IMPLEMENTATION PLAN 2017–2019

RESEARCH, DEVELOPMENT & INNOVATION ROADMAP 2017–2026

DRAFT FOR PUBLIC CONSULTATION

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EXECUTIVE SUMMARY

This document is the fourth edition of the ENTSO-E Implementation Plan (IP) and the first after the revision of the original ENTSO-E R&D Roadmap 2013 – 2022 into the new ENTSO-E R&I Roadmap 2017 – 2026. This IP 2017 – 2019 is one of the planning instruments for coordinating efforts in research, development, and innovation with the overarching goal of establishing and maintaining an efficient, cost-effective, reliable & secure European power system.

Looking at the current state of the art and how technology and business are evolving, the Implementation Plan streamlines the topics earmarked for starting in year 2017 and outlines R&I topics to be tackled in years 2018 and 2019.

R&I topics have been identified using a balanced mix of those originating from addressing EU funded calls (top-down approach) with topics stemming originally from TSOs (bottom-up approach); such topics shall be carried out with international funding programs as well as with own resources, in particular those characterised as inter-TSO cooperation / knowledge sharing initiatives among groups of TSOs. In total, a set of 23 topics could be identified, to be started in the next three years, which have then been matched with the Clusters and Functional Objectives of the ENTSO-E R&I Roadmap for the sake of consistency with its own planning framework and vision. The list of identified topics is given in Section 3 and described in detail in Appendix 3.

The set of topics has been prioritised applying the following criteria: innovation level expressed through Technology Readiness Level (TRL), applicability/replicability of the expected outcomes, added value both in terms of economic amount and of European footprint.

Figure 1 gives an overview of the topics, arranged by Roadmap Cluster, with an indication of the guiding budget, the type of expected output (tools, methods/assessment and field demonstration) and the technology readiness level. (TRL).

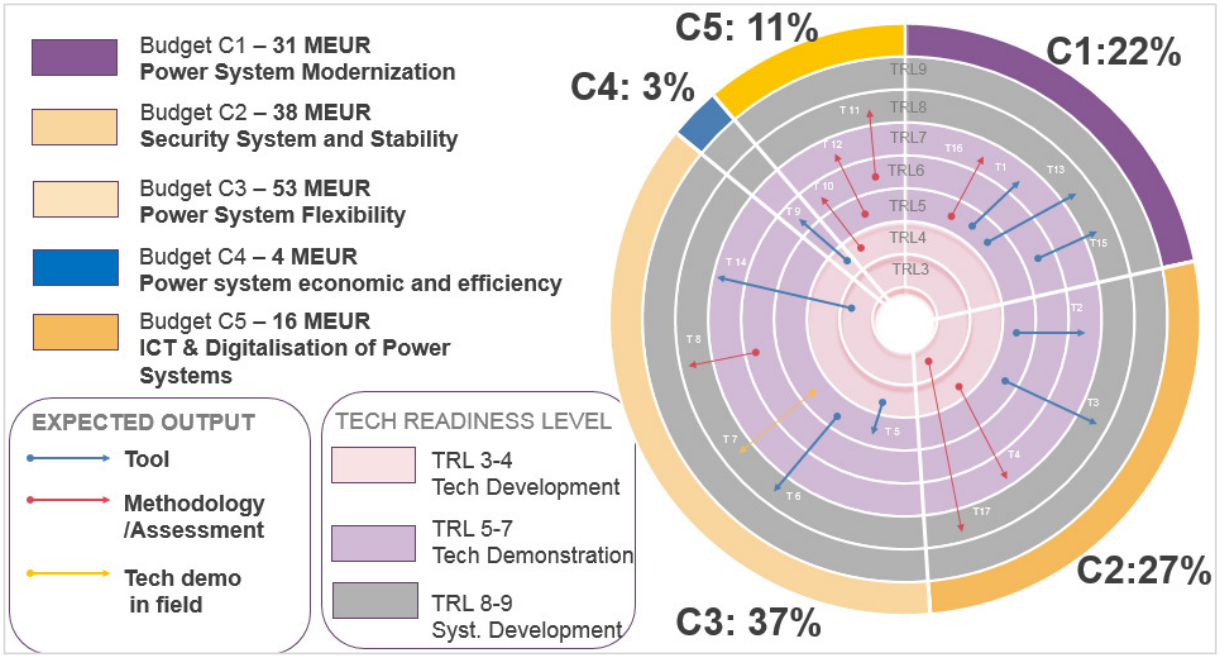

FIGURE 1: OVERVIEW OF THE TOPICS OF THE IMPLEMENTATION PLAN

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The estimated budget for topics starting 2017 is around 100 million Euros; this is to be intended as a preliminary indication, while a more precise quantification shall be possible when the topics are transformed into concrete projects.

Funding coordination and harmonization of regulatory treatment within the European jurisdictions are still pending issues, on which ENTSO-E is actively working with EC and ACER as interlocutors.

Among the different stakeholders who interact in the power sector, TSOs have a global view on the European power system, from generation to end-consumers, and from long term planning and adequacy to short term operational and market issues. TSOs are also key innovation enablers for field testing and deployment of innovative technological components and systems, therefore they are ready to be fully involved into the quest for smarter grids.

Appendix 1 and 2, report respectively the outcome of public consultation and a summary of ENTSO-E R&I Roadmap.

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1. INTRODUCTION

1.1. What is ENTSO-E Implementation Plan?

ENTSO-E Implementation Plan (IP) is intended to streamline the research, development and innovation (R&I) actions and activities with a European dimension by the Transmission System Operators (TSO) community; the framework of the IP 2017-2019 is the ENTSO-E R&I Roadmap 2017 – 2026, published in mid-2016 and setting the medium term vision and technological/operational targets of the fast-changing European electricity system.

The deployment of R&I programs was mandated in the third legislative energy package by Regulation (EC) 714/2009, and has been again promoted in the Regulation of the European Parliament and of the Council on the internal market for electricity (COM(2016)861 final) approved on 30th November 2016.

1.2. Objectives & Vision

The TSO European community is composed of 42 TSOs, each company is quite active on performing R&I activities for its own business. On top of stressing the added value of R&I carried out by TSOs, the IP emphasizes the prioritized subjects that need to be done in a broader collaborative way in order to reach the impact for the entire European energy system and contribute to progress on reaching the targets set by the European Commission (EC) at a large. Commitment, cooperation and European social economic view are crucial for success.

The second objective is to contribute with R&I priority inputs to the European Commission for developing its energy research agenda (ETIP-SNET, etc) and its strategy guidelines described in the Strategic Energy Technology Plan (SET Plan), which will the basis for setting corresponding supportive funding schemes such as Horizon 2020 (H2020) and others.

The vision of the IP 2017-2019 is to become an instrument for coordinating efforts in research, development, demonstration and innovation in the short term with the overarching goal of establishing and maintaining an interconnected European transmission system that is efficient, cost-effective and reliable.

ENTSO-E will keep providing its key contribution in the definition and implementation of R&I actions, deriving from its pivotal position in the power system, and from the medium/long term duties assigned to its member TSOs (grid and system planning, market change enablement) on top of other short-term, assignments, as grid operation and balancing.

1.3. Scope and making of the process

Looking at the current state of the art and how technology and business are evolving, the IP 2017 – 2019 details the topics earmarked for early starting in year 2017 and outlines R&I topics to be tackled for years 2018 and 2019.

The contents set in the IP reflects the proposals coming directly from the TSOs following a so called “bottom-up” approach, complemented with topics stemming from EC guidelines and funding programs (so called “top down” approach); indeed, EC approach considers a wider perspective, envisaging an integrated energy system, encompassing transport, heat, gas and power-to-X options. In this way, the IP is a mean for balancing these two approaches in a pragmatic and concrete way while harmonizing the visions of different stakeholders.

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The IP is updated every year, in order to keep the planning process aligned with the ever-changing needs of the power system, as well to cater for R&I developments by TSO community, at a European level. Therefore, identification, prioritization and timing of the topics are yearly fine-tuned or refocused after objective consideration by member TSOs, outcomes of public consultation and interaction/feedback from specific stakeholders.

Once topics have been identified and prioritised they are then articulated in specific projects addressing individual R&I targets. The projects are performed by ad-hoc consortia that pool the resources from multiple TSOs and other partners. Realisation of R&I projects is then monitored during the life time of the projects and shortly after their completion. The detailed description of each proposed concept and topic is given in Appendix 3.

