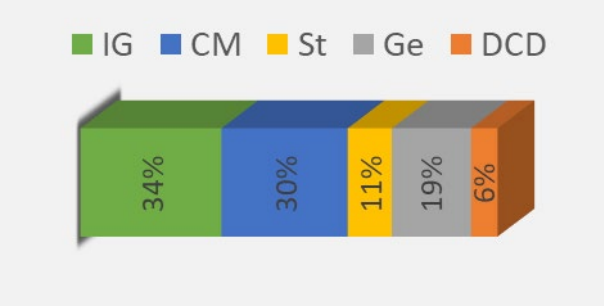
The following tables (Table 2-17) show the findings on R&I status in these countries. The highly focused technologies/systems have been outlined under each category.

Table 2 R&I status of Bulgaria (BUL)

Number of Projects: 15	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG2 - Models, Tools, Systems for the operation analysis, control and development of the integrated grid, including cost elements IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control

CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St23 – Other Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 3 R&I status of Croatia (CRO)

Number of Projects: 16	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control
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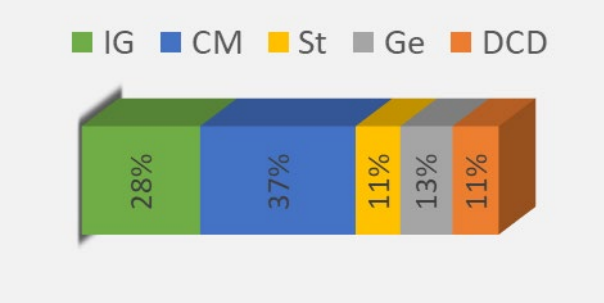
St	St19 – Electric Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power Ge26 - Wind
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 4 R&I status of Cyprus (CYP)

Number of Projects: 38	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG7 - Equipment and apparatus of the integrated grid IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG9 - Advance distributed control

CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 5 R&I status of Czech Republic (CZE)

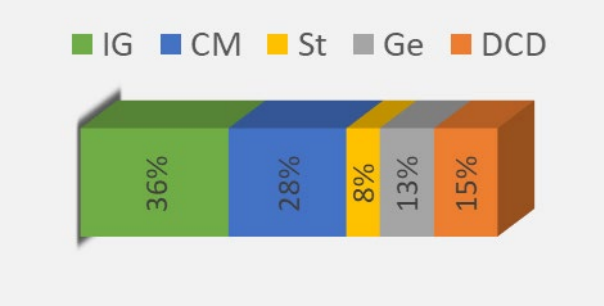
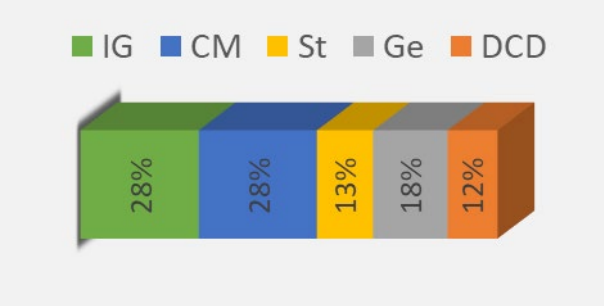
Number of Projects: 20	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM14 - Building control, automation and energy management systems CM18 – Electricity Market
St	St19 – Electric Storage
Ge	Ge24 - Flexible generation
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 6 R&I status of Estonia (EST)

Number of Projects: 11	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 - Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems

	CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 7 R&I status of Greece (GRE)

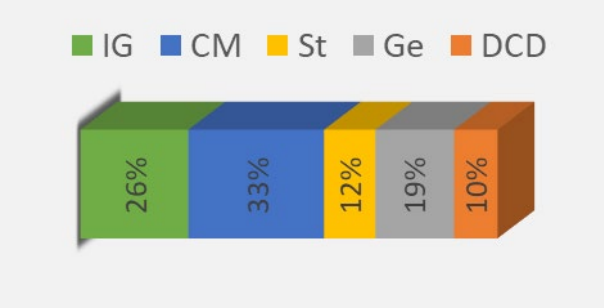
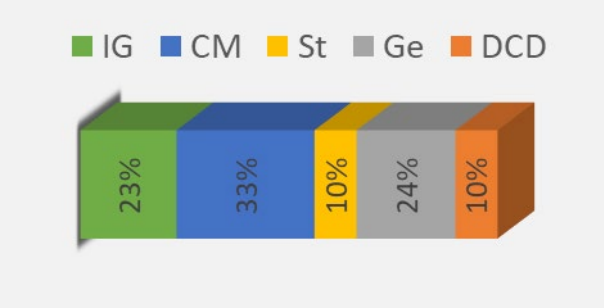
Number of Projects: 87	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power Ge26 - Wind
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 8 R&I status of Hungary (HUN)

Number of Projects: 23	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 - Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems

	CM18 – Electricity Market
St	St19 – Electric Storage
Ge	Ge24 - Flexible generation Ge29 – Other generation
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 9 R&I status of Ireland (IRE)

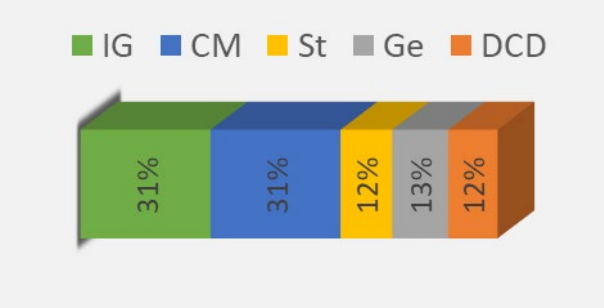
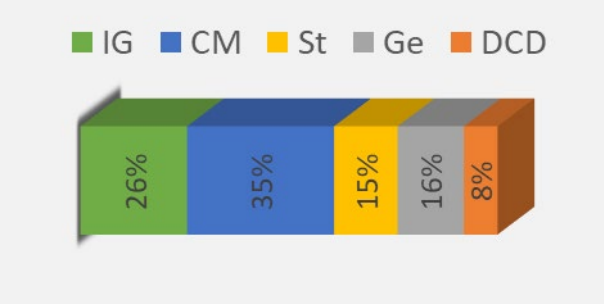
Number of Projects: 26	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge26 - Wind
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 10 R&I status of Italy (ITA)

Number of Projects: 65	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM16 – Energy Community CM18 – Electricity Market

St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power Ge26 - Wind
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 11 R&I status of Latvia (LAT)

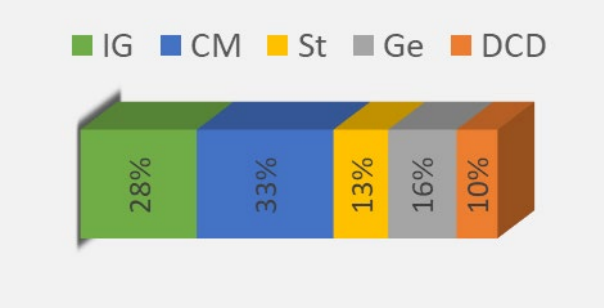
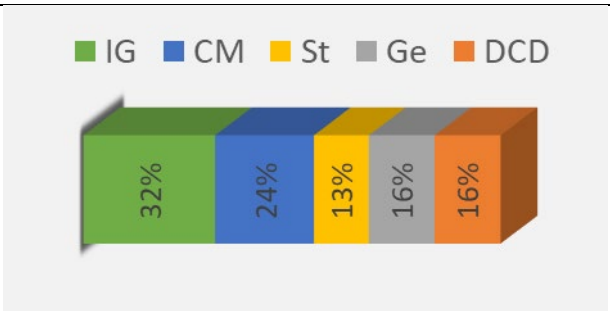
Number of Projects: 9	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG2 - Models, Tools, Systems for the operation analysis, control and development of the integrated grid, including cost elements IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power Ge26 – Wind Ge29 – Other generation
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 12 R&I status of Lithuania (LIT)

