PANTERA
Pan European Technology Energy Research Approach

Work Package WP4 "Key Topics and Content Management"

Deliverable D4.1

Content and Topics for Dissemination and Networking Activities

Grant Agreement No:	**824389**
Funding Instrument:	**Coordination and Support Action (CSA)**
Funded under:	**H2020 LC-SC3-ES-7-2018: Pan-European Forum for R&I on Smart Grids, flexibility and Local Energy Networks**
Starting date of project:	**01.01.2019**
Project Duration:	**48 months**

Contractual delivery date:	**01.09.2019**
Actual delivery date:	**08.10.2019**
Lead beneficiary:	**SINTEF Energi AS**
Deliverable Type:	**Report**
Dissemination level:	**Public**
Revision / Status:	**Final**

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action Programme under Grant Agreement No. 824389

Document Information

Document Version: 04

Revision / Status: Final

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Keywords: technological topics, decision-making, regulatory issue

Document History

Revision	Content / Changes	Resp. Partner	Date
00	Creation of the document.	SINTEF	2019-05-28
01	Issued for comments to the project group	SINTEF	2019-08-26
02	Issued to public consultation	SINTEF	2019-09-16
03	Issued to internal approval	SINTEF	2019-10-03
04	Comments from the internal approval implemented.	SINTEF	2019-10-07

Document Approval

Final Approval	Name	Resp. Partner	Date
approved on task level	Shafi Khadem	IERC	03.10.19
approved on WP level	Rad Stanev	TUS	03.10.19
approved on Board level	Venizelos Efthymiou/Christina Papadimitriou	FOSS	05.10.19

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Abbreviations

Acronym	Meaning
AD	Active Demand
CHP	Combined heat and power
CINELDI	Centre for Intelligent Energy Distribution
CSA	Coordination and Support Action
DER	Distributed Energy Resources
DSO	Distribution System Operator
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
ETIP-SNET	European Technology and Innovation Platform Smart Networks
EV	Electric Vehicle
HV	High Voltage
ICT	Information and Communication Technology
IoT	Internet of Things
IRP	Integrated Research Program
LV	Low Voltage
MV	Medium Voltage
NRA	National Regulating Authority
NVE	Norwegian Water Resources and Energy Directorate
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaics
R&D	Research and Development
R&I	Research and Innovation
RES	Renewable Energy Sources
TSO	Transmission System Operator

1 Introduction

The work in this report is carried out under activity "Key topics and content management" of the PAN European Technology Energy Research Approach (PANTERA) project. PANTERA is an EU H2020 project aimed at setting up a European forum composed of Research & Innovation stakeholders active in the fields of smart grids, storage and local energy systems, including policy makers, standardisation bodies and experts in both research and academia, representing the EU energy system.

1.1 Activity "Key topics and content management"

The objective of the activity is to identify and deliver an updated set of topics for dissemination and networking conditions activities in such a way that it will ensure the compliance of project activities with the stakeholders' needs. The activity aims to identify the proper content and topics for dissemination and networking activities within the project, consisting of setting up a forum, events organisation, virtual meetings, establishing collaborative working spaces and social media.

This deliverable is one in the series of three reports, seeking to carry out the following analysis:

- Initial definition of the content for dissemination and networking activities
- Identification of gaps and missing subjects throughout the course of the project
- Final assessment of the defined topics; relevance, driving forces and trends.

The main objective of this report is to present the initial identification of the content aligned with Pan-European goals and priorities. This will form the baseline for the needs' identification of the stakeholders and thus the content of the dissemination and networking activities.

Additional evaluation of learnings from the first identification as well as further elaboration of the topics of content will be discussed in the following related deliverables:

- D4.2 "The 1st report on identification of gaps and missing subjects"
- D4.3 "Final report on identification of gaps and missing subjects"
- D4.4 "Assessment of the defined topics; relevance, driving forces and trends"

More details as regards next steps of WP4 activities and their connection with this deliverable and in general the PANTERA process,l will be highlighted in the last section.

1.2 Purpose and limitations of the document

The document presents results from the first task in activity "Key topics and content management", outlining the first version of content and topics for dissemination and networking activities within PANTERA.

At the time of writing, the project still has an ongoing discussion with several Pan-European industrial associations, related to the selected model and approach, meaning that these can be modified in order to achieve the most efficient impacts of the project. In addition, the present version of the document does not include results of the ongoing survey, which has been initiated based on learnings from the first project's workshop which was held on 02 July 2019 in Sofia, Bulgaria. The survey will contribute to time differentiation of the technological topics.

1.3 Structure of the Document

The document starts with establishment of the common high-level structure for the key topics, binding together decision-making and regulatory aspects supporting Research and Innovation (R&I) with technical content, specific for the Smart Grids, energy storage and local energy systems domain. The document further explains selection of technological topics, which are based on the work done by the European Technology and Innovation Platform Smart Networks for Energy Transition (ETIP-SNET)[1].

The following section presents a short case-study related to R&I decision-making practice in Norway, using this as a background for defining the main roles and responsibilities in the process. The document further presents results of the first organised interaction with PANTERA stakeholders – interviews organised in Sofia, during dedicated PANTERA workshop 2019-07-02. At the moment of writing a survey, which was created after the workshop and related to priority of the technical topics is still in process (see Section 4.1.4.). This report is concluded with discussion and conclusions revealing plans for ongoing work in the field of Key Topics and Content Management and the planned forthcoming deliverables .