2. EUROPEAN DIMENSION AND INNOVATION FRAMEWORK

2.1. Evolution of European R&I framework

The importance of innovation has been stated in the regulation of the European Parliament and of the Council on the internal market for electricity approved on 30th November 2016; in the general rules for the electricity market it has been mentioned that market rules shall allow for progress in R&I to be realized and used to the benefit of society, concluding that it is a task of ENTSO-E to deploy research programs addressing the overall system needs.

The European R&I framework is an ecosystem in constant evolution and with a huge number of actors in permanent interaction. The main actor is the EC which has recently set up ETIP SNET, a widely participated platform pulling together the most representative stakeholders, aimed at elaborating long term scenarios, R&I integrated-approach Roadmap and consequential the technical basis for the various funding programs. In Figure 2 a simplified scheme of the main interrelations and info exchange is given, focused on the TSOs pathways heading to EC on R&I issues.

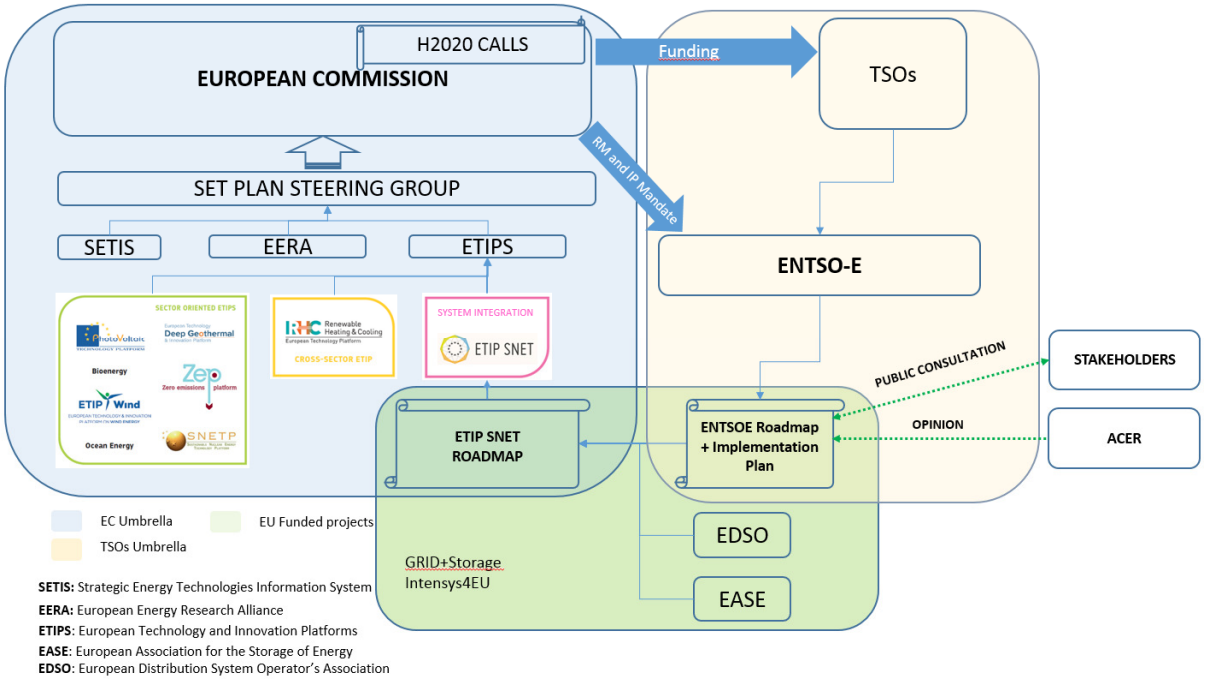

FIGURE2: INTERRELATIONS BETWEEN ENTSO-E AND OTHER EC BODIES

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From Figure 2, several points are worth to be highlighted:

- The SET Plan steering group has fixed 10 key priority actions for Europe and EC has put in place the ETIP SNET platform to tackle the priority 4 ("Increase the resilience, security, smartness of the energy system").
- The SET Plan is backgrounded by a collaborative work with multiple inputs and contributions from most energy players and bodies as well as research institutions, this work is referenced in the 10-year ETIP SNET R&I Roadmap covering the period 2017-2026.
- TSOs are fully committed to help reaching the targets fixed by the SET Plan: firstly, by meeting the EC mandate fixed by the 3rd Energy Climate package - the ENTSO-E Roadmap and the Implementation Plan – highlighting the work to be done from a system perspective in order to address the SET Plan priority 4. Secondly, ENTSO-E actively participates into the several initiatives launched by the EC, in particular the ETIP SNET platform. Thirdly, ENTSO-E has worked and will continue to work with other stakeholders (DSO, storage association) to deliver integrated roadmaps and integrated implementation plans within consortium supported by European funding (Grid+Storage project and Intensys4EU project).
- This process presents a positive circular reference in the sense that projects financed by the Horizon 2020 calls have a significant impact in the definition of the short term set of topics and projects. Activities financed by the Horizon 2020 program address both emerging technologies with medium to long term time prospect until deployment in the R&I area and the integration into the system of these technologies, taking into account interoperability and flexibility issues.

The activities supported under the H2020 in 2018 – 2020 will be structured according to the Energy Union priorities system perspective and the SET Plan key actions. Among them, some cross-cutting issues could be supported by TSOs innovation activities, such as those dealing with digitisation, based on the integration of information and communication technology Information and Communication Technology (ICT) and Big Data.

ENTSO-E Roadmap (and IP as well) follows the fast technological changes in energy sector, evolution of the EC policy framework, changes in funding schemes; indeed, funding tools were shifted from a technology-driven approach in the previous funding program FP7 to a challenge-driven approach in the current program H2020.

2.2. Paving the way towards an energy system integrated IP

IP 2017 – 2019 is framed within the challenging environment of the European energy system and the visions set forth by the establishment of European Energy Union. ENTSO-E has been an active partner in the GRID+Storage project, a consortium appointed by the EC (DG Energy) to support the development of a European R&I Roadmap integrating energy storage and other flexibility options into grid activities, both at electricity transmission and distribution levels. Moreover, ENTSO-E is participating in the Intensys4EU project, aiming at supporting the further integration of innovative solutions in view of hosting up to 45% of variable renewables sources by year 2030 while continuing to operate the energy system in a safe, stable and secure way. In this respect, the core of ENTSO-E Roadmap i.e. the list of Clusters and Functional Objectives (FOs) has been integrally included in the Integrated Roadmap, and similarly the core of IP (the list of topics) will form integral part of the Integrated IP.

In addition, ENTSOE is chairing the ETIP SNET, building on the consolidated and wide experience of its TSO members carrying out in EU research projects.

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2.3. ACER perspective on ENTSO-E R&I

As per EC set of rules and as done in previous ENTSO-E R&I deliverables, the Agency for the Cooperation of Energy Regulators (ACER) provided its feedback on the Roadmap 2017 – 2026, addressing both the methodologies and the contents; the positive opinion encourages the governance process effort on R&I, from identification of needs to deployment of results. The main issues raised and the relevant consequential actions on this Implementation Plan are summarised hereinafter. R&I funding and regulatory framework issues, key aspect for ACER intervention is outlined in section 4.

ACER recommended to report on the effectiveness and potential for upscaling and widespread deployment of technologies and innovative solutions in TSOs daily business of concluded R&I projects in terms of quantification of their benefits or even better their monetisation by potentially utilising the "Return on Research Capital"; according to this recommendation the next ENTSO-E Application Report will take this into consideration. Regarding dissemination of R&I results, which is anyway a fundamental duty of the individual R&I projects, ENTSO-E is actively pursuing also dissemination tasks at several levels:

- enacting its role of natural platform for internal dissemination through regular workshops, conferences and webinars;
- increasing emphasis on specific inter-TSO initiatives of knowledge sharing and best practices exchanges;
- dedicating external dissemination efforts and benchmarking through direct involvement in the most important worldwide arenas: Innogrid2020, Cigrè General Session, several international symposia and events, both sector-specific and broadly innovation-oriented.

2.4. Addressing energy system stakeholders concerns

Public consultation strategy has been improved from "pull" (only publishing and announcing the IP at ENTSO-E web site for consultation) to "push" approach (pro-actively pursuing feedbacks from particularly relevant stakeholders, collecting significant response.

In order to obtain a broad public opinion, the following stakeholders have been involved: national and European energy regulators, market players, consumers, DSOs, ETIPs members, research institutions, technology providers, generation companies, associations, NGOs.