Number of Projects: 8	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	

IG	IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM14 - Building control, automation and energy management systems CM18 – Electricity Market
St	St19 – Electric Storage St22 – Pumped Storage
Ge	Ge24 - Flexible generation
DCD	DCD33 - Data and cyber security, including repositories

Table 13 R&I status of Malta (MAL)

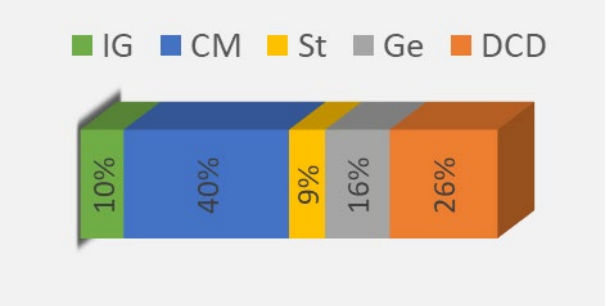
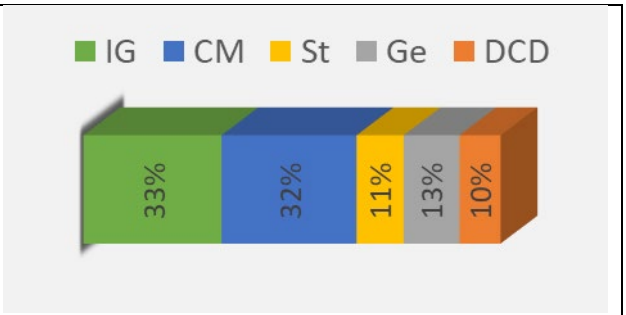
Number of Projects: 12	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM14 - Building control, automation and energy management systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage St21 – Power to X
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power Ge28 - Hydrogen & sustainable gases
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 14 R&I Status of Poland (POL)

Number of Projects: 16	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	

IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 15 R&I status of Portugal (POR)

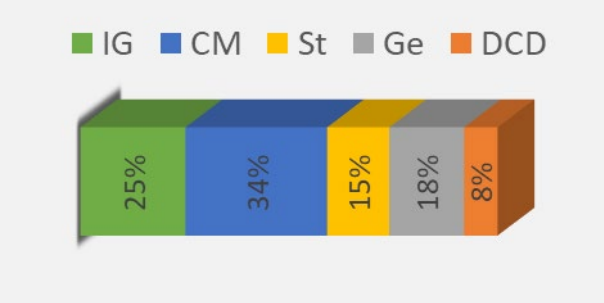
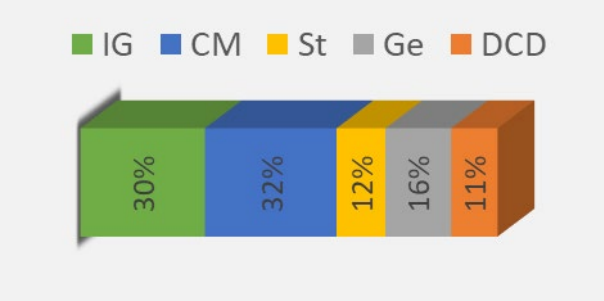
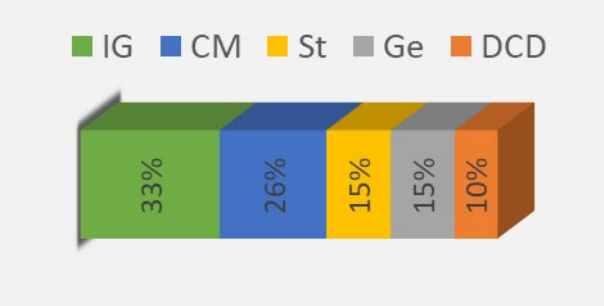
Number of Projects: 36	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 16 R&I status of Romania (ROM)

Number of Projects: 22	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	

IG	IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage St20 – Thermal Storage
Ge	Ge24 - Flexible generation Ge25 - Solar, including PV & Concentrated Solar Power
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

Table 17 R&I status of Slovakia (SLO)

Number of Projects: 5	
IG – Integrated Grid CM – Customers and Market St – Storage Ge – Generation DCD - Digitalisation, Communication and Data	
Highly focused technologies	
IG	IG2 - Models, Tools, Systems for the operation analysis, control and the development of the integrated grid including cost elements IG8 - Equipment, sensing, monitoring, measuring for analysis and solutions and control IG11 – Smart metering infrastructure
CM	CM12 - Distributed flexibility, load, forecasting, management & control and demand response, including end devices, communication infrastructure and systems CM18 – Electricity Market
St	St19 – Electric Storage
Ge	Ge24 - Flexible generation
DCD	DCD30 - Communication networks, including devices and systems for signals and data connectivity and solutions DCD33 - Data and cyber security, including repositories

3.2 R&I priorities

All EU countries have prepared their 10-year NECPs for the period from 2021 to 2030 based on the framework given by the EC [13]. The NECPs reflect the objectives, policy and measurable plan to achieve their national target. This will help EC to analyse the national progress on achieving their targets by 2030. At a very high level, the R&I dimension and plan to support in achieving the national target are also a part of these NECPs.

PANTERA team has taken the initiative to understand the R&I activities as outlined in the NECPs, and an attempt has been made here to link the R&I priorities to the smart grid technologies/systems. Following sub-

sections show the outcomes of this study for the selected countries.

It is to be noted that the R&I dimension, as outlined in the NECPs, is linked to the overall national energy and climate plan. In contrast, based on our understanding, we have extracted the key points/terms in the R&I priorities that are directly linked with the smart grid technologies/systems. Again, we find that the involvement of a national expert in the analysis process or direct interaction with specific projects is crucial, and this would provide some more in-depth information in linking the smart grid technologies.

Progressing with time, it is expected that countries will develop a more detailed specification of their R&I plans in their NECPs that will define their future involvement in smart grid projects. This will further help to fine-tune the R&I priorities and their link with smart grid technologies/systems. The following tables (Table 18 – 33) show the R&I priorities outlined in the national NECPs and the corresponding technologies that will be focused on as future R&I activities.