2 Structure for the main topics of content: from the political goals to R&I activities

Strategic priorities and overall national and Pan-European political goals in many ways decide the scope of R&I activities. Strategic priorities and political goals guide the direction of the decision-making, which again decides the funding and support schemes for different R&I activities. The strategic priorities and political goals might also create technological challenges which need to be solved. This again leads to certain technological topics, which need to be further investigated in R&I activities. Furthermore, in case there is a research gap related to a certain issue, this gap must be identified and highlighted with key priority, while the R&I community must be encouraged to work on this issue by different means, including dedicated funding.

Definition and structuring of technical topics in a very specific interdisciplinary domain as Smart Grids is obviously a none-trivial task. In order to save time and efforts, it was planned already during the preparation phase of PANTERA to use one of the well-established technical taxonomies for the Smart Grids domain.

2.1 Proposal for the technological topics: background and previous work

Several partners participating in PANTERA have been previously involved in European Technology and Innovation Platform Smart Networks for Energy Transition (ETIP-SNET) and more specifically in the development of ETIP-SNET's Integrated Roadmap 2017-2026 [1]. It is also necessary to mention that several PANTERA partners are also participating in the development of 2020 to 2030 roadmap.

The integrated roadmap is built upon a tree-like structure creating a comprehensive framework for evolution of the power system in the next decades and connecting this to the future European R&I strategic needs. The roadmap's structure establishes a logical connection between several key steps for evolution of the power system:

[1] https://www.etip-snet.eu/

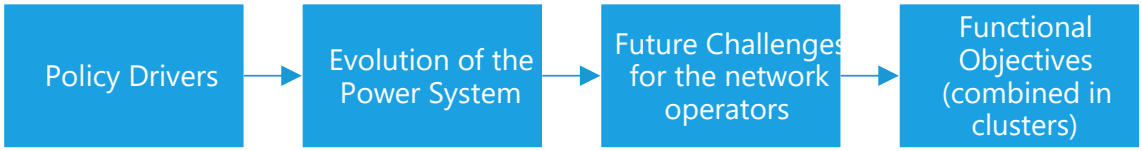

Figure 1 Logical structure applied in ETIP-SNET's Integrated Roadmap 2017-2026.

The provided sets of functional objectives are further combined into several clusters for TSO and DSO corresponding to their main business activities.

The integrated roadmap is a thorough and well-detailed framework, but due to its complexity and since it is intended to serve a different purpose, it is not feasible to transfer the whole roadmap structure to PANTERA's communication with stakeholders. On the other hand, the suggested taxonomy of the functional objectives for the Smart Grid domain has been validated by key European actors as ENTSO-E and DSOs and thus can be deployed as a starting point for PANTERA, as it was initially stipulated in PANTERA Description of Work.

Table I and Table II present an overview of functional objectives as it has been elaborated in the Integrated Roadmap. Since ETIP-SNET uses very specific terminology and for the sake of simplicity, the present document will use term "topics" instead of "functional objectives" from now on.

Table I Functional objectives (topics) for the distribution system, Source: [1]

Cluster (main activity)	FO ID	Functional Objectives (Topics)
C1 – Integration of smart customers and buildings	D1	Active demand response
	D2	Energy efficiency from integration with smart homes and buildings
C2 – Integration of decentralised generation, demand, storage and networks	D3	System integration of small DER
	D4	System integration of medium DER
	D5	Integration of storage in network management
	D6	Infrastructure to host EV/PHEV – Electrification of transport
	D7	Integration with other energy networks
	D14	Integration of flexible decentralised thermal power generation
C3 – Network operations	D8	Monitoring and control of LV network
	D9	Automation and control of MV network
	D10	Smart metering data processing and other big data applications
	D11	Cyber security (system approach)
C4 – Planning and asset management	D12	New planning approaches and tools
	D13	Asset management

Table II Functional objectives (topics) for the transmission system, Source: [1]

Cluster (main activity)	FO ID	Functional Objectives (Topics)
C1 – Modernization of the network	T1	Optimal grid planning
	T2	Smart asset management
	T3	New materials and technologies
	T4	Environmental challenges and stakeholders
C2 – Security and system stability	T5	Grid observability
	T6	Grid controllability
	T7	Expert systems and tools
	T8	Reliability and resilience

	T9	Enhanced ancillary services
C3 - Power system flexibility from generation, storage, demand and network	T10	Storage integration
	T11	Demand response
	T12	RES forecast
	T13	Flexible grid use
	T14	Interaction with non-electrical energy networks
	T22	Flexible thermal power generation
C4 - Economic	T15	Market-grid integration
	T16	Business models
	T17	Flexible market design
C5 – Digitalization of power system	T18	Big data management
	T19	Standardization and data exchange
	T20	Internet of Things
	T21	Cybersecurity

More detailed description of these is presented in the Annex, page 18.

2.2 Proposal for the decision-making, political and regulatory topics: background and previous work

One of the key objectives in PANTERA is to research and transfer best practices across countries in order to support and accelerate R&I activities in the Smart Grid domain. During the course of the project it has been established that organisation of regulatory and decision-making processes can be equally important as the technical part.

Several transformation processes in today's power sector are driven by the overarching political goals related to the global climate challenges. Therefore, the regulatory and decision-making part is an important trigger for targeted R&I activities. Definition of the key elements for this part is initially based on similar activities done by ELECTRA IRP (FP7) [2] and further refined by case study, supported by the feedback from selected stakeholders.

In a previous FP7 project ELECTRA IRP (2014-2018) [3] a considerable work has been done in aligning and coordination of its activities with the major smart grids R&D activities in Europe. The results were summarised in several publications, where [2] makes a critical outline for a first scenario and state of the art of the European strategies, priorities, on-going programs, results obtained and stakeholders involved (with particular reference to industry) in the smart grids and energy sector for the evolution of the European energy system towards a Smart Energy System. This document appears to be very relevant for the scope of the present activity and serves as an important inspiration by defining the so-called Smart Grid R&I landscape across several European countries and thus providing the main input to identification of the politico-regulatory aspects, discussed in the present document.