The consultation process, run at the beginning of year 2017, has been conducted in a form of questionnaire, which allowed the respondents not only to answer the questions, but also to make comments and to propose suggestions to improve the process of selection of topics and concepts. Suggested changes to the text and to the structure have been carefully considered and reactions taken accordingly. The comments have been categorized and summarized in Appendix 1, while further details are published on ENTSO-E website. [1]

[1] This will be completed after the public consultation

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3. R&I ACTIONS

3.1. Evolution from previous IPs

In the previous years focus was on the modernisation of the European electricity network with emphasis on the scenarios and methods for developing a network infrastructure that hosts massive amounts of renewable energy sources. Emphasis has also been put on the improvement on the power technologies, addressing the affordability and technical performance of components of emerging technologies that can significantly improve the operations of the interconnected transmission systems. Still the efforts need to be directed to the demonstration of innovative power technologies and to their integration in the processes and network.

The main activities for 2017 aim at monitor and control the entire pan EU grid in order to improve its flexibility: there will be a need to assess, measure and provide flexibility to the system. There is also a focus in the stability of the system, taking into consideration the great amount of RES in place and the plans for 2030 and the relevance of the consumer.

Also the coordination between TSOs and DSOs needs to be increased, therefore the IP consider this issues focusing the innovation activities in the ICT aspects and the data exchange in order to promote an efficient and secure coordination.

RES forecast, flexibility in all the areas (operation, markets, resources), and smart planning approach, the market grid integration of new technologies, the resilience, business models and smart asset management are also innovations that will have to be covered in the near future.

To meet the challenges of future Low Carbon Energy R&I activities beyond 2019 will be focused on flexible and smart planning approaches, taking also into consideration resources not yet with a market integration but with a big potential, such as storage, demand response (prosumers).and cross border services will gain in importance in the future. This leads to innovations in the field of the network controllability and observability, since bidirectional and loop power flows will be present in the system due to the distributed energy resources. For realizing these challenges there is a need to deploy and manage a cost efficient ICT infrastructures for handling and analyzing all the data. In a nutshell these are the priority topics to be developed in the short term:

3.2. The identified R&I topics

IP 2017-2019 aims at detailing as much as possible the concrete challenge to be addressed in each topic, the state of the art and the results to be targeted, which improves the quality of the topic description and enables a better comprehension.

The topics are reported in table 1 to 3; they have been determined using a mix of those originating from addressing EU programs and topics related to the inter-TSO cooperation and knowledge sharing initiative among groups of TSOs. These two pillars aligned with the R&I Roadmap gaps serve as basis for the development of a consistent, robust and exhaustive structure of R&I plans.

More specifically R&I priorities and topics for 2017-2019 are based on the following:

- R&I Roadmap which serves as a reference and more specifically the relations of the topics with its Clusters and FOs. Topics are in line with the Roadmap time planning (see Appendix 2).
- EU funding programs with emphasis on those referring to the Transmission System as well as links between Transmission and distribution system and to other energy networks.

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- Inter-TSO Cooperation and knowledge sharing, aimed at addressing topics either short-term or not included in the wide EU system vision, still in any case deemed very important to improve grid operation and mandated duties of TSOs.

Table 1 reports the list of topics 2017 (Coloured in purple) where the projects are more concrete and mature. The proposed R&I topics are focused on power system flexibility, security and system stability, storage integration and on digitalisation of power system.

Topic Number	Cluster Reference Roadmap 2017-2026	Topics starting 2017
1	C1/T1	Power system planning for flexible transmission systems
2	C2/T5 & C3/T13	Enhanced grid observability
3	C2/T9	Cross-border use of ancillary and flexibility services
4	C2/T7 , T6 & C1/T1	Assessment of pan European system stability
5	C3/T11, C4/T16 & C5/T19	Coordination of centralized and distributed flexibility
6	C3/T13 & C4/T16	Measuring grid flexibility
7	C3/T10 & C2/T6	Multiservice storage applications
8	C3/T11 & T19	Demand Response engineering
9	C4/T17	Flexible market design
10	C5/T18 & C4/T16	ICT tools for data management
11	C5/T18 & T19	ICT systems and data handling for ICT systems and data handling for system control.
12	C5/T21	Project on cybersecurity improvement

TABLE 1: TOPICS STARTING 2017

- **Topic 1-2017:** A comprehensive platform of tools will be developed to study grid storage as transmission asset and RES forecasting with storage, thus optimizing grid flexibility.
- **Topic 2-2017:** Smart control system tools for real-time grid monitoring will be deployed; these will evaluate using a new uniform methodology the smart asset management technologies (WAMS, PMUs, FACTS, Dynamic line rating).
- **Topic 3-2017:** Tools will be deployed to examine the optimal development of flexibility resources and ancillary services with a focus on cross border coordination; this will be covered at pan-European level.
- **Topic 4-2017:** Fast real time predictive and preventive mechanisms are to be developed for continuous dynamic stability; cross border response on dynamic stability issues will be examined as well as the use of market based instruments. Stability services provided by all the players in the electricity value chain (TSO/DSO/storage/generation/load/crossborder) will be assessed. Tools and mechanisms will be also explored to detect stability margins, predict short term

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stability prognoses and optimal predictive response. In general optimal asset utilization and system planning will be compared versus stability limits.

- **Topic 5-2017:** Tools are to be developed regarding the cross border use of flexibility services and transmission services based on distribution connected flexibility means namely demand response and storage.
- **Topic 6-2017:** Real-time tools for measuring grid flexibility with new, consistent methodology encompassing scenarios, social welfare and stakeholders' impact will be developed. This methodology will exploit dynamic line rating and sensors to enhance the absorption of RES power while mitigating new infrastructure needs and cost at the same time.
- **Topic 7-2017:** Multiservice applications will be tested focused on the use of storage technologies (in particular applications of hybrid storage, batteries, flywheel, supercapacitors) for providing system services: congestion management, synchronization, frequency and voltage control.
- **Topic 8-2017:** Innovative ancillary services will be developed provided by large size prosumers and by medium-small prosumers connected to the HV, MV and LV grid; advanced management of selected industrial clients based on system benefits analysis will be explored.
- **Topic 9-2017:** Market simulation tools will be developed and tested on the integration of distributed flexibility resources into wholesale market. Also roles and interaction of regulated and deregulated players will be assessed.
- **Topic 10-2017:** This topic will focus on smart data management using suitable ICT tools as added value for all electricity and system value chain. The assessment and development of ICT architecture, standards, requirements, roles, business models, exchange platforms and TSO/DSO processes will be also included.
- **Topic 11-2017:** Cloud based ICT supportive infrastructure will be developed; it will be focused on data monitoring and analysis of the control system actions to enhance system's performance by improving its predictability and controllability.
- **Topic 12-2017:** This topic will deliver a fully-developed framework for the validation of innovative cyber-physical security technologies. Virtual and physical testing will be developed to assess the cyber-physical security within the energy sector.

The list of topics for 2018 and 2019 is given in Table 2 (Coloured in blue and light yellow):

Topic Number	Cluster Reference Roadmap 2017-2026	Topics starting 2018	Starting
13	C1/T2	Smart asset management through use of Big Data	2018
14	C3/T14	Smart interfaces between generation and transmission	2018

Topic Number	Cluster Reference Roadmap 2017-2026	Topics starting 2019	Starting
15	C1/T1	Optimal grid design/planning based on the use of most cost effective solutions/ technologies that should enable more flexibility.	2019
16	C1/T4	Public acceptance and stakeholders participation	2019
17	C3/T12	Improve RES forecasting and optimal capacity operation	2019

TABLE 2: TOPICS STARTING 2018-2019

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Topic 13-2019: Smart ICT tools will be developed to integrate new sensors, new monitoring devices and robotics for automated intervention especially in hostile environments.

Topic 14-2018: Tools and models for the management of balancing and congestion problems will be developed as well as platforms to enhance coordination with other energy system players.

Topic 15-2019: This topic will explore new planning methods that combine variable RES and DER, production capacities, storage and environmental constraints at both transmission and distribution level. The proposed methodology will also take into account, the market aspect and the coupling with other energy sectors such as gas, heat and cold.

Topic 16-2019: This topic will focus on the enhancement of public acceptance taking into account not only the communication to the public aspect but also the technical part; the latter will analyse new technologies that have reduced environmental footprint; new towers, new station designs with less visual impact, audible noise, EMF, etc.

Topic 17-2019: Effective mechanisms, instruments and rules will be validated for the management of variable sources in the system based on RES forecasting with a high level of accuracy.

The following topics shall be carried out as inter-TSO cooperation (coloured in beige) .