Table 18 R&I Priorities and relevant technologies (BUL)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
More use of low-carbon technologies Developing smart energy systems, grids and storage capacity outside TEN-E Smart transport systems Development of hydrogen technologies	Solar including PV & CSP, Wind, Hydropower Storage Electric, Electric Vehicles, Integrated Grid (all technologies/systems) Hydrogen & sustainable gases
Energy Efficiency	
More use of new energy-saving technologies that reduce technical losses in electricity transmission and distribution Increasing the reliability of electricity measuring and monitoring systems Building SMART GRID networks Improvement of Energy Efficient Buildings	Customers and Market (all technologies/systems)
Energy Security	
Development of innovative technologies for energy storage Digitalisation 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	Storage Electric, Pumped Storage, Thermal Storage Digitalisation, Communication and Data (all technologies/systems)
Internal Energy Market	

Development of system services for electricity demand response measures, demand management and distributed generation on organised 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	Integrated Grid (all technologies/systems) Customers and Market (all technologies/systems) Digitalisation, Communication and Data (all technologies/systems)

Table 19 R&I Priorities and relevant technologies (CRO)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	
Advancement in conventional energy solutions New technologies and improvements related to power plants, substations, components and systems related to renewable energy sources Energy management systems for planning, investment, real-time management and monitoring, energy efficiency Development of new and improvement of existing primary and secondary equipment for power system Sustainable conversion of biomass into energy, biogas technologies for electricity and heat generation Promoting the use of innovative information and communication technologies (ICTs) to reduce greenhouse gas emissions Systems for CO2 capture, transport, use and storage.	Integrated Grid (all technologies/systems) Other Generation, Hydrogen and sustainable gases Communication networks including devices and systems for signals and data connectivity and solutions Other storage
Energy Efficiency	
Application of advanced grids and complex energy systems Energy-efficient lighting	Integrated Grid (all technologies/systems) Lighting
Energy Security	
Advanced energy storage systems	Electrical Storage, Thermal storage
Internal Energy Market	
Systems for energy management and support to the functioning of the energy market at the levels of microgrids, advanced grids and smart cities	Energy Communities, Electricity Market Distributed flexibility, load, forecasting, management & control and demand response including end devices, communication infrastructure and systems

Table 20 R&I Priorities and relevant technologies (CYP)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	

Utilisation of wind parks in operation Utilisation of photovoltaic parks in operation Electric Vehicles	Wind Solar including PV & CSP Electric Vehicles
Energy Efficiency	
Deployment of photovoltaic panels Deployment of heat pumps for heating Utilisation of biomass boilers Promotion and utilisation of high-efficiency air conditioning units Street lighting Pumped hydro, Electric storage	Solar including PV & CSP Storage (all technologies/systems) Hydrogen and sustainable gases Lighting
Energy Security	
Optimisation and control of the distribution system Load and generation forecasting Supervisory Control and Data Acquisition of PV systems	Integrated Grid (all technologies except HVDC, FACTS)
Internal Energy Market	
Load profile management through demand response Direct participation of customers in all market stages, through aggregation Increased distribution system observability	Customers and Market (all technologies/systems) DCD

Table 21 R&I Priorities and relevant technologies (CZE)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	
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 Development of intelligent transport systems	Generation (all technologies/systems) Electric Vehicles Hydrogen and sustainable gases
Energy Efficiency	
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	Storage (all technologies/systems)
Energy Security	
Increase in the efficiency and reliability of energy systems and distribution networks Development of production and consumption management	Integrated Grid (all technologies) Digitalisation, Communication and Data (all technologies/systems)

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	Customers and Market (all technologies/systems)

Table 22 R&I Priorities and relevant technologies (EST)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
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	Solar including PV & CSP Electric Vehicles Hydrogen and sustainable gases
Energy Efficiency	
Development of "Smart House" concept Deployment of IT solutions towards energy efficiency	Customer and Markets (all technologies/systems) Lighting
Energy Security	
Optimisation of network usage Transmission network improved observability	Integrated Grid (all technologies)
Internal Energy Market	
Synchronisation 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)	Integrated Grid (all technologies) Wind

Table 23 R&I Priorities and relevant technologies (GRE)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
Utilisation of geothermal potential for electricity generation Development and deployment of marine wind parks (use of small wind turbines) Wave energy utilisation Increase in RES hydrogen production	Wind Solar including PV & CSP Other generation Hydrogen and sustainable gases Electric Vehicles
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 optimisation of the energy system	Solar including PV & CSP Electric Storage, Thermal Storage Lighting
Energy Security	
Observability and controllability of medium and low voltage networks with high penetration of DER Transmission network improved observability	Integrated Grid (all technologies)
Internal Energy Market	
Load profile management through demand response Observability and controllability of medium and low voltage networks with high penetration of DER	Customers and Market (all technologies/systems)

Table 24 R&I Priorities and relevant technologies (HUN)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	
Electrification of the transport sector, with the penetration of electric vehicles in the market Increase in the penetration of RES in transport Increase in the penetration of RES to cover heating and cooling needs	Electric Vehicles Solar including PV & CSP, Wind
Energy Efficiency	
Modernisation of residential building stock, non-residential building stock Modernisation of heating systems	Smart Appliances, Thermal storage,
Energy Security	
Digitalisation of the energy system, enabling the dynamic pricing of energy supply and demand through the processing and exploitation of consumer data Development of demand response systems and operators to increase the system capacity and decrease energy dependency Enhancement of cybersecurity mechanisms	Integrated Grid (all technologies) DCD (all technologies)
Internal Energy Market	
Development of distribution network operation, as a decentralised intervention capability, and its transparent market mechanisms (distribution flexibility market)	Customers and Market (all technologies/systems)

Table 25 R&I Priorities and relevant technologies (IRE)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
High penetration of RES, especially from Wind, floating solar and wind Utilisation of wave / tidal energy Development of power-to-gas storage systems	Generation (all technologies) Power to Gas
Energy Efficiency	
Network stability improvement Energy Storage integration, flexibility and demand response Smart metering EV integration Heat pump	Integrated Grid (all technologies) Customers and Market (all technologies/systems) Thermal Storage
Energy Security	
Increase security of supply including gas network	Power to Gas, Thermal Storage
Improvement in network operation and management Interconnection	Integrated Grid (all technologies)
Internal Energy Market	
Single Electricity Market	Electricity Market
Promoting sustainable energy communities	Energy Communities, Smart Appliances

Table 26 R&I Priorities and relevant technologies (ITA)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
Further exploitation of solar PV and CSP renewable sources Utilisation of wave / tidal energy Development of power-to-gas storage systems	Wind Solar including PV & CSP, Other generation, Power to X
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	Integrated Grid (all technologies) Storage (all technologies/systems) Hydrogen and sustainable gases Artificial Intelligence
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 communication systems in the electricity sector	Integrated Grid (all technologies)

Management of the distribution network and the energy system	
Internal Energy Market	
Increase in the generation of distributed energy resources Load profile management through demand response	Customers and Market (all technologies/systems)

Table 27 R&I Priorities and relevant technologies (LAT)

R&I Priorities in NECP	**Smart Grid Technologies / Systems**
Decarbonisation	
Biomethane, Hydrogen, biofuels, biomass etc Solar Energy Wave Energy Storage for Renewable Energy Intelligent transport systems More RES	Hydrogen and Sustainable gases Solar PV Other generation Electrical Storage Electric Vehicles Wind, Flexible Generation
Energy Efficiency	
Modernisation of existing energy production technologies Digital energy innovation Modernisation of electricity metering Cogeneration in district heating	Integrated Grid (all technologies/systems) Digitalisation, Communication and Data (all technologies/systems) Building control, automation and energy management systems Power to Gas, Thermal Storage
Energy Security	
Energy storage, Smart transmission system, Reinforcement of existing interconnections and the development of new interconnections, Promotion of Self-generation of energy	Electrical Storage, Integrated Grid (all technologies/systems) Flexible Generation Other generation
Internal Energy Market	
Full integration of energy markets and modernisation of infrastructure New-market model (including P2P, aggregation) Local energy community systems Improvement of electrical system management	Electricity Market, Energy Communities, Distributed flexibility, load, forecast, management & control and demand response including end devices, communication infrastructure and systems, Smart Appliances