3 Case study for the main topics of content

The intention of the case study was to validate and refine the first draft of a rather generic decision-making and regulatory structure for support and coordination of national R&I activities. Norway was selected as main reference country for the case study mostly due to easy access to the necessary information.

The following types of organisations have been explored:

- National advisory body

- National decision-making bodies
- Funding bodies and programmes (national and regional)
- National supporting and coordinating organisations

3.1 National advisory body for R&I – Energi21

The Energi21 strategic body was established by the Ministry of Petroleum and Energy in 2008 to promote coordinated, efficient and targeted efforts in research and technology for the energy sector, and its strategy is aligned with the Norwegian energy policy [4]. Energi21 has defined several important actions for realising its strategy, such as developing a framework of funding instruments to promote rapid innovation and results and increasing the budget for R&I projects. Figure 2 shows the connection between Energi21 and the Ministry of Petroleum and Energy in Norway.

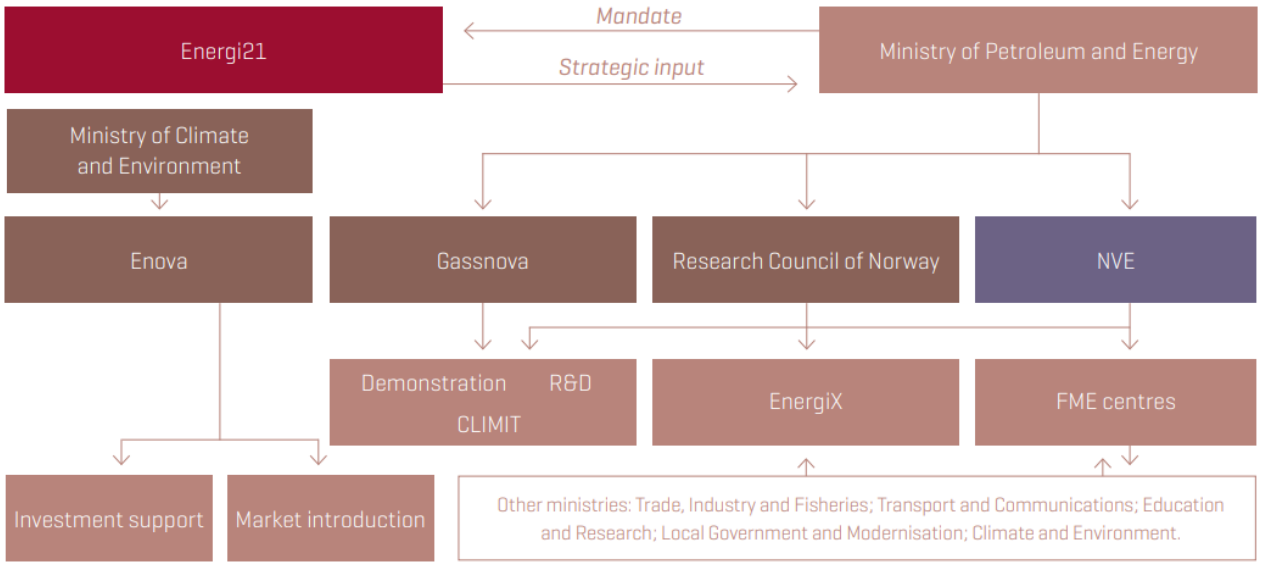

Figure 2: The organisation of the energy research under the Norwegian Ministry of Petroleum and Energy. Source [4].

Energi21 functions in practice as an interdisciplinary advisory organ comprising approx. 100 representatives from industry, academia, interest organisations and authorities, for defining thematic and financial priorities for R&I activities within the Energy domain. Similar organs are established for other domains as for instance transport, ICT etc.

3.2 National Decision-making body (-es)

In case of Norway, the involved national decision-making bodies are the Ministry of Climate and Environment and the Ministry of Petroleum and Energy.

3.3 Funding bodies and programmes

There are three main funding bodies within the Smart Grids field in Norway, for R&I, innovation and regional funding, see Figure 2.

National R&I funding body - Research Council of Norway:
In Norway, the main funding body for R&D activities is the Research Council of Norway. The Research Council works to promote R&I and to generate knowledge in priority areas. There are

several research programmes, where a programme is a targeted research effort to provide new knowledge and innovation in a limited field; it can be a subject area, theme and/or industry. The two programmes that are most relevant for the smart grids field are ENERGIX and FME Centres.

EnergiX is a research programme that seeks to facilitate the transition to a "low-emission society" and promote a competitive Norwegian business sector [5]. The programme is funded by several ministries. One of them is the Ministry of Petroleum and Energy, which gets input from the strategic body Energi21, see Figure 2. The programme funds research and innovation through several types of projects. In order to secure a sufficient engagement of industry into R&I activities (both with regard to funding and direct involvement), the Research Council applies several organisation models for the funded projects. The most relevant projects for industry are Competence and Cooperation Project for the Industrial Sector and Innovation Project for the Industrial Sector, where the latter presumes a higher level of industrial funding.

Centres for Environment-friendly Energy Research (FME centres) work with long-term research aimed at renewable energy, energy efficiency, CO2 management and social science and are established for a period of up to eight years. Centre for Intelligent Electricity Distribution (FME CINELDI) was established in 2016 and aims to enable a cost-efficient realisation of the future flexible and robust electricity distribution grid.

The Research Council also manages the financial support scheme SkatteFUNN, which does not fund basic research projects, but funds projects that develop new or better products, services or production processes for the benefit of a business. Businesses can get up to 20 % of their project costs deducted as tax credit.