Topic Number	Cluster Reference Roadmap 2017-2026	Topics of interest for TSOs that are being developed and surveyed in an inter TSO cooperation
18	C1/T1	Probabilistic methods for generation and adequacy planning
19	C2/T18	High impact low probability events
20	C3/T10	Optimal use of storage plants. Use of existing Storage Lab facilities for demonstration of typologies and added value from storage technologies
21	C5/T21	Best practices exchange in Cybersecurity
22	C1/T3	Partially insulated OHL Conductor: operate a 400kV circuit on a 110 kV tower
23	C2/T6 &C5/T18	Developing tools for better system awareness based on big data analysis

TABLE 3: INTER TSO TOPICS

Topic 18: New methods and tools for adequacy planning based on probabilistic approach.

Topic 19: Tools and methods to evaluate the high impact of low probability events based on stochastic methods.

Topic 20: This topic will analyse the performance of different storage technologies for ancillary services provision based on scenarios related to storage penetration.

Topic 21: Best practices exchange in Cyber - Security are to be explored in terms of standards, security measures, prevention procedures, on-site resolution of attacks, etc.

Topic 22: Partially insulated OHL Conductor will be examined; the main goal is to explore if a 400kV circuit can operate on a 110 kV tower.

Topic 23: Methods and tools will be developed so the TSOs will fully utilize their data to improve system awareness and operation.

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It is also useful to consider how the identified topics address the clusters and Functional Objectives of the ENTSO-E Roadmap, which is reported in Tables 4-8. For details and full reference to the Roadmap, see Appendix 2.

ORGANIZATION PER ROADMAP 2017-2026 CLUSTER

Topic Number	Cluster Reference Roadmap 2017-2026	C1. Power system modernization	
1	C1/T1	Power system planning for flexible transmission systems	2017
15	C1/T1	Optimal grid design/planning based on the use of most cost effective solutions/ technologies that should enable more flexibility.	2019
18	C1/T1	Probabilistic methods for generation and adequacy planning	2017
13	C1/T2	Smart asset management through use of Big Data	2018
22	C1/T3	Partially insulated OHL Conductor: operate a 400kV circuit on a 110 kV tower	2018
16	C1/T4	Public acceptance and stakeholders participation	2019

TABLE 4: TOPICS ADDRESSING CLUSTER 1

Topic Number	Cluster Reference Roadmap 2017-2026	C2. Security and system Stability	
2	C2/T5 & C3/T13	Enhanced grid observability	2017
4	C2/T7 , T6 & C1/T1	Assessment of pan European system stability.	2018
3	C2/T9	Cross-border use of ancillary and flexibility services	2017
23	C2/T6 &C5/T18	Developing tools for better system awareness based on big data analysis	2018
19	C2/T18	High impact low probability events	2017

TABLE 5: TOPICS ADDRESSING CLUSTER 2

Topic Number	Cluster Reference Roadmap 2017-2026	C3. Power System Flexibility	
20	C3/T10	Optimal use of storage plants. Use of existing Storage Lab facilities for demonstration of typologies and added value from storage technologies	2017
5	C3/T11, C4/T16 & C5/T19	Coordination of centralized and distributed flexibility.	2017
7	C3/T10 & C2/T6	Multiservice storage applications	2017
8	C3/T11 & T19	Demand Response engineering.	2017
17	C3/T12	Improve RES forecasting and optimal capacity operation	2019
6	C3/T13 & C4/T16	Measuring grid flexibility	2017
14	C3/T14	Smart interfaces between generation and transmission	2018

TABLE 6: TOPICS ADDRESSING CLUSTER 3

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Topic Number	Cluster Reference Roadmap 2017-2026	C4. Power system economic and efficiency	
9	C4/T17	Flexible market design.	2017

TABLE 7: TOPICS ADDRESSING CLUSTER 4

Topic Number	Cluster Reference Roadmap 2017-2026	C5. ICT & Digitalisation of Power System	
10	C5/T18 & C4/T16	ICT tools for data management	2017
11	C5/T18 & T19	ICT systems and data handling for system control.	2017
12	C5/T21	Cybersecurity improvement	2017
21	C5/T21	Best practices exchange in Cybersecurity	2017

TABLE 8: TOPICS ADDRESSING CLUSTER 5

According to the Technology Readiness Level (TRL), which is the method to estimate the technology maturity, the proposed topics aim at developing components, models and prototypes system which could be tested in a relevant environment and that are planned to become operational systems (TRL 5 -TRL 8). In Figure 3 the key IP 2017-2019 topics expected outcomes, excluding the inter- TSO cooperation topics, are represented according to the TRL. The topics delivering a tool are represented in blue, the topics delivering methodologies, assessment or frameworks are represented in red, and finally, the demonstration in field are represented in yellow.

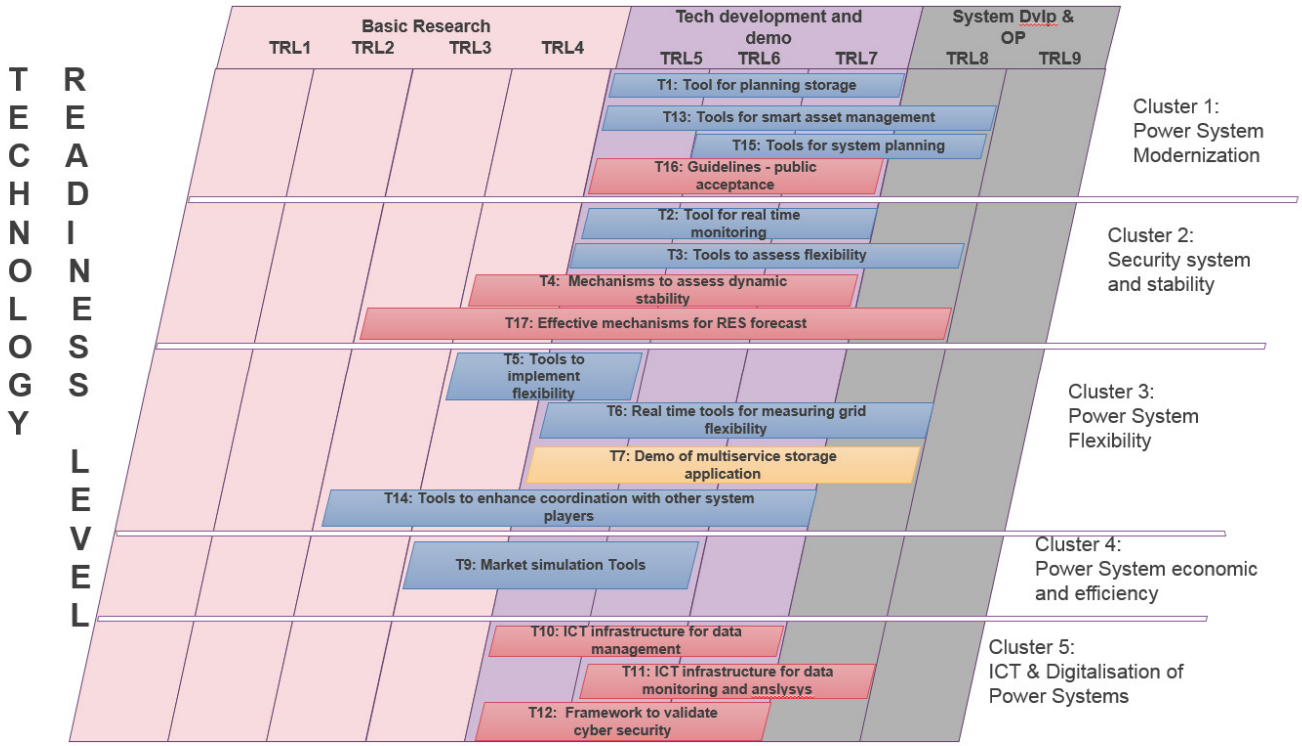

FIGURE 3: IMPLEMENTATION PLAN TOPICS MATURITY LEVEL

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3.3. Input to the ETIP SNET Implementation Plan

The set of topics has been identified from the perspective of system needs viewed by the central position of TSOs, where the priority is based on: innovation level expressed through Technology Readiness Level (TRL), applicability/replicability of the expected outcomes, added value both in terms of economic amount and European footprint.

The prioritization methodology has considered in several iterations, valuing the metrics of urgency, timeliness for availability and system impact on system planning, operation and maintenance once the system integration has been successfully implemented.