Table 28 R&I Priorities and relevant technologies (LIT)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	

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, bio-methane)	Wind Solar including PV & CSP Electric Vehicles Hydrogen and sustainable gases
Energy Efficiency	
Modernisation 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	Integrated Grid (all technologies) Solar including PV & CSP Lighting Flexible generation
Energy Security	
Security and quality of the electricity supply, optimisation 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	Storage (all technologies/systems)
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	Customers and Market (all technologies/systems)

Table 29 R&I Priorities and relevant technologies (MAL)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
Wind energy resources utilisation Solar Energy exploitation (PV panels, solar water heaters)	Wind Solar including PV & CSP
Energy Efficiency	

Thermal insulation building systems Deployment of energy-saving lighting systems Deployment of energy efficient appliances Double-glazing utilisation (Double Glazed Windows) Deployment of heat pumps	Customers and Market (all technologies/systems) Smart Appliance Lighting
Energy Security	
Development of energy storage market, leading to increased photovoltaic capacity and optimisation of the power system	Storage (all technologies/systems) Integrated Grid (all technologies)
Internal Energy Market	
Load profile management through demand response	Customers and Market (all technologies/systems)

Table 30 R&I Priorities and relevant technologies (POL)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	
Carbon capture and storage activities Environment-friendly transport solutions Minimisation 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)	Other storage Electric Vehicles Other generation
Energy Efficiency	
Smart and energy-efficient building technologies; High-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems	Solar including PV & CSP Storage (all technologies/systems) Lighting Integrated Grid (all technologies)
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 of technologies,	Flexible generation Generation (all technologies)
Internal Energy Market	
Continuous enhancement of technological advancement and the quality of operation; Implementation of competitive organisational and business models; Optimisation of capital use.	Customers and Market (all technologies/systems)

Table 31 R&I Priorities and relevant technologies (POR)

R&I Priority in NECP	**PANTERA Technologies**

Decarbonisation	
Reinforcing the use of renewable energies (focus on solar and onshore/offshore wind technologies) Reinforcement and optimisation of transport and distribution networks and promotion of pilot projects (concentrated photovoltaic, stimulated geothermal and wave power) Increased use of endogenous resources to produce electricity Increase in the penetration of RES to cover heating and cooling needs (Biomass, renewable gases) Penetration of advanced biofuels in the transport sector	Generation (all technologies) Electric Vehicles
Energy Efficiency	
Rehabilitating and making buildings more efficient Energy renovation of the building stock New energy building certifications Redesigning mechanisms to fund/support the renovation of buildings Technologies for NZEB	Storage (all technologies/systems) Hydrogen and sustainable gases Lighting
Energy Security	
Diversification of energy sources Development of endogenous renewable energy resources Increase of underground storage capacity (Carriço) Natural gas provisions through Sines LNG Terminal Reinforcing interconnections with Spain (improved network balance and supply security) Existence of storage systems in different forms – optimised management of energy system – promotion of flexibility and stability of the national energy system Reversible pumping systems in hydroelectric plants	Integrated Grid (all technologies)
Internal Energy Market	
Digitalising the electricity system and making it more flexible	Customers and Market (all technologies/systems) Digitalisation, Communication and Data (all technologies)

Table 32 R&I Priorities and relevant technologies (ROM)

R&I Priority in NECP	**PANTERA Technologies**
Decarbonisation	
Decarbonize the energy sector Adopt advanced technologies in the energy sector Integration of distributed production systems and prosumers into the power grid system	Integrated Grid (all technologies)
Energy Efficiency	

Implementation of smart city concept, integrating developed infrastructure; implementation of IoT at residential level	Customer and Markets (all technologies)
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 Digitisation 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.	Electric Vehicles Digitalisation, Communication and Data (all technologies)
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	Customers and Market (all technologies/systems)

Table 33 R&I Priorities and relevant technologies (SLO)

R&I Priority in NECP	PANTERA Technologies
Decarbonisation	
Development of technologies for the generation of electricity and heat from RES (water, sun, wind, biomass and geothermal energy) Big Data in the processing, analysis, prediction and visualisation of large volumes of data in real-time, as well as to use of artificial intelligence	Generation (all technologies/systems) Digitalisation, Communication & Data (all technologies/systems)
Energy Efficiency	
Development of new network, consumption, production and interoperability technologies, increase energy efficiency and decrease energy intensity Development of high-efficiency cogeneration in district heating systems, construction, reconstruction and modernisation of heat distribution systems	Integrated Grid (all technologies/systems) Thermal Storage, Other Storage
Energy Security	
Development of energy conversion and storage technologies (possibilities of energy storage in the form of mixture of natural gas and hydrogen) Creation of new energy transmission systems	Electrical storage, Power to X, Other storage Integrated Grid (all technologies/systems)

Internal Energy Market	
Development of local power consumption management concepts, Research on the involvement of consumers in the electricity system and markets	Customers and Market (all technologies/systems)

4 Gaps in Technology Implementation

Considerable variations are occurring among countries in terms of the number of analysed projects, as shown in Figure 4. In total, 409 projects have been analysed, and around 30% of these projects have at least two of these countries in collaboration. In most cases, the contribution from each participating partner/country in a specific technology/system is not available; thus, it is very difficult to identify the individual contribution. Nevertheless, based on the available information, this study is a very high-level indication of the R&I status, priorities and gaps in smart grid technologies/systems.
Previous sections show the R&I status, which indicates the highly focused technologies by the countries (based on their participation in the projects) and the priorities as outlined in the NECPs.
This section shows the outcome of project analysis where gaps have been identified for each country and the technologies/systems in general.
This "group of technologies/systems" study (a combined effort from these selected countries) also suggests that there are considerable gaps present at the country level where each country should focus more on these technologies/systems in future.
Based on the "R&I status" and "R&I priorities" studies, the following sub-sections briefly discuss the gaps in "technologies/systems" that countries may consider in their future NECPs. As the regional desk (RD) approach is strongly focused on the PANTERA activities and the EIRIE platform for developing future collaboration to accelerate the R&I activities within the regional countries, the analyses in the sub-sections here are presented through this RD approach.

Based on all this high-level information on R&I dimensions and our mapping with smart grid technologies, it appears that most of the countries still have big gaps in R&I status and specially in the technologies under the "integrated grid" and "customers and market" technologies. It is expected and reasonable that all countries will focus more on all these technologies considered under the "Integrated Grid" and "Customers and Market" groups. These are very much aligned with their 2030 target and adequate to the present energy sector situation. One of the core parts of the advancement and development of the smart grid electricity grid and active customers' participation in the electricity market is to develop the digitalisation infrastructure, including advances in communication, big data analysis and cybersecurity systems. Thus, the technologies/systems under the "digitalisation, communication and data" group are equally important for all countries. Thus, we expect that all countries will focus on these technologies more in their R&I priorities and will also participate in projects accordingly. Depending on the geographical locations and resource availability, the technologies under the "generation" and "storage" groups can differ.
The following sub-sections briefly outline these technological gaps in the current R&I status and R&I priorities. The green dots indicate that the countries are somehow considering the technologies in their R&I priorities. The red dots indicate a clear gap in their existing R&I priorities as planned in the current NECPs.

4.1 Technological Gaps in RD1 Countries

RD1 consists of three countries: Latvia (LAT), Lithuania (LIT) and Estonia (EST). Table 34 also shows the

analysis outcomes for the countries.