Innovation funding body - Enova SF:
Enova SF was established in 2001 and aims to contribute to reduced greenhouse gas emissions and a strengthened security of supply for energy, in addition to development of technology that in the longer term also will contribute to reduced greenhouse gas emissions. As shown in Figure 2, Enova gets funding from the Ministry of Climate and Environment. Enova aims to support industry to develop both technology and markets, so that new technology can be utilised. Normally Enova supports not research, but specific implementation projects, for both end-users and businesses.

Regional funding body - Nordic Energy Research:
Nordic Energy Research is the platform for cooperative energy research and policy development under the Nordic Council of Ministers covering Norway, Sweden, Denmark and Finland. They fund research of joint Nordic interests within four areas: Clean energy for electricity, heating and transport; Regional grids; Active end users; Nordic energy system studies.

3.4 National regulating authority – NVE

The Norwegian Water Resources and Energy Directorate (NVE) is a directorate under the Ministry of Petroleum and Energy. Among other tasks, NVE regulates the Norwegian grid companies' income, to ensure an efficient operation, development and utilisation of the power grid. For the present study it is interesting to mention that NVE in its capacity of the National Regulating Authority (NRA) has introduced a specific support scheme in order to encourage DSOs to fund R&I projects: the grid companies can get 0.3 % of their expenses related to R&D covered, as an attempt to stimulate to more research in the field.

3.5 Supporting and coordinating organisations

There are several supporting and coordinating organisations for R&I in Norway. A description of the most relevant organisations for R&I within the Smart Grids field follows.

Coordinating organisation - Energy Norway:
Energy Norway is a non-profit industry organization representing about 280 companies involved in the production, distribution and trading of electricity in Norway [6]. Energy Norway works actively to improve the regulatory framework both in Norway and Europe. They also host seminars and conferences as well as develop and manage research projects, where Energi Norge functions as a coordinating body for pooling together several DSOs and raising funding for R&I.

REN:
REN is owned by 61 DSOs and has 126 DSOs as members/customers. REN works with standardisation and guidelines for industry, by providing guidebooks and tools and hosting seminars to share knowledge and best practice [7].

The Norwegian Smartgrid Centre:
The Norwegian Smartgrid Centre is a national centre for competence within Smart Grids, and works with R&D, demonstration projects and commercialization. The centre also operates a national demo committee, which aims to contribute to establishment of demonstration activities at energy and grid companies within Smart Grids.

3.6 Steps in the decision-making part

A generalised version of the process described in the previous section is shown in Figure 3. National goals and political strategy lead to a national R&I strategy, which again leads to funding for R&I activities, either through national regulations or directly to research programmes. The R&I activities could be industry support schemes or research programmes. The national goals and political strategy also lead to a strategic input to the national R&I strategy. The national R&I strategy also gives input back to the strategic input. In addition to the national, there are also regional goals and political strategy, which again lead to a regional R&I strategy, finally leading to research programmes.

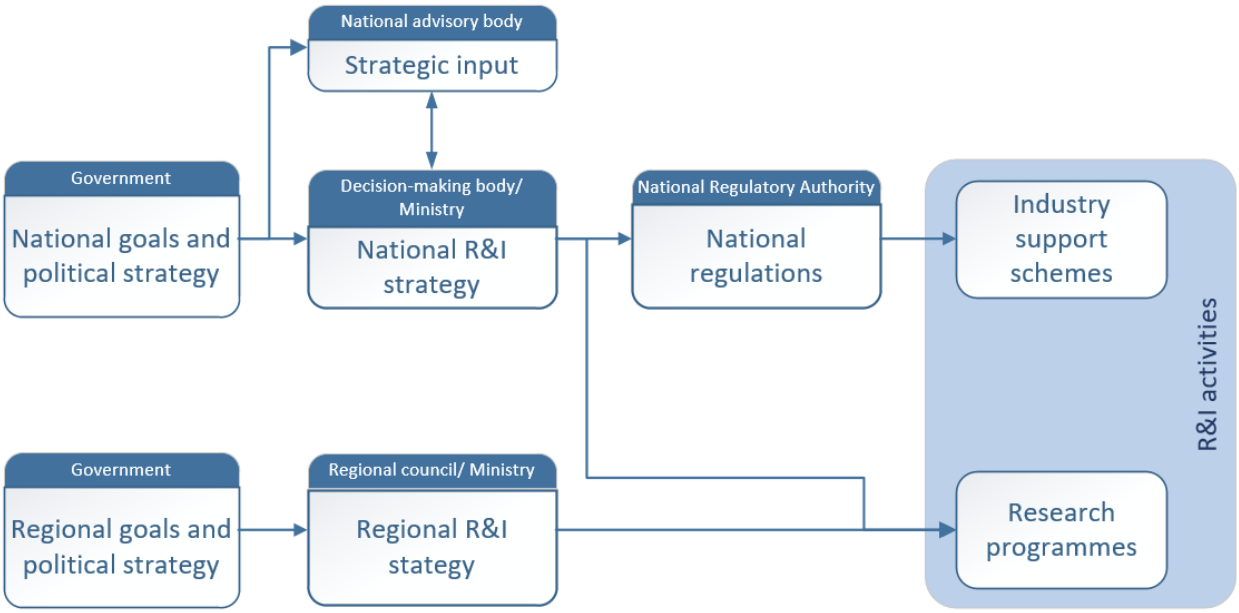

Figure 3: Steps in the decision-making process of funding for R&I activities.

Figure 3 summarises results of the case study, describing a generic decision-making process, which includes several national and regional institutions. The figure depicts a set of roles, which can be populated with instances appropriate for any given country.