The second iteration has taken into consideration the ENTSO-E Roadmap scope, ensuring the coverage of the topics and FOs expected to be performed within the implementation plan framework (see Figure 4):

- Power system planning for flexible transmission systems and probabilistic methods for generation adequacy planning
- Enhanced grid observability and assessment of pan European system stability
- Cross-border use of ancillary and flexibility services
- Optimal use of storage plants and multiservice storage application
- Demand response
- Measuring and coordination of centralized and distributed flexibility
- Flexible market design
- ICT systems and data handling for system control: TSO & DSO interaction.

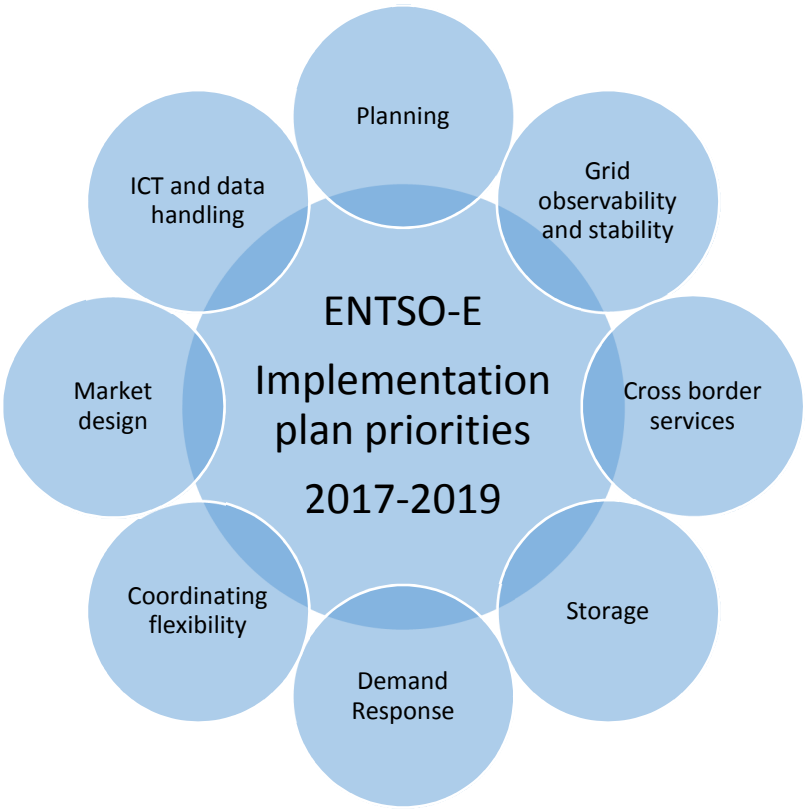

FIGURE 4: IMPLEMENTATION PLAN PRIORITIES

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4. R&I ECONOMICS AND REGULATORY APPROACH

The Third Internal Energy Market Package has stimulated National Regulatory Authorities (NRAs) to support TSOs and DSOs in their R&I efforts (directive 2009/72/EC, art 37.8).

In spite of this provision, only a few EU countries currently account for R&I expenses explicitly through tariff structures. When there is no explicit national regulation for R&I expenses, these financial efforts tend to be considered as operational expenses. These costs are therefore recovered through normal tariff mechanisms, updated accordingly and in many cases subject to efficiency mechanisms, hence with the incentive – paradoxically - to reduce them.

ENTSO-E is actively working together with ACER and the EC on achieving common ground regarding the regulation of R&I activities in the TSO community. Official recognition from NRAs and ACER/CEER of the need for covering R&I expenses would bring benefits by leveraging on the TSO natural independence and distinctive expertise towards engaging stakeholders, operating and managing research programmes, and disseminating results, thus promoting a smooth, effective and efficient implementation of the EU energy strategy.

The Clean Energy Package, as well as the governance under ETIP umbrella, try to be more effective in the coordination of financial efforts of national/regional funding programs and the European ones.

The estimated budget for topics labelled as to be addressed starting 2017 is around 100M EURO; this is to be intended as a preliminary indication, since a more precise quantification shall be possible when the topics are transformed into concrete projects. For the projects beyond 2017 the budget estimation stands around 40 M EURO, but this amount will be refined in subsequent implementation plans. For more data and statistics on dedicated resources, reference is made to ENTSO-E R&I Roadmap, published in mid 2016.[2]

Funding coordination and harmonization of regulatory treatment are still pending issues, on which ENTSO-E is actively working with EC and ACER as interlocutors.

[2] *https://www.entsoe.eu/publications/research-and-development-reports/rd-roadmap/Pages/default.aspx*

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ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
DER	Distributed Energy Resources
DSO	Distribution System Operator
EASE	European Association for the Storage of Energy
EC	European Commission
EERA	European Energy Research Alliance
EII	European Industrial Initiative
ENTSO-E	European Network of Transmission System Operators for Electricity
ETIP	European Technology and Innovation Platform
ETIP-SNET	European Technology and Innovation Platform - Smart Networks for Energy Transition
FO	Functional Objective
FCR	Frequency Containment Reserve
FRR	Frequency Restoration Reserve
H2020	Horizon 2020 (EU research and innovation programme 2014 – 2020)
ICT	Information and Communication Technology
IP	Implementation Plan
NGO	Non-Governmental Organisations
NRA	National Regulatory Authority
R&I	Research, Development and Innovation (sometimes also referred to as R&D or RD&I)
RES	Renewable Energy Sources
RIA	Research and Innovation Actions
SET Plan	Strategic Energy Technology Plan
SETIS	Strategic Energy Technologies Information System
SNET	Smart Network for Energy Transition
TRL	Technology Readiness Level
TSO	Transmission System Operator

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APPENDIX 1 – CONSULTATION OUTCOMES

To be elaborated after consultation, in similar way and format as previous IP

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APPENDIX 2 – ENTSO-E R&I ROADMAP 2017-2026

In the revised R&I Roadmap 2017-2026, ENTSO-E made a strategic repositioning of R&I, bridging a potential gap between TSOs' R&I priorities and EC funding policy, which could lead to the situation that topics of interest for TSOs would not be properly covered in the EC calls, the latter one being of more integrated nature. In the revised Roadmap, ENTSO-E strategy is based on the two main pillars:

- EC driven projects, where ENTSO-E has central aggregation and coordination role,
- Inter-TSO approach, where TSOs may execute projects in a lighter framework than the one provided by EC and on topics not addressed by EC calls.

The first pillar denotes interactions and formal collaborations also with associations of DSOs (EDSO4SG), storage operators (EASE) and research institutes (EERA) in the spirit of the Europe-wide integrated approach advocated by EC, whilst the second pillar will enable TSOs to cope with challenges not covered by EU funding schemes and also to secure funds for issues close to the TSO core business.

The adopted strategy has implied a structural change in the Roadmap, reflecting transformation of the European energy system into an integrated one and emphasizing strong links between electricity, gas, heat and transport sectors. Thus the new Roadmap anticipates the integration of different technologies within European market framework.

Cluster	Functional Objective		FO content
C1 Power System Modernisation	T1	Optimal grid design	Optimal grid design: planning, adequacy, tools
	T2	Smart Asset Management	Smart Asset Management; predictive and on-condition maintenance; capex optmisation
	T3	New materials & technologies	Use of new materials and power technologies; new construction and maintenenance methods
	T4	Environmental challenges & stakeholders	Environmental impact, public acceptance, stakeholders participation
C2 Security and System Stability	T5	Grid observability	Observability of the grid: PMUs, WAM, Sensors, DSO information exchange
	T6	Grid controllability	Controllability of the grid: frequency and voltage stability, power quality, synthetic inertia
	T7	Expert systems and tools	Decision support tools, automatic control and expert systems
	T8	Reliability and resilience	Reliability and resilience: defense and restauration plans, probabilistic approach, risk assessment, self healing
	T9	Enhanced ancillary services	Enhanced ancillary services for network operation; cross-border supply of services
C3 Power System Flexibility	T10	Storage integration	Storage integration, definition and use of storage services; system added value from storage
	T11	Demand Response	Demand Response, tools to use DSR; Load profile, EV impact
	T12	RES forecast	Improved RES forecast and optimal capacity operation
	T13	Flexible grid use	Flexible grid use: dynamic rating equipment, power electronic devices; use of interconnectors
	T14	Interaction with non electrical energy networks	Interaction/coordination with other energy networks (gas, heat, transport)
C4 Power System Economics & Efficiency	T15	Market - grid integration	Integration of market and grid operation across timeframes (up to real time)
	T16	Business models	Business models (for storage, grid extension, distributed generation) for optimal investments in the network
	T17	Flexible market design	Market design for adequacy, flexibility use, cross border exchanges, rationale use of RES, demand management
C5 ICT & Digitalisation of Power System	T18	Big data	Big data, data mining, data management
	T19	Standardisation & data exchange	Standardisation, protocols for communications and data exchange with DSOs and other grid operators
	T20	Internet of Things	New communication techonologies, Internet of Things
	T21	Cybersecurity	Cybersecurity

TABLE 9: LIST OF CLUSTERS AND FOS OF THE ENTSO-E R&I ROADMAP 2017-2026

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The revised ENTSO-E R&I Roadmap 2017-2026 contains five Clusters, where each cluster comprises several FOs, as shown in Table 9. The clusters and FOs are greatly interdependent, meaning that each cluster (or FO) addresses at least one task or duty that is relevant for all TSOs: Network Operation, Asset Management, Network Planning, Market, or duties stemming from Societal & Stakeholder needs. Likewise, each task or duty of a TSO may be assigned to more than one cluster. The interested reader in ENTSO-E R&I Roadmap 2017-2026 is referred to the official ENTSO-E website[3].