In the case of “storage” technologies, all countries in this region show very limited/no interest in the case of “pumped storage” and “other storage” technologies. Geographical and other non-technical issues could have an impact on these decisions. Gaps also appear in “power to x” technologies for Estonia and this category is very important for sector coupling under the “storage” group.

When it comes to the “generation” group, all countries intend to implement more low-carbon technologies and all of them also emphasise “Solar, Wind, Flexible, Hydrogen and sustainable gases”. All of these countries also do not have much interest in “hydropower” technologies.

Gaps still appear in “digitalisation, communication and data” group. For example, Estonia and Lithuania have a very limited focus on “digital twins and artificial intelligence” technologies.

Table 34 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD1 countries

RD-1			LAT		EST		LIT	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)						
	IG2	Models, Tools, Systems for the operation						
	IG3	HVDC						
	IG4	Forecasting (RES)						
	IG5	Asset management						
	IG6	Outage management, fault finding and associated						
	IG7	Equipment and apparatus of the integrated grid						
	IG8	Equipment, sensing, monitoring, measuring for						
	IG9	Advanced distributed control						
	IG10	Feeder auto-restoration / self-healing						
	IG11	Smart metering infrastructure						
CM	CM12	Distributed flexibility, load, forecasting,						
	CM13	Smart appliances						
	CM14	Building control, automation and energy						
	CM15	Electric vehicles						
	CM16	Energy communities						
	CM17	Lighting						
	CM18	Electricity market						
St	St19	Electric Storage						
	St20	Thermal Storage						
	St21	Power to X						
	St22	Pumped storage						
	St23	Other Storage						
Ge	Ge24	Flexible generation						
	Ge25	Solar including PV & Concentrated Solar Power						
	Ge26	Wind						
	Ge27	Hydropower						
	Ge28	Hydrogen & sustainable gases						
	Ge29	Other generation						
DCD	DCD30	Communication networks including devices and						
	DCD31	Digital Twins						
	DCD32	Artificial intelligence						
	DCD33	Data and cyber security including repositories						

4.2 Technological Gaps in RD2 Countries

RD2 consists of three countries: Bulgaria (BUL), Romania (ROM) and Greece (GRE). Table 35 also shows the analysis outcomes for the countries.

Romania still shows limited interest in “smart appliances” and “lighting” technologies under the “Customers and market” group.

In the case of “storage” technologies, all countries in this region show very limited/no interest in the case of “other storage” technologies. Gaps also appear in “power to x” technologies for Bulgaria and this category is

very important for sector coupling under the “storage” group.

When it comes to the “generation” group, all countries intend to implement more low-carbon technologies and all of them also emphasise “Solar, Wind, Flexible, Hydrogen and sustainable gases”. Bulgaria and Romania also do not have much interest in “other generation” technologies.

Gaps still appear in “digitalisation, communication and data” group. All countries could give a more importance on “digital twins and artificial intelligence” technologies.

Table 35 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD2 countries

RD-2			BUL		ROM		GRE	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)						
	IG2	Models, Tools, Systems for the operation						
	IG3	HVDC						
	IG4	Forecasting (RES)						
	IG5	Asset management						
	IG6	Outage management, fault finding and associated						
	IG7	Equipment and apparatus of the integrated grid						
	IG8	Equipment, sensing, monitoring, measuring for						
	IG9	Advanced distributed control						
	IG10	Feeder auto-restoration / self-healing						
	IG11	Smart metering infrastructure						
CM	CM12	Distributed flexibility, load, forecasting,						
	CM13	Smart appliances						
	CM14	Building control, automation and energy						
	CM15	Electric vehicles						
	CM16	Energy communities						
	CM17	Lighting						
	CM18	Electricity market						
St	St19	Electric Storage						
	St20	Thermal Storage						
	St21	Power to X						
	St22	Pumped storage						
	St23	Other Storage						
Ge	Ge24	Flexible generation						
	Ge25	Solar including PV & Concentrated Solar Power						
	Ge26	Wind						
	Ge27	Hydropower						
	Ge28	Hydrogen & sustainable gases						
	Ge29	Other generation						
DCD	DCD30	Communication networks including devices and						
	DCD31	Digital Twins						
	DCD32	Artificial intelligence						
	DCD33	Data and cyber security including repositories						

4.3 Technological Gaps in RD3 Countries

RD3 consists of three countries: Cyprus (CYP), and Malta (MAL). Table 36 also shows the analysis outcomes for the countries.

In the case of “storage” technologies, Malta shows very limited/no interest in the case of “pumped storage” and “other storage” technologies. Geographical and other non-technical issues could have an impact on these decisions.

When it comes to the “generation” group, all countries intend to implement more low-carbon technologies and emphasise “Solar, Wind, Flexible, Hydrogen and sustainable gases”. These countries also do not have much interest in “other generation” technologies.

Gaps still appear in “digitalisation, communication and data” group. Both countries have very limited focus on “digital twins and artificial intelligence” technologies.

Table 36 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD3 countries

RD-3			CYP		MAL	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)				
	IG2	Models, Tools, Systems for the operation				
	IG3	HVDC				
	IG4	Forecasting (RES)				
	IG5	Asset management				
	IG6	Outage management, fault finding and associated				
	IG7	Equipment and apparatus of the integrated grid				
	IG8	Equipment, sensing, monitoring, measuring for				
	IG9	Advanced distributed control				
	IG10	Feeder auto-restoration / self-healing				
	IG11	Smart metering infrastructure				
CM	CM12	Distributed flexibility, load, forecasting,				
	CM13	Smart appliances				
	CM14	Building control, automation and energy				
	CM15	Electric vehicles				
	CM16	Energy communities				
	CM17	Lighting				
	CM18	Electricity market				
St	St19	Electric Storage				
	St20	Thermal Storage				
	St21	Power to X				
	St22	Pumped storage				
	St23	Other Storage				
Ge	Ge24	Flexible generation				
	Ge25	Solar including PV & Concentrated Solar Power				
	Ge26	Wind				
	Ge27	Hydropower				
	Ge28	Hydrogen & sustainable gases				
	Ge29	Other generation				
DCD	DCD30	Communication networks including devices and				
	DCD31	Digital Twins				
	DCD32	Artificial intelligence				
	DCD33	Data and cyber security including repositories				

4.4 Technological Gaps in RD4 Countries

RD4 consists of three countries: Czech Republic (CZE), Poland (POL) and Slovakia (SLO). Table 37 also shows the analysis outcomes for the countries.

In the case of “storage” technologies, all countries in this region show very good focus on all technologies. When it comes to the “generation” group, all countries intend to implement more low-carbon technologies and all of them also emphasise “Solar, Wind, Flexible, Hydrogen and sustainable gases”. All of these countries also have much interest in other technologies.

Gaps still appear in “digitalisation, communication and data” group. All countries have very limited focus on “digital twins and artificial intelligence” technologies.