4 Input from the stakeholders

PANTERA project was initially planned to function in a close and continuous dialogue with stakeholders, realised in different forms of cooperation e.g. workshops, surveys and interviews. In this particular activity the first interaction was done via a set of interviews with a representative selection of stakeholders, which was conducted during the first PANTERA workshop in Sofia (BG) in July 2019.

In addition to the interviews carried out during the first PANTERA workshop, another form of a stakeholders' consultation was attempted too. Prior to issuing this final version, a pre-final version of the current deliverable was uploaded to the PANTERA's homepage along with an invitation to the stakeholders to provide a feedback on the project as a part of a so-called public consultation. No specific comments have been received within the scheduled (opened/provided) consultation period

4.1 Summary of the interviews in Bulgaria

The project arranged its first official workshop in Sofia (BG), where mostly stakeholders from Bulgaria were represented. Based on results from the interviews, an additional survey has been initiated in order to clarify relevance of the suggested technical topics (See Section 4.1.3).

4.1.1 Purpose and method for the interviews

The first draft of the suggested approach for this activity was presented to the stakeholders during the workshop. The interviews were therefore an attempt to receive an immediate feedback from the stakeholders and if needed to make the necessary adjustments to the process.

Since this study can be defined as a rather qualitative research with a fairly limited number of respondents, the interviews were initially planned and conducted as so-called semi-structured interviews, allowing new ideas to be brought up during the interview as a result of what the interviewee says. The set of guiding questions was related to four main topics to be explored:

- Architecture of Smart Grid landscape: specifics of the national organisation, decision-making and national R&I support schemes (see Section 2.2)
- Technical issues (functional objectives, see Section 2.1) from the Smart Grid domain, including importance/prioritising and if possible, reasoning.
- The first feedback to the overall PANTERA's approach
- Any other relevant information and inputs

Results of the interviews unlike online surveys are not statistically significant and thus have to be analysed in a qualitative way.

The intention of the interviews was to receive opinions from representatives of different type of institutions, which are directly relevant to the activity. The group included:

- Two representatives from DSOs (one of them former)
- One representative from TSO
- One representative from R&I (academia)
- One representative from Electric Vehicle Cluster
- One representative from a manufacturing company

The interviewees represent positions of different stakeholders and have naturally different and somewhat contradicting opinions.

4.1.2 **Architecture of Smart Grid landscape**

The issue of coordination of R&I was not initially included into the interviews. It was therefore one of the most interesting feedbacks from the interviews, when the coordination was independently brought up by several of the participants referring to different purposes.

Analysing the results, at least three different points related to coordination were defined:

- It was indicated that better coordination is needed between the R&I community and industrial companies, especially when it comes to fundamental research financed by the government. Thinking was mentioned as one of the most obvious barriers preventing integrated and coordinated research.
- Long-term alignment and coordination of R&I efforts within the research community on national level will support meeting the overall implementation of Smart Grids technologies.
- The respondents were not aware of any existing practice of coordinated research funding pooled together from several industrial partners, as for example several DSOs together or DSOs plus manufacturers. No organisation at the moment takes a coordinating role for related industry funded R&I projects.

The last point was referring in general to funding of R&I and more specifically in Smart Grids domain.

It was mentioned that there are no specifically targeted support schemes (as tax breaks, revenue adjustments or similar), encouraging network operators to participate in and fund R&I activities. Participation in European projects is not attractive to network operators due to limitations of cost recognition from the Commission and depreciation rules.

Using of different funding schemes for coupling of different financial instruments, is possible but it is not well-documented as to what are the difficulties to apply these.

Somewhat different opinion was expressed by the TSO, which involves academia in applied research projects, necessary to resolve specific challenges.

Another complicating factor is that implementation of Smart Grid solutions in the household sector is currently difficult due to limited wealth and cost concerns of the end-users.

4.1.3 Feedback to the technical topics

The first draft of the technical topics is directly based on the taxonomy, which was previously suggested and verified by ETIP-SNET. Interviewees were asked about feedback to the list of the technical topics (functional objectives in ETIP-SNET's terminology). Some of the respondents pointed out that it can be too early to explore some of the suggested topics. This does not necessarily mean that these are irrelevant but can be introduced later on. It is difficult to introduce active demand response schemes, before deployment of advanced metering systems, which function as a key enabler.

This supports the chosen approach for definition of the technical topics by referring to ETIP-SNET work. The topics however should be introduced sequentially, closed to roadmap pathway, following interdependencies between different technical elements.

4.1.4 Survey monitoring priority of the technical topics

Based on the above-mentioned conclusion, the project group prepared an additional follow-up survey, asking the stakeholders to range relevance of the suggested technical topics. The survey was divided in TSO- and DSO-related parts, the respondents may answer in both parts, what is especially relevant for R&D stakeholders, invited to the survey. The survey is intended to last throughout the course of the present activity. At the time of writing the present report however, the number of responses was not sufficient to derive sound conclusions, so the survey will be followed-up in the succeeding activities.

4.1.5 The first feedback to PANTERA's approach

PANTERA is a very positive and timely initiative. It is expected that the project will contribute to better access to information, specifically related to funding tools and possibilities. Pooling together different available instruments into one platform will be favourable for all stakeholders. It is expected that it will contribute to increase of knowledge, coordination of R&I and network contacts.

4.1.6 Other relevant information and inputs

The following two additional points were made by the respondents:

- Configuration of the distribution networks in Greece is very different from Bulgaria and Romania, what may cause challenges for the present regional division as suggested by PANTERA members.
- Discrepancy between the national and European regulatory and technical requirements.