Roadmap timeline is given in **FIGURE** 5.

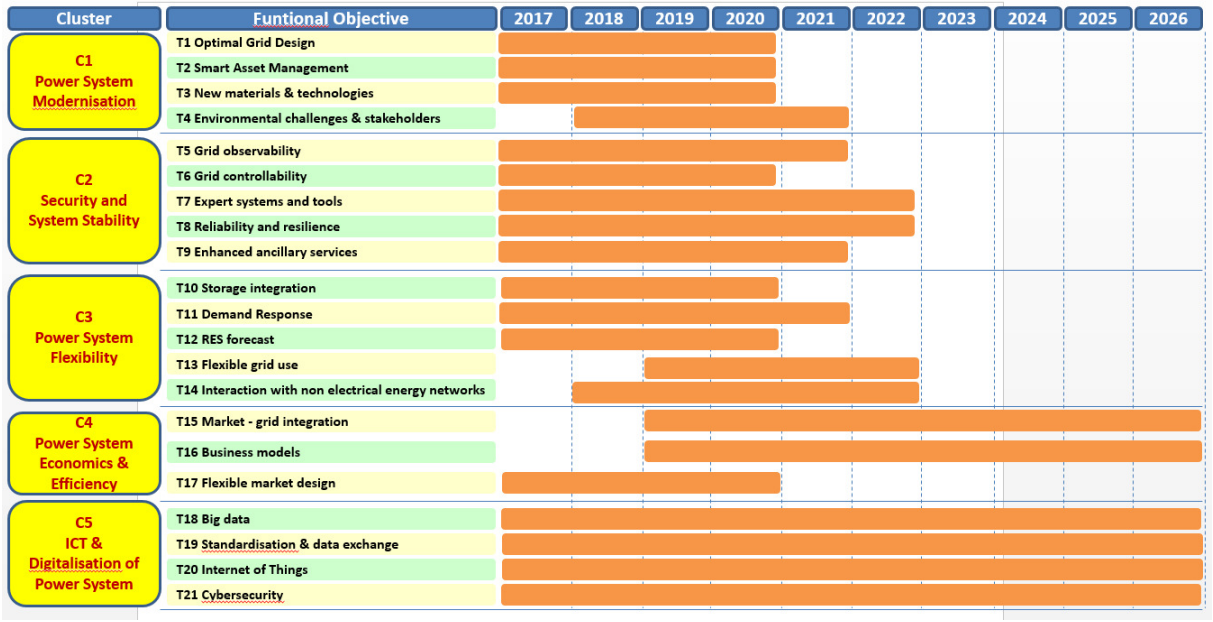

FIGURE 5: TIMELINE OF ROADMAP 2017-2026

[3] http://riroadmap.entsoe.eu/

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APPENDIX 3 - DETAILS OF TOPICS

Topic N. 1 - 2017	Power system planning for flexible transmission systems
Cluster	C1
Main FO addressed	T1
Supported FO	T7, T13
Specific Challenge	Different resources such as intermittent RES, storage and demand will play a central role in the future power system. This brings for the challenge of power system planning for flexible transmission systems in order to preserve the same levels of security of supply and power quality in the interconnected pan-European system that will be exposed to a massive level of uncertainty.
Content/Scope	Develop power system planning tools that optimise transmission grid flexibility according to specific metrics.
Expected results	Detailed planning methodology that enables and monitors grid flexibility based on specific metrics. Modelling, simulation and decision support tools for optimal grid design with high flexibility potential.
Expected Impact	• System design with high system flexibility, stability and security. • Promote a strong transmission backbone for freeing the electricity market and develop business opportunities. • Improved RES penetration reliably.
Additional Information	Partners involved are research institutions and TSOs Outputs will be modelling tools, decision support mechanisms and use-cases
TRL range	Initial TRL 5 – Final TRL 7
Proposed timeline	2017-2020
Estimated budget	8 M EURO
Funding Scheme	Mainly EC and national Type of project: RIA: Research and Innovation Actions
Background/State of the art	Recent projects that have researched possible scenarios of pan EU network expansion are: iTesla, Best Paths, Twenties, e-Highway, GridTech, RealiseGrid. The obtained results could be considered as an input to the development of the power system planning. Other EU projects, such as Umbrella, have assessed the effectiveness of control actions that deliver the right level of reliability while facing uncertainties from the large-scale deployment of RES and market integration.

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Topic N. 2 2017	Enhanced grid observability
Cluster	C2, C3
Main FO addressed	T5, T13
Supported FO	T6
Specific Challenge	To get a smart control system for real-time grid monitoring, yet to assess with a new uniform methodology the smart asset management technologies (WAMS, PMUs, FACTS, Dynamic line rating)
Content/Scope	Develop a methodology that exploits the real time grid monitoring information for system planning, operation and decision support. Specify and implement pilot project with dynamic line rating, FACTS, WAMS, PMU in order to harness the capacity of the transmission system closer to its limits with high reliability and defer new infrastructure while absorbing more RES power
Expected results	• Methodology and use cases for setting up and exploiting real time monitoring schemes. • Pilot project: specification and deployment of real time monitoring devices and improvement of grid performance, DSO exchange information, interconnector's optimization.
Expected Impact	Promote the observability of the network. Maintain European leadership in state-of-the-art technology. Reduce the costs of new infrastructure and boost coordination with the DSOs and cross border trading.
Additional Information	Real time monitoring improves system stability and power quality. Methodologies, simulation tools use-cases and business models will be the output, as well as lab demo.
TRL range	Initial TRL 3 - Final TRL 7
Proposed timeline	2017-2020
Estimated budget	8 M EURO
Funding Scheme	Mainly EC and national; type of project: research action
Background/State of the art	Indicative list of relative projects: Twenties, Bestpaths

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Topic N. 3 2017	Cross-border use of ancillary and flexibility services
Cluster	C2
Main FO addressed	T9
Supported FO	T1, T13
Specific Challenge	TSO are responsible for the secure and reliable operation of their systems, as well as for the interconnections with other transmission systems, the challenge then lies in optimising the operation of the system at wider than national level; this is addressed in particular through cross-border use of ancillary and flexibility services.
Content/Scope	Exchange of flexibility resources/ancillary services with the focus to specific service elements and their respective business role models, control mechanisms, responsibilities and cross border capacity treatment procedures.
Expected results	• Outputs will be market design proposals, prototype and simulation tools
Expected Impact	Increased amount of ancillary services and flexibility resources made available across the interconnected borders and market zones. Improved control of renewable energy sources in the conditions of reduced control reserves from coal fired and gas fired production units Improved security of operation derived from energy efficient solutions Avoided or deferred investments into new storage capacities
Additional Information	Partners involved are research institutions, solution and IT providers, retailers and TSOs
TRL range	Initial TRL 5 -Final TRL 8
Proposed timeline	2017-2020
Estimated budget	10 M EURO
Funding Scheme	EC and national; Type of project: Research and Demonstration action
Indicative list of related projects	Future Flow