Table 37 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD4 countries

RD-4			CZE		POL		SLO	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)						
	IG2	Models, Tools, Systems for the operation						
	IG3	HVDC						
	IG4	Forecasting (RES)						
	IG5	Asset management						
	IG6	Outage management, fault finding and associated						
	IG7	Equipment and apparatus of the integrated grid						
	IG8	Equipment, sensing, monitoring, measuring for						
	IG9	Advanced distributed control						
	IG10	Feeder auto-restoration / self-healing						
	IG11	Smart metering infrastructure						
CM	CM12	Distributed flexibility, load, forecasting,						
	CM13	Smart appliances						
	CM14	Building control, automation and energy						
	CM15	Electric vehicles						
	CM16	Energy communities						
	CM17	Lighting						
	CM18	Electricity market						
St	St19	Electric Storage						
	St20	Thermal Storage						
	St21	Power to X						
	St22	Pumped storage						
	St23	Other Storage						
Ge	Ge24	Flexible generation						
	Ge25	Solar including PV & Concentrated Solar Power						
	Ge26	Wind						
	Ge27	Hydropower						
	Ge28	Hydrogen & sustainable gases						
	Ge29	Other generation						
DCD	DCD30	Communication networks including devices and						
	DCD31	Digital Twins						
	DCD32	Artificial intelligence						
	DCD33	Data and cyber security including repositories						

4.5 Technological Gaps in RD5 Countries

RD5 consists of three countries: Croatia (CRO), Italy (ITA) and Hungary (HUN). Table 38 also shows the analysis outcomes for the countries.

In the case of “storage” technologies, all countries in this region show very good interest in electrical and thermal storage technologies but have limited/no interest in the case of “pumped storage” and “other

storage" technologies. Geographical and other non-technical issues could have an impact on these decisions. Gaps also appear in "power to x" technologies for Estonia and this category is very important for sector coupling under the "storage" group.

When it comes to the "generation" group, all countries intend to implement more low-carbon technologies and all of them also emphasise "Solar, Wind, Flexible, Hydrogen and sustainable gases". All of these countries also do not have much interest in "hydropower" and "other generation" technologies.

Gaps still appear in "digitalisation, communication and data" group. Hungary has very limited focus on "digital twins and artificial intelligence" technologies.

Table 38 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD5 countries

RD-5			CRO		ITA		HUN	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)						
	IG2	Models, Tools, Systems for the operation						
	IG3	HVDC						
	IG4	Forecasting (RES)						
	IG5	Asset management						
	IG6	Outage management, fault finding and associated						
	IG7	Equipment and apparatus of the integrated grid						
	IG8	Equipment, sensing, monitoring, measuring for						
	IG9	Advanced distributed control						
	IG10	Feeder auto-restoration / self-healing						
	IG11	Smart metering infrastructure						
CM	CM12	Distributed flexibility, load, forecasting,						
	CM13	Smart appliances						
	CM14	Building control, automation and energy						
	CM15	Electric vehicles						
	CM16	Energy communities						
	CM17	Lighting						
	CM18	Electricity market						
St	St19	Electric Storage						
	St20	Thermal Storage						
	St21	Power to X						
	St22	Pumped storage						
	St23	Other Storage						
Ge	Ge24	Flexible generation						
	Ge25	Solar including PV & Concentrated Solar Power						
	Ge26	Wind						
	Ge27	Hydropower						
	Ge28	Hydrogen & sustainable gases						
	Ge29	Other generation						
DCD	DCD30	Communication networks including devices and						
	DCD31	Digital Twins						
	DCD32	Artificial intelligence						
	DCD33	Data and cyber security including repositories						

4.6 Technological Gaps in RD6 Countries

RD6 consists of three countries: Ireland (IRE) and Portugal (POR). Table 39 also shows the analysis outcomes for the countries.

Portugal shows good interest in all the technologies. Ireland has still gaps in “pumped storage” and “other storage” technologies. Also shows less interest in “hydropower” technologies.

Table 39 Presently focused technologies/systems in R&I status (S) and priorities (P) given by the RD6 countries

RD-6			IRE		POR	
Group of Technologies	**№**	**Technology/Systems**	S	P	S	P
IG	IG1	Flexible ac transmission systems (FACTS)				
	IG2	Models, Tools, Systems for the operation				
	IG3	HVDC				
	IG4	Forecasting (RES)				
	IG5	Asset management				
	IG6	Outage management, fault finding and associated				
	IG7	Equipment and apparatus of the integrated grid				
	IG8	Equipment, sensing, monitoring, measuring for				
	IG9	Advanced distributed control				
	IG10	Feeder auto-restoration / self-healing				
	IG11	Smart metering infrastructure				
CM	CM12	Distributed flexibility, load, forecasting,				
	CM13	Smart appliances				
	CM14	Building control, automation and energy				
	CM15	Electric vehicles				
	CM16	Energy communities				
	CM17	Lighting				
	CM18	Electricity market				
St	St19	Electric Storage				
	St20	Thermal Storage				
	St21	Power to X				
	St22	Pumped storage				
	St23	Other Storage				
Ge	Ge24	Flexible generation				
	Ge25	Solar including PV & Concentrated Solar Power				
	Ge26	Wind				
	Ge27	Hydropower				
	Ge28	Hydrogen & sustainable gases				
	Ge29	Other generation				
DCD	DCD30	Communication networks including devices and				
	DCD31	Digital Twins				
	DCD32	Artificial intelligence				
	DCD33	Data and cyber security including repositories				

5 Identification of gaps through Workshops and individual interview process

This section represents the main part of the feedback from stakeholders which was received during interviews and surveys with the stakeholders. Following the description of work and feedback from the stakeholders, the project group recognised the necessity to establish a direct interaction with various groups of stakeholders in order to obtain interdisciplinary feedback allowing to uncover gaps, barriers and in some cases best local practices. The interaction started at the first workshop in Sofia in 2019, when the first interviews were conducted. Introduction of COVID restrictions limited the possibility of physical interviews, therefore the project group continued with web-based interviews, which proved to function even better than physical interviews. All interviews were carried out according to GDPR requirements and organised as semi-structured interviews with rather qualitative results.

At the moment of writing, more than 30 semi-structured interviews and surveys have been accomplished in order to establish an open dialogue and identify specific stakeholder needs and expectations.

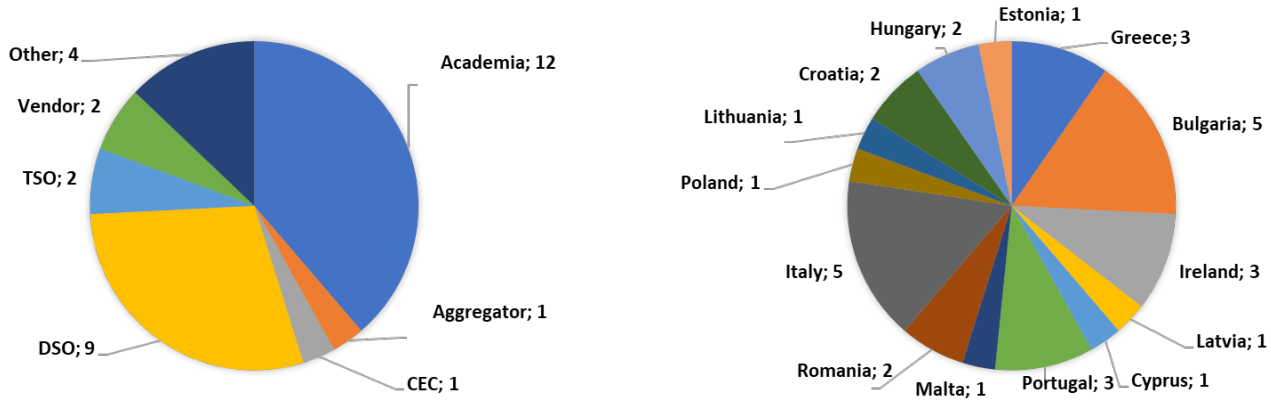


Figure 5 Interviews conducted by the project by November 2022.