5 Discussion and Conclusions

Being the first deliverable in "Key topics and content management" activity, the present report outlines the key topics for dissemination and communication activities, which will be applied in the PANTERA platform. The topics will be further elaborated in the subsequent tasks of the activity.

Dissemination and communication topics related to R&I activities in the Smart Grid domain appear to have a complex structure, combining both decision-making/regulatory aspects with technology-related areas. The first set of topics is intended to guideline the stakeholders to the technological dimension of the Smart Grids domain, ensuring that the activities will match the overall national and Pan-European goals in a timely and systematic manner.

Having said that, within this deliverable, preparatory and baseline activities regarding the content of dissemination and networking, are included and their outcomes were presented. Under this frame:

- The technical content overview in order to make the approach more systematic was identified. The content was assessed, categorized and aligned with Pan-European roadmaps from ETIP-SNET.
- Under this technical content, the needs of the stakeholders and the challenges that may confront was identified through the interviewing process within the 1st workshop of PANTERA.
- The national research and innovation on Energy support structure of the Norwegian case was described as a good example of having institutions that can support dissemination of results and networking activities of the interested parties.

There are several issues, which are still not adequately investigated requiring attention to provide clarifications in the succeeding activities of PANTERA. At this stage we can note the following that call attention:

- The level of granularity for the suggested topics i.e. whether it is sufficient or more specific sub-categories will have to be defined.
- Priority selection criteria, which can be applied for the topics, in order to initiate specific topic-related activities. The initial idea was to interact with stakeholders and assign rating levels to each of the topics. After the first interaction it appears that the project should rather align topics with a timeline (see results of the interviews).
- Extension of the scope with inclusion of new topics may become relevant during the course of the project and beyond.

So, in the deliverables to follow, a wider perspective will be given for all countries in Europe and the content of interest will be related to the PANTERA outcomes that will support the dissemination and networking:

- The technical content will be further updated by taking into consideration D6.1 feedback regarding the gaps on policy and regulation as identified for all PANTERA regions under that

package.

- Regarding the needs and the challenges of the stakeholders, feedback from D2.1 and the workshops that will take place in between will be included. It is of crucial importance to map all the needs under different stakeholders' categories. Towards, this direction, the next deliverable will include results from both our ongoing discussion with several Pan-European industrial associations and results of the ongoing survey. In the meantime, the public consultation is running so the outcome will also be included and analyzed.
- Finally, the analysis on the existing mechanisms of supporting R&I for countries within PANTERA regions will be analyzed and will be compared with the Norwegian case study and other countries that reveal best practice cases. This task will identify the missing links of dissemination and networking within the countries that are lagging in R&I on smart grids.

These activities outcomes' will be included in the first report of WP4. This will give significant feedback to the PANTERA platform for both content and functionalities to be included but also extend it to other PANTERA activities such as desks in order to address limits and bidge gaps with agreed procedures.

The final conclusion is that common configuration and interlinking of several interdisciplinary topics is a non-trivial issue. The gathered learning proves that to combine an empirical knowledge from a case study together with a direct interaction with stakeholders is a correct methodology (an appropriate approach), which can provide valuable input to the project.

6 References

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7 Annex

7.1 List of Figures

7.2 List of Tables

7.3 Description of functional objectives for distribution systems

The following table summarizes the objective of each Functional Objective for Distribution System, as given in [1].

Cluster	FO ID	Functional Objectives for Distribution Systems	Objectives
C1 – Integration of smart customers and buildings	D1	Active demand response	Some major European DSOs and market players have already tested and demonstrated the technical feasibility of AD response in projects targeting samples of end-users (of the order of magnitude ~100 consumers): Further R&I work must be promoted to foster end-consumers' participation in the retail electricity markets, so as to enable the provision of system services for network flexibility (e.g. the real-time optimisation of power flows at distribution level) and possible transmission level.
	D2	Energy efficiency from integration with smart homes and buildings	The main objective of D2 is the deployment of smart grid technologies in urban areas in order to reach the goals set by the EC in terms of energy efficiency in buildings. The fulfilment of this objective implies a close cooperation between network operators and market players (retailers and aggregators) so as to optimize the operation and planning of the network, taking into account the interactions with the other urban networks (cf. D7).
C2 – Integration of decentralised generation, demand, storage and networks	D3	System integration of small DER	The main objective of D3 is to increase the penetration of small DER (mainly PV) in the LV networks, within a well-planned process, covering the full range of encountered combinations between the spatial distribution of PV and network topologies, while keeping the network within its stability limits. Monitoring and control (D8) in combination with the implementation of advanced Network Energy Management systems will help DSOs to better operate the LV distribution grids hosting large amounts of PV.
	D4	System integration of medium DER	The main objective of D4 is to increase the penetration of medium DER in the MV(HV) networks, covering the full range of encountered combinations between generation portfolios and network topologies, while complying with power quality limits and keeping the network within its stability limits. Active Control (D9) in combination with the implementation of advanced Network Operation and Energy Management systems will help DSOs to better operate the distribution grids hosting large amounts of DER.