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Topic N. 4 2017	Assessment of pan European system stability
Cluster	C1, C2
Main FO addressed	T6, T7
Supported FO	T1
Specific Challenge	Increasing renewable generation and cross-border interconnection significantly influences the dynamics of the grid and poses serious challenges to the stability of power transmission networks. The power system should ride through any single disturbance event such as failures of generation, load or transmission lines, and reach a new operation without impacting customers. However, increasing penetration of renewables and power electronics across Europe means that disturbances can affect the system too rapidly for conventional control and protection approaches to contain the events. Risks of cascading, damage, network separation, loss of voltage or frequency stability, and blackout of large areas may increase unless innovative containment measures can be applied. These risks are not only local phenomena, but they have to handle across countries, TSOs and DSOs.
Content/Scope	Develop, build and demonstrate synchro phasor-based integrated systems for dynamic stability monitoring and response for the European power system, to be able to cope with closer to 100% inverter based renewable energy sources (RES), storage systems and embedded HVDC. For the European power system responsible parties, it will be investigated how far the current and the future planned European power system can be pushed, with and without advanced dynamic stability mitigation mechanisms in place, before it reaches its stability limits. Assessment of system services available by all players in the power system value chain (TSO/DSO/storage/generation/load/HVDC…). Demonstration of all parts of the monitoring and control chain for future needs for stability control actions in the power system. The overall tasks to take into consideration are: - Monitoring System: Sensors and Observability - Real-time Analysis, Prediction, Warning and Guidance - Real-time Response-driven Control Processes and Infrastructure - Market Activation and Settlement using Market Based Instruments
Expected results	New advanced tools and means including market based instruments for secure operation of the future power system with close to 100% inverter based renewable energy sources: - For optimal system planning and asset utilisation closer to stability limits - For fast real-time and continuous prediction of dynamic stability margins - For fast real-time determination of preventive mechanisms for continuous dynamic stability - For optimal and market based activation of Cross-border dynamic stability services Recommendations and roadmap for utilisation of real-time dynamic stability

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	monitoring and control mechanisms.
Expected Impact	Room for increased integration of renewable generation through optimal system observation and cross border use of and grid-wide assets to provide new grid services for ensuring continuous stable power system operations.
Additional Information	At least following type of partners are needed for a proper coverage of stakeholder interests and competencies relevant for execution of development and demonstration : TSOs, Universities, Technology providers
TRL range	Initial TRL 4 - Final TRL 7
Proposed timeline	2018 - 2021
Estimated budget	20 M EURO
Funding Scheme	European Funding Research and innovation action
Background/ State of the art	MIGRATE

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Topic N. 5 2017	Coordination of centralized and distributed flexibility
Cluster	C3,C4, C5
Main FO addressed	T11,T16,T19
Supported FO	T5,T6
Specific Challenge	The power system has classically relied on a range of services from transmission connected synchronous generators that has maintained the resilience of the power system that society has come to expect. These are now being displaced by non-synchronous RES. In the future many of the resources will be embedded in the distribution networks will require to be aggregated. This creates two fundamental issues: • There are barriers (operational and communication) to allowing new technology from providing these to the system (no grid codes, no scheduling and dispatch tools, no control and observation signals, no access to revenues for services) • The traditional roles and responsibilities do not hold.
Content/Scope	This work should explore the need to the power system at high RES and examine new technologies to see how they can provide the needed services. Assessment of Roles and interactions of regulated and deregulated players; Integration of distributed flexibility resources into wholesale market; Design options using “shadow markets” platforms; Cross-border use of flexibility services. Transmission services based on distribution-connected flexibility means, including demand-response and storage as well as embedded RES and changing make up of demand (electrification and machine to machine connection)
Expected results	Clarity around the barriers and solutions to providing needed services complimentary to high RES policy objectives
Expected Impact	• Materially consider effective integration of embedded capability aligned to facilitating EU Energy Policy
Additional Information	Research institutions, DSOs and TSO
TRL range	Initial TRL 4 - Final TRL 5
Proposed timeline	2017-2021
Estimated budget	4 M EURO
Funding Scheme	EU funding and national funding
Background/State of the art	ANEMOS Plus, MERGE, “From wind power to heat pumps”, GridTech, OPTIMATE, Ecogrid EU, Gredor, Cell Controller Pilot Project

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Topic N. 6 2017	Title: Measuring and Forecasting the System flexibility
Cluster	C3,C4
Main FO addressed	T13, T16
Supported FO	T1, T4
Specific Challenge	Measuring and forecasting grid flexibility with new, consistent methodology: encompassing scenarios, social welfare, stakeholders' impact
Content/Scope	According to EEGI (GRID+ KPIs definition) System Flexibility is defined as the amount of electrical power that can be modulated to the needs of the system operation within a specific unit of time. This refers mainly to flexible generation and load resources but also the Grid could become a source of flexibility itself by using technologies that bring similar effects as the aforementioned in order to overcome system constrains. Examples of this last group are basically DLR (Dynamin Line Rating) systems (sensors and algorithms) and different kind of power flow control devices (phase shifter transformers, HVDC links, FACTS…) In order to get as much benefit as possible from these resources it is essential to count with consistent methodologies and mechanisms not only to measure this flexibility but also to forecast it in order to make proper decisions in D-X operation and not only in real time (or close to real time). Develop low-cost solutions (sensors) and methodologies for forecasting and real time measurement of dynamic line rating to increase system flexibility while ensuring the current security and stability standards of the network to absorb RES power and mitigate new infrastructure needs and costs (social welfare). It is essential that these solutions can be as much affordable as possible (low cost), suitable for use them in existing infrastructure with minimum adaptation and robust (reliable and minimum maintenance). Develop market mechanisms that integrates new storage technologies, demand side management resources and DLR to boost the capacity of the network and incentivize for new flexibility services by stakeholders, prosumers, TSO/DSO coordination and cross-border trading
Expected results	Methodology and use cases for setting up and exploiting real time monitoring schemes and best use of PFCD (Power Flow Control Device) for increased flexibility; respective pilot project to implement the method, Methodology for market based mechanisms to remunerate flexibility services and promote new business opportunities for storage and demand side resources integration and optimal investments in the network; simulation tools and use-cases, lab demo.
Expected Impact	• High system flexibility and security with a strong transmission backbone for freeing the electricity market • Tools and mechanisms for a system operation beyond current static ratings while keeping same security allowing for minimizing generation re-dispatching cost and RES curtailments. • Develop new business opportunities and remuneration mechanisms for flexibility services that will lead to an optimal generation and demand dispatch and boost socioeconomic benefits for grid users and stakeholders

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Additional Information	Promoting real time monitoring and dynamic line rating improves the utilization of existing grid infrastructure and might defers conventional investment in new OHLs TSOs, universities/research institutes, manufacturers The outputs will be proposed configurations, use cases and pilot projects, evaluation of results.
TRL range	Initial TRL 5 final TRL 8
Proposed timeline	2017-2020
Estimated budget	8 M EURO
Funding Scheme	Mainly EC and national; type of project: research action
Background/State of the art	Indicative list of projects: evolvDSO, Optimate, SEETSOC

Topic N. 7 2017	**Multiservice Storage Applications**
Cluster	C2,C3
Main FO addressed	T6, T10
Supported FO	
Specific Challenge	The European electricity system is challenged by the high penetration of renewable electricity generation with fluctuating feeds. Developments in advanced storage technologies are able to offer capabilities and deployment possibilities that support the long term EU energy policy objectives. Storage technologies can provide several services for both regulated entities and market players: congestion management, synchronization (grid forming after disconnections/black-outs), frequency & voltage control, integration of RES in the competitive energy markets, No single service is currently profitable on its own, but the sum of all services provided probably is. The key challenge is to favour a complete integration of storage in the electric system that enable to recover the full value of storage. A coordinated management of these flexibilities means is a real challenge for TSOs: it will impact all time horizon, from long term planning to very short term stability measures.
Content/Scope	Activities should focus on storage integration in the electric system that aim to valorise the multi services offered by storage facilities. There are technical issues to overcome and many economic, regulatory, market and environmental aspects must be addressed. From a technical point of view, flexibility can be provided by four distinct players: flexible power plants, Demand Response, storage and the network itself (Dynamic Line rating, topology shifts,). Storage can be used to address a very large range of needs of the system: investment deferrals, congestion management, balancing, and stability.