The interviews include persons representing key stakeholders such as DSOs, TSOs, vendors, academia, citizens energy communities (CECs) and aggregators, as presented in Figure 5.

5.1 Limitations of the method

The following limitations of the method can be marked (and need to be taken into account when performing analysis of the results):

- The selected approach presents rather indicative than precise results, showing the most obvious gaps and shortages.
- The interviewed and surveyed stakeholder represent different actors, belonging to the SmartGrid domain, and their views and opinions vary accordingly.
- There is a certain level of personal opinions, which are presented at the interviews.
- Since the number of interviews is limited, applying statistical methods for data analysis is impossible.

5.2 The challenges requiring implementation of Smart Grid Technologies

There is a variety of feedback related to the challenges, the country and the affiliation of the specific stakeholders. The following selection is representative:

- The main challenge is high variability in production of electricity based on renewables. Massive deployment of RES (as for example in Poland) has not been followed by development of the grid.
- Growing necessity for consumers' empowerment and engagement.
- Deployment of electric mobility, especially in the major European cities.
- Necessity to improve the economics within the power sector, making it more targeted, and to facilitate reliability and security of energy supply.
- Optimal use of the existing assets and avoiding stranded assets.

5.3 Priority areas for implementation of Smart Grids solutions

An overview of the received feedback related to national priorities for the implementation of Smart Grid technologies is presented in Table 40. In some countries, more than one interview has been conducted, thus some priorities are listed multiple times for a country.

Table 40 National priorities for the deployment of SmartGrid Technologies

Country	Indicated priorities
Romania	• Operational improvement for safe and secure supply. • Extension of metrological metering within balancing market products. • Design of developed Big Data systems.
	(1) Advanced metering infrastructure. (2) Integration of renewable and distributed generation. (3) Charging infrastructure for electric vehicles.
Latvia	• Prepare the T&D grids for smart grid solutions through e.g., standards and connection requirements. • Data protection. • Regulatory framework for how the available infrastructure should be shared between the actors. • Clear rules for billing and settlement of active customers that will not have demotivating effect.
Italy	• Observability provided by advanced metering functionality and sufficient settlement. The first generation of smart meters has already been deployed. • Controllability. • Flexibility capability i.e., demand-side response management capability.
	• Develop tools for smarter use of resources in the grid, e.g., better utilisation of smart metering. • Establish advanced services for the demand side. • Creating new business models, regulations, and market actors to fully exploit the data and new functionality.
	• Observability • Controllability • Charging infrastructure for electric vehicles
Poland	• Smart metering • Observability • Better use of flexible resources.

Lithuania	• System adequacy • System reliability • System stability
Greece	• Roll-out of Smart Meters for all consumers, including LV residential. (Currently most MV and big LV customers) • Improved observability for DSOs • Application of controllability of production based on renewables and increase of hosting capacity.
Hungary	• Smart metering • Optimal integration of technologies. Often a strong focus on certain technologies without considering how these should interact with the rest.
Portugal	• Smart metering • Solve regulatory and administrative issues that are not prepared for technological development. Most technologies are ready, while the framework around them is not.
Croatia	• Improvement of observability, especially in LV networks. • Improve data processing • Improve the controllability of the network by either installing new smart components or by digitalising and unlocking the controllability/automation of the existing equipment • Create a framework to get customers to go from passive to active participants in the power system.

Based on the provided overview two important things can be observed:

1. There is a striking similarity in technological priorities, even though the answers are provided from different countries and different stakeholder groups.
2. What is more interesting is that the feedback complements an additional level of detail across countries

A summary of the answers in Table 40 is given below:

- The first technological priority is Advanced Metering Infrastructure (AMI), as a mandatory enabler of the next steps. However, proper utilisation of its potential requires a set of actions, including standardisation, and regulatory and administrative conditions, allowing to use and exploit the data. Installation of AMI is not a one-time action but a continuous stepwise improvement.
- The second technological priority is related to enabling observability and controllability functions for DSOs which allow handling RES and the deployment of EVs without compromising the overall reliability of the system.
- The third priority points towards enabling flexibility and Big Data technologies for enhancing the planning and operation of the grid.

In addition, the feedback underlines the importance of timely knowledge transfer from the countries which were forerunners in implementing new technologies, for example, Italy in the case of AMI, to the following countries.

In addition, the feedback underlines the importance of timely knowledge transfer from the countries, which were forerunners in implementing new technologies, for example, Italy in the case of AMI to the following countries.

5.4 Additional barriers for more activities in the SmartGrids domain

The question about additional barriers was not divided into technical or non-technical areas but an attempt to collect a comparative overview of both sides. Several topics were stated as barriers for more activities in the Smart Grid domain and are described as follows.

Lack of Targeted funding

Lack of targeted funding towards Smart Grids was mentioned as the main barrier and showstopper for many R&I activities. Several respondents pointed out that incentives should be focusing on specific topics.

Part of turnover at System Operators should be used for the development of Smart Grid solutions.

Change of mindset both on the industry and customer sides

In several cases, DSOs instead of deployment of Smart Grids choose to use conventional solutions, even though they are more expensive. It is necessary to convey to the industrial actors that Smart Grids actually work and apply targeted support schemes.

Smart Grids is more a philosophical concept than a technical concept, allowing active involvement of citizens. However, citizens are not familiar with the Smart Grid concept.

Standardisation

Different aspects of standardisation issues, including interoperability and legacy problems (products, services and technologies) were mentioned as pre-dominant technical barriers for development in the Smart Grids domain. This issue is so urgent that it calls for necessary actions from the regulatory part. It was also mentioned that this, apart from the electricity sector, also acts as a barrier for the sector coupling process.

Demanding application procedures at national levels

Countries may have several national funding agencies with different requirements, especially for paperwork. It is very difficult to obtain a clear overview and follow different rules and requirements. Harmonisation of the application process, at least at the national level, can be a solution.

Shortcomings of the legislation

Different aspects of national legislation, including the slow transposing of European Directives into national legislation and the consequences of this, were mentioned as a barrier. This delays the implementation of several changes regarding the evolution of different roles and responsibilities in the energy sector. There are several open questions about which actor in the power industry does what. This is the first thing to be done i.e., a clear market role model should be defined.

While changes in national regulations are ongoing, National Regulating Authorities (NRAs) should allow the creation of so-called "sandboxes" where new solutions can be tested and demonstrated.

Obsolete market design

Several respondents mentioned the organisation of markets as a barrier, such as:

- Many of the present market mechanisms are specific to certain technology and can act as a barrier to the entrance and implementation of new technologies. This applies, for example, to markets for

ancillary services, which were initially designed for thermal energy, and do not allow the use of alternative technologies such as storage.

- The present market design for electricity trading is based on marginal production costs. This has not changed much in the last 30 years and is becoming obsolete nowadays when RES production costs are close to zero.
- Marked design for “flexibility” products is still missing.

This issue should be approached as a common approach from the Pan-European level because solving it on a single-country level should be linked to and justified by the common Pan-European approach.

6 Conclusion:

PANTERA RICAP is an ongoing process that has been developed to analyse the “R&I status” and “R&I priorities” of smart grid technologies at the national and EU level and thus will also identify the technological gaps.

In parallel, the workshop, interview and survey outcomes are analysed to validate part of the RICAP findings and identify other non-technical barriers. The identified gaps and shortcomings have been used to shape the EIRIE platform's overall structure and content. The feedback from the interviews was specifically applied to selecting topics for case studies and Best Practices in the activity “Collaboration Working Groups” (WP6).