	D5	Integration of storage in network management	The main objective of D5 is to specify, simulate and set up real-life demonstrations that will help market players and network operators better appraise the real added-value (technical and economic) brought by storage in the operations of the power system (flexibility and system services). These demonstrations will include specific work on innovative business models and recommendations regarding the necessary regulatory framework to be put in place.
	D6	Infrastructure to host EV/PHEV – Electrification of transport	The main objective of D6 is the evaluation of the impacts of electrification of transport (mainly EVs) may have on the European distribution grids from the perspective of planning, operation and market design. The massive integration of EVs and electric transport in cities could allow load control (load shaping) and system services (from distributed storage with V2G -vehicle-to-grid- applications), but could also result in overloads and power quality issues (voltage profiles and harmonics).
	D7	Integration with other energy networks	The main objective of D7 is to demonstrate that the flexibility options brought by the coupling of the electricity distribution grid with other energy networks can help DSOs better operate the network with very high penetration of intermittent generation.
	D14	Integration of flexible decentralised thermal power generation	For thermal power plants (including industrial cogeneration units, small and micro CHP units, etc.), the main challenges are to further improve the flexibility and efficiency performance to back-up renewables, to better integrate the existing and future units in the grid/energy system, to develop technologies with high electrical efficiency that can use hydrogen, biomass and biofuels and to demonstrate their techno-economic performances in comparison to other flexibility solutions.
C3 – Network operations	D8	Monitoring and control of LV network	Some major DSOs have started to equip and test their distribution LV networks with some TSO and MV-like monitoring and control equipment: however, there is still a need to demonstrate under real operating conditions and at a large scale, an integrated set of new solutions to improve LV network monitoring and control for all distribution grids in Europe, at affordable costs.
	D9	Automation and control of MV network	Major DSOs have equipped and tested their distribution MV networks with advanced monitoring and control equipment: however, there is still a need to demonstrate under real operating conditions and at a large scale, an integrated set of new solutions to improve MV

			network automation and control for operation and maintenance of all distribution grids in Europe in order to better integrate renewables and new loads.
	D10	Smart metering data processing and other big data applications	Scalable solutions to address large-scale data management issues in the electric distribution systems must be developed, which implies the standardisation of data models, methods and tools for data storage, data mining techniques, and data editing solutions. The availability of such solutions is a key to develop data mining algorithms for all stakeholders of the distribution system. For DSOs, data management solutions associated to modern data mining techniques will allow the optimisation of the grids (power flow optimisation, faults detection, power quality, DER hosting capacity, asset management). For other market players, it will create new business opportunities.
	D11	Cyber security (system approach)	The main objective of D11 is to map and appraise cyber-security issues for the distribution grid, and propose solutions to mitigate these risks, ideally in an integrated manner in order to solve the problem in a systematic way.
C4 – Planning and asset management	D12	New planning approaches and tools	The purpose of D12 is to develop the next generation of planning tools able to account for the fast-evolving environment of distribution networks.
	D13	Asset management	The main objective of D13 is to provide DSOs with methodologies and tools to optimise the yearly expenditures for operation and maintenance by moving from planned maintenance to condition-based and risk-based maintenance (both for the existing and the next generation of power components) as well as for the new digital environment, therefore extending the lifespan of assets while reducing service interruption times and ensuring safety.

7.4 Description of functional objectives for transmission system

The following table summarizes the objective of each Functional Objective for Transmission System, as given in [1].

Cluster	FO ID	Functional Objectives for Transmission System	Objective
C1 – Modernization of the network	T1	Optimal grid planning	The objective is to develop planning tools methodologies and simulation software to assess the options for a pan-European power system, in particular for the transmission system infrastructure. It should also facilitate system simulations at the European level to compare several design options based on different technical, economic and environmental criteria, and accounting for emerging technologies and business models. Another objective is to integrate the planning perspectives: how the grid planning phase can best serve the future operational needs during the grid operation phase.
	T2	Smart asset management	The objective is to maintain robust and cost-effective network infrastructures with reliable performance by optimising asset management through: • Validation of new monitoring concepts for components and systems in view of scheduling maintenance that maximises network flexibility; • Elaboration and validation of new selective maintenance methodologies that leverage condition-based, predictive-based and risk-based approaches; • Development of new failure models by improving the understanding of how working conditions impact the aging of critical network components, creating enhanced monitoring systems or performing ex-post analysis of assets that have been removed from the grid. • Implementation of new breakthrough technologies, such as robotics or drones, in order to reduce costs and increase human safety and asset availability.
	T3	New materials and technologies	• Emerging power technologies will be demonstrated and validated to increase the flexibility and capacity of the existing power grid. • New materials and technologies, including energy storage, will be tested and validated to increase performance, extend lifetime, improve the maintenance of current assets,

Cluster	FO ID	Functional Objectives for Transmission System	Objective
			find efficiency opportunities, and set standards for the transmission system.
	T4	Environmental challenges and stakeholders	To improve public acceptance and stakeholders' participation in transmission infrastructure, while also reducing environmental impact.
C2 – Security and system stability	T5	Grid observability	The main focus is to improve transmission system observability at the pan-European level by developing new methods, technologies and tools capable of handling the process and interchange of an immense amount of measured and forecasted data in real time, both horizontally between TSOs and vertically with distribution grids/demand.
	T6	Grid controllability	• Propose new tools and methods to monitor, control and protect an electricity system with low inertia. Identification of suitable methods for building dynamic system-security models and developing the appropriate tools. Existing control and protection schemes must be reviewed and may need to be redefined to allow secure, stable and reliable operation of the network. • Methods and tools to ensure the required level of inertia to the transmission system, and connection of relevant equipment to the networks. • Identification of possible links between the electricity system and the other energy systems in the specific view of help increasing inertia (real or synthetic). • Deployment of Wide Area Control (WAC) devices at the pan-European, system-wide level, which will enable the operators to operate the system close to its stability margins without jeopardising its security.
	T7	Expert systems and tools	Develop expert systems and decision-making support tools to anticipate potential emergencies, provide early warning to system operators and suggest possible solutions based on the estimated probability of success in real time. The developed tools will include, but not be limited to, suggesting changes to network topology based on intelligent switching operations, protective relay settings and dynamic rating of the power system elements according to the actual system conditions. In order to deal with this vast amount of data, as well as with the uncertainty and variability associated with RES, innovative expert