Both of the processes have been well established by this time. As the processes are ongoing, more input will be collected and analysed during the PANTERA project time, and the findings will be updated in the EIRIE platform.

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8 Annex

List of the analysed projects:

BUL	CRO	CYP	CZE
GARPUR	SIREN	FLEXITRANSTORE	AFTER
ZAS	CROSSBOW	BestRES	Arrowhead
CROSSBOW	FLEXITRANSTORE	INTERRFACE	e-Highway2050
FLEXITRANSTORE	TRINITY	FARCROSS	GARPUR
INTERRFACE	FARCROSS	SINFONIA	UMBRELLA
TRINITY	EV BASS	VIMSEN	BECA
FARCROSS	iUrban Project	GOFLEX	ENERsip
iUrban Project	OS4ES	inteGRIDy	EPIC-HUB
CryoHub	SUNSHINE	MERLON	FINESCE
INVADE	COMPILE	SMARTPV	Grid4EU
X-FLEX	UGRIP	StoRES	INTREPID
FLEX4FRID	FLEXCoop	InforPV	IoE
Energy Shield	SINCRO.GRID	FLEXCoop	PV Grid
EnVision 2020	SYNERGY	INTERPLAN	Smart Grid Prague
ICE-WISH	INSULAE	SYNERGY	Smart Region Vrchlabí
	FLEX4FRID	X-FLEX	TURBO-REFLEX
		NESOI	FLEXTURBINE
		PARITY	SHAR-Q
		INSULAE	InterFlex
		FEVER	ACON
		Cyprus RESGRID	
		BERLIN	
		DELTA	
		DRIMPAC	
		Dem4BIPV	
		ERIGENEIA	
		EdgeWise	
		HYBUILD	
		MEnS	
		PV-Estia	
		PEGASUS	
		eNeuron	
		EDDIE	
		ERIGrid 2.0	

		DATA CELLAR FLEXGRID MOST TwinERGY	
EST	**GRE**	**HUN**	**IRE**
Desire ICOEUR MIGRATE EU-SysFlex INTERRFACE EcoGrid EU e-GOTHAM I3RES Urb.Energy NESOI SOGNO	EWIS iTESLA CROSSBOW FLEXITRANSTORE INTERRFACE TRINITY FARCROSS Distribution Network Projects Agios Efstratios – Green Island AMBASSADOR BEAMS BESOS BeyWatch CORE GRID CRISTAL DERRI Dispower DOLFIN DREAM EDISON ELECTRA ELECTRA top up ENER - SUPPLY EnVision 2020 EU-DEEP FINESCE Grasp GRIDSOL Hybrid Energy project of Ikaria:Energy Sustainable island for real life community ICE-WISH IGREENGrid INCREASE INERTIA M2RES MERGE	Arrowhead Best Paths ETM LASTBEG FLEXITRANSTORE INTERRFACE TRINITY FARCROSS FutureFlow Distribution Network Projects CORE GRID E-mobility Hungary ENER - SUPPLY EU-DEEP GrowSmarter M2RES MANERGY NATCONSUMERS RE-SEEties SOLID-DER VIS NOVA Smart Synergy IElectrix	PROMOTioN EU-SysFlex FLEXITRANSTORE MIGRATE FARCROSS COOPERaTE ELSA GrowSmarter Mas2tering ModeSto RealValue SmartGridEnable SmartRuralGrid SPARKS VIMSEN GOFLEX RESERVE FLEXCoop Power Line Guardian/Tower Router Schwungrad Rhode SOGNO Power Off and Save DS3 SUCCESS CITIES PlanGridEV

	MIRABEL More Microgrids NATCONSUMERS NOBEL GRID NRG4Cast OS4ES PowerUp PV Grid PV-NET RERUM RE-SEEties SafeWind SEESGEN-ict SELFNET SINGULAR Smart Build SmarterEMC2 SmartHouse/SmartGrid SmartKYE SMART-NRG STORIES SUNSHINE TILOS VIMSEN COMPILE ebalance-plus E-LAND Energy Shield FEVER FLEXCoop FLEX4FRID iDistributedPV IElectrix INSULAE InterConnect inteGRIDy MERLON NESOI PARITY REACT RENAISSANCE SHAR-Q StoRES SUCCESS SYNERGY		

	WiseGrid X-FLEX SMILE PlatOne GIFT Coordinet BD40PEM		
ITA	**LAT**	**LIT**	**MAL**
Best Paths EU-SysFlex INTERRFACE MIGRATE PROMOTioN BeyWatch CityOpt City-Zen Amsterdam ELECTRA top up ELSA Encourage FLEXICIENCY Flexmeter FLEX4FRID INCITE Mas2tering NATCONSUMERS NETFFICIENT NOBEL GRID SCISSOR SELFNET SINFONIA SmarterEMC2 SMART-UP TILOS USmartConsumer VIMSEN Coordinet BD40PEM ebalance-plus Energy Shield FLEX4FRID FLEXMETER FLEXTURBINE iDistributedPV inteGRIDy InterConnect	Arrowhead ELECTRA ELECTRA top up EU-SysFlex INTERRFACE "ITCITY" CloudGrid RealValue Promoting Energy Efficiency in Households	LASTBEG PEGASE "VIDIŠKIAI DIGITALIZATION" Distribution Network Projects ECO-LIFE SOLID-DER Urb.Energy iDistributedPV	EMPOWER Grasp GrowSmarter SMART-UP SUNSHINE WISEPV BIG-HIT DELL4ALL TwinERGY HELENUS JUMP2Excel NEEMO

INTERPLAN INSULAE FLEXIGRID GRIDSOL GIFT MUSE GRIDS NESOI PlatOne PLATOON REACT RENAISSANCE RESERVE SMILE SOGNO StoRES SUCCESS SYNERGY TURBO-REFLEX WiseGrid OSMOSE plan4res subzéro STORE&GO SmartNet StorageLab Hybrid HVAC / HVDC overhead lines in Switzerland Advance Dispatching & LFOR LIVING GRID			
POL	**POR**	**ROM**	**SLO**
EU-SysFlex ELECTRA top up M2MGrids SALVAGE SCISSOR Smart Toruń UPGRID USmartConsumer iDistributedPV INTERPLAN TURBO-REFLEX RENAISSANCE PLATOON	EU-SysFlex FLEXITRANSTORE INTERRFACE AnyPLACE DREAM-GO E-BALANCE ELECTRA ELECTRA top up GReSBAS GrowSmarter INCITE M2MGrids MERGE	CROSSBOW INTERRFACE FARCROSS FutureFlow TRINITY FLEXMETER GID-MicroRede GrowSmarter M2MGrids NOBEL GRID SUNSHINE inteGRIDy FlexiGrid	EU-SysFlex FLEX4FRID INERTIA SHAR-Q ACON

InterConnect EUniversal ebalance-plus	NOBEL GRID SEGRID SELFNET SENSIBLE SmarterEMC2 UPGRID COMPILE EUniversal ebalance-plus GIFT inteGRIDy InterConnect INSULAE NESOI OSMOSE SHAR-Q SMILE StoRES SYNERGY InteGRID Graciosa Project Sinapse TDX-ASSIST	Energy Shield "ITCITY" SOGNO E-LAND RESERVE SUCCESS WiseGrid RERUM SMILE	