Cluster	FO ID	Functional Objectives for Transmission System	Objective
			systems, highly sophisticated decision-making support tools and advanced automated control systems should be used.
	T8	Reliability and resilience	The main objective is twofold. The first aspect is to create an improved defence and restoration plan for the pan-European grid. To enhance the resilience of this grid, new approaches and technologies to reduce the probability of failure (including those failures stemming from climate change), as well as the consequences of such failures and time to recovery, should be developed and applied. The second aspect is the development of new tools to help TSOs to increase their reliability, consequently enhancing their role as market facilitators.
	T9	Enhanced ancillary services	To address technical and regulatory aspects of providing enhanced ancillary services for TSOs from DER, and storage through a new framework involving the services provided by units connected at DSO networks and by DSO facilities. To allow cross-border provision of ancillary services. To allow new players to provide valuable services.
C3 – Power system flexibility from generation, storage, demand and network	T10	Storage integration	Develop storage availability schemes for system planning and operation purposes, while analysing in parallel the integration of storage technologies, in close contact with the relevant manufacturers, in order to maximize their application possibilities in terms of both performance and time-to-market development.
	T11	Demand response	The main objective is to develop and integrate demand response mechanisms to provide services to the system. • Add flexibility to the system (modulate the load curve) in order to increase overall system efficiency. • Foster active customer participation in the system.
	T12	RES forecast	The main focus is to improve the forecasting of RES to ensure optimal capacity operation and maintain the quality and security of supply. At the same time, focus should be placed on building up the structure to handle the large amounts of data that need to be collected, processed and analysed.
	T13	Flexible grid use	The scope includes all devices that can be used to increase the flexibility of grid operation, new services rendered by interconnectors, and new materials/ operating modalities that can

Cluster	FO ID	Functional Objectives for Transmission System	Objective
			broaden the palette of tools for use by grid operators to achieve secure and efficient network management.
	T14	Interaction with non-electrical energy networks	• Promote actions that foster the transition towards a new model for a European energy system (heat, transport, gas, electricity). • Develop tools to analyse balancing and congestion issues across the entire energy system and to support gas technologies in restoration plans.
	T22	Flexible thermal power generation	The main objective is to have a thermal power generation fleet (including industrial cogeneration) that can react rapidly and contribute to deliver the flexibility needed to allow the integration of an increased share of variable RES, while ensuring the stability of the grid and the security of supply.
C4 - Economic	T15	Market-grid integration	Network-constrained market simulation tools should be developed to provide recommendations about specific network management and market designs. This will make it possible to manage congestion within the pan-European grids without affecting system reliability and while taking into account uncertainties, all possible corrective actions and dynamic ratings. The resulting simulation tools need to be synchronized with current market coupling initiatives. More specifically, evolution of the flow-based model for capacity calculation, with, for instance, stochastic approaches that enable better coordination between the market and the network, will be proposed.
	T16	Business models	The objective is to switch from tools that very precisely model the electricity sector under the assumption that the market is pure and perfect, to tools that take into account the entire energy sector and consider different actors that have various business models and strategies.
	T17	Flexible market design	On the short-term horizon, market models will provide recommendations of specific rules for integrating renewables/DER in power, balancing, and system services, therefore enabling massive integration of RES/DER. For the long-term horizon, the impacts of intermittency of energy sources on other generation means due to zero marginal costs cannot be ignored. Investment issues will be the key issues in the forthcoming years.

Cluster	FO ID	Functional Objectives for Transmission System	Objective
C5 – Digitalization of power system	T18	Big data management	• Develop ENTSO-E strategy for the application of Big Data management tools and applications in selected areas within the electricity sector. The expected value of the strategy shall be quantified/justified via descriptions of cases with high impact and/or increased efficiency resulting from use of the available information and/or prognostic information, thanks to improved data management practices/data processing technologies and intuitive visualisation. The aim of the strategy shall be to enhance TSOs decision making. The primary approach will be to identify and describe cases for transmission system operation, asset management and market facilitation. • Integrate the big data management tools into the planning, asset management and operation activities of TSOs, taking all relevant stakeholders into account.
	T19	Standardization and data exchange	The purpose of standardising a harmonised and limited set of protocols to support pan-European communication within the energy sector from a single generating unit to the market platform, as well as the transmission and distribution of energy to demand units, is to provide energy in an efficient manner by lowering the system integration barrier. An additional objective is to lower the integration cost and ease the system integration process through the use of standardised protocols. In order to lower the entrance cost of protocol stacks, it could be relevant to analyse the use of open source societies. The parties with the greatest interest in the outcome of this work stream will be actors in the electricity sector. Manufacturers, system integrators, system operators and project developers will have a major interest in the deliverables.
	T20	Internet of Things	Create awareness in the ENTSO-E organization of the benefits of applying IoT technologies in combination with Big Data applications. Recommend an ENTSO-E strategy for application of IoT in selected areas within the electricity sector. The expected outcome/value of the strategy will be quantified/justified via descriptions of cases involving a high number

Cluster	FO ID	Functional Objectives for Transmission System	Objective
			of distributed sensors and an increased efficiency due to use of IoT. The aim of the strategy shall be to enhance decision-making in targeting the TSOs in the first round.
	T21	Cybersecurity	The objectives to be dealt with for this task, among others, include the following: • Security measures, monitoring, detection and reactions; • Reducing vulnerabilities; • IT Security by design for power system security; • Security architecture; • Hardware protection mechanisms; • Secure and robust controls and operating systems; • Secure coding and encryption; • Secure cross-sector identification and authentication; • Network and information access control; • Response to breaches, and warnings to actors within the sector; • Cross-border coordination within the electricity sector.