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	From an economic point of view, none of the single service offered by storage is profitable. The key challenge is to envisage a new regulatory framework that enables to recover the full value of storage. This implies a mutualisation between the different services and avoid dedicated approach. A holistic approach should be adopted, that encompasses both regulated and deregulated services and all time horizons. This will lead to new loop between activities and actors that were previously separated.
Expected results	Recommendations for a new regulatory framework and a new market design that enable to recover the full value of storage in a cost effective way. These recommendation should be technological neutral, so that the most efficient flexibility means emerge. Pilot demonstration of highly responsive power and energy storage integrated at both transmission (HV) and distribution levels (LV) to show potentials for balancing, congestion management , ancillary services and new system services (grid forming) in a context a proliferation of power electronics. Tools for operation that enable to mutualize the flexibilities offered by storage facilities and those offered be the grid itself (Dynamic Line Rating for instance).
Expected Impact	• Enhanced integration of RES thanks to the surge in flexibility offered by storage • Enhanced integration of power electronics in the electric system • Deferred investments for transmission and distribution grids reinforcements and lower social costs associated with high penetration of fluctuating renewable power generation.
Additional Information	Partners involved are TSOs, universities/research institutes, manufacturers
TRL range	Initial TRL 5 – Final TRL 8
Proposed timeline	2017- 2022
Estimated budget	20 M EURO
Funding Scheme	Research an Innovation actions
Background/State of the art	EU funded projects : MIGRATE, e highway 2050, Optimate

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Topic N. 8 2017	Demand Response Engineering
Cluster	C3
Main FO addressed	T11, T19
Supported FO	T5, T6, T13, T15, T17, T19.
Specific Challenge	Services provided by large size prosumers and by medium-small prosumers connected to the HV, MV and LV grid; advanced management of selected industrial clients based on system benefits analysis
Content/Scope	Scope is to demonstrate the feasibility of Demand Side Response (DSR) to provide ancillary services to power systems. The topic aims at analysing different operation schemes, providing scenario analysis on the feasibility and penetration of DSR techniques and defining case studies for real-environment implementation.
Expected results	Scenario identification of development trends in European electrical system: • Expected evolution of the electrical demand • Electrical mobility scenario and renewables penetration • Electrical Market trends An exhaustive identification of the possible services that can be provided with DSR like FCR, FRR, congestion management; for each specific function, a comparison with traditional resources should be considered. Model for customer behaviours and baseline forecasting. Analysis of key-factors and guidelines for DSR implementation: consumer and producer aggregators, capacity market, advanced dispatching tools, unbalances regulation and new market schemes. Study on the coordination and interoperability of electrical grid with other networks for DSR implementation: Grid to Vehicle (G2V), Power to Water (P2W), Power to Gas (P2G). Definition of communication tools, platforms and devices for increased observability and controllability of the resources, measurement acquisition and control of the resources. Suitable conditions for the settlement of the units, especially considering load aggregates, compliant with regulatory framework. Availability assessment of the resources as regards regulating power. Considering all the deliverables, the implementation of physical demonstrators will prove the increased grid flexibility and the possibility to provide enhanced ancillary services.
Expected Impact	DSR services will provide: • An increase of the available resources for ancillary services provision, an improvement of the system flexibility and a higher security. • The possibility for electrical consumer to exploit economic advantages associated to the service provision.
Additional Information	DSR has to be considered in the broader context of higher system flexibility (T13). Physical demonstrators implementation requires a strong improvement on measurement and control (T5 and T6), together with the assessment of standardized communication protocols for units management (T19). Integration with new market schemes for ancillary services (T15 and T17) will also be a crucial aspect.

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	Research centres or Academic institutions may be involved in scenario identification; big industrial consumer may contribute to demonstrators' implementation. Process integrators, electrical distributors and external suppliers may also been considered.
TRL range	Initial TRL 6 – Final TRL 8
Proposed timeline	2017-2022
Estimated budget	4 M EURO
Funding Scheme	EU funding: Research an Innovation actions
Background/State of the art	According to SEDC (Smart Energy Demand Coalition (SEDC), "Mapping Demand Response in Europe Today – 2015"), DSR implementation is different across Europe: most of the infrastructures are already available and some national regulators have just included this service in the market structure. A dissymmetry can still be identified on National Authorities' regulations; this represents, up to now, one of the mayor barriers to European market uniformity.

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Topic N. 9 2017	Flexible market design
Cluster	C4
Main FO addressed	T17
Supported FO	T15,T16
Specific Challenge	Integration of distributed flexibility resources into wholesale market and new design options
Content/Scope	Identify the technical scarcities at high RES and then design products to incentives these needs into the future. Study the detailed impact of scalable and replicable solutions for RES integration, using not only power markets but also system services. Development of tools that involve a global modelling of the major energy carriers, able to account for different roles and players involved. Studies on tariffs and dynamic pricing.
Expected results	A simulation toolbox quantifying the economic impact of the different proposed designs. New mechanisms pushing towards the optimal investments needs.
Expected Impact	A more efficient internal energy market that takes into account grid flexibility, and an explicit modelling of uncertainties to increase cross-border exchange.
Additional Information	There will be a need to count on other TSOs, research institutes.
TRL range	Initial TRL 4 – Final TRL 6
Proposed timeline	2017-2021
Estimated budget	4 M EURO
Funding Scheme	National and EU funding Research and innovation action
Background/State of the art	Optimate

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Topic N. 10 2017	**ICT tools for data management**
Cluster	C4, C5
Main FO addressed	T18, T19
Supported FO	T11, T14, T16, T21
Specific Challenge	Using ICT tools for data management enabling smart development of electricity system and synergies with other sectors (gas, heat, transport, and telecommunication). Assessment and development of ICT architecture, standards, requirements, roles, business models, exchange platforms, TSO/DSO processes, consumer engagement. Demonstration of cross-border data exchange.
Content/Scope	Defining data sharing models (architecture, functionalities, and processes). Socio-economic costs and benefits of different data sharing models. Describe high-level use cases of data services for market participants both at national level, and across borders. Options for collecting, storing and processing massive flows of data – more granular and closer to real time data. Develop the concept for common interface for customer, considering the differences in data exchange platforms across countries. Applications facilitating TSO-DSO cooperation, e.g. provision of flexibility services. Synergies between metering and operational data. Suitable cyber security methods and data privacy requirements for data sources. Necessary standards and protocols for data sharing between energy market participants. Testing the cross-border communication between data exchange platforms. Tackle the issue of data ownership and related responsibilities.
Expected results	Data sharing models that can be implemented in EU countries with descriptions, including architecture, functionalities and processes. Demonstration of cross-border data exchange. Pilot applications targeting different groups (consumers, network operators). Data security and privacy requirements and feasible cyber security methods for data exchange platform. Suitable standards and protocols for data exchange.
Expected Impact	• Increased energy efficiency • Smarter, i.e. more efficient asset management and system operation • RES development • Development of standards and improved cooperation with standardization bodies • Synergies through deeper TSO-DSO cooperation • New business opportunities for different existing and new stakeholders • Engagement of active consumer and other flexibility sources
Additional Information	Partners involved: TSOs, DSOs, ICT companies, research institutions.
TRL range	Initial TRL 4 – Final TRL 6
Proposed timeline	2017-2020
Estimated budget	4 M EURO

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Funding Scheme	Horizon2020, demonstration project, research and Innovation action
Background/State of the art	Estfeed (www.estfeed.ee), FutureFlow (www.futureflow.eu), SGIH – Smart Grid Innovation Hub (www.eirgridgroup.com)

Topic N. 11 2017	**ICT systems and data handling for system control**
Cluster	C5
Main FO addressed	T18, T19
Supported FO	C2 / T5, T6, T7
Specific Challenge	The future power system will become much more complex and generation will be more uncertain compared to the current situation. Generation facilities will be smaller, scattered over larger areas and then aggregated. Demand facilities will become more flexible and respond to price changes. All in all, a massive communication task is foreseen. The intensive application of converter based power electronics in generation and demand facilities will continue, e.g. electrical vehicles and storage units will explode. The grid system will be facing a complex mix of AC and DC interconnectors in order to control direction of active power flows. The active power flow will no longer be from high voltage level to low voltage level only, as generation facilities will be connected at the lower voltage levels. The predictability of the system stability as well as stability margins will be challenged, and so more advanced control strategies are requested. The information exchange needs will increase dramatically and the needs for IT applications to transmit, secure and process huge amount of data will be a serious driver. Currently, there is a critical need for cost efficient ICT infrastructure to monitor, control and store real time information, such as efficient data warehouse solutions, data mining tools to analyse huge amount of real time and processed data, advanced application to determine preventive control actions for further automation of the system controls in order to keep the stability of the grid.
Content/Scope	Development of cloud based ICT supportive infrastructure; data monitoring and analysis of the control chain actions and automation of basic as well as the higher level control strategies.
Expected results	• Cost effective solutions for a modern ICT infrastructure. • Advanced algorithms for implementing decision support applications to grid control centres. • Solutions of implementing automatic control and balancing of the grid system.
Expected Impact	• Improved system performance by increasing stability predictability and controllability based on improvements in observability, serviceability and user interfaces

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	• Preservation and improvement of present high level of security of supply. • Pushing for a higher level of operator training and initial skills • Requesting a more simulation tools to support a higher level of automation in grid management
Additional Information	A huge amount of conferences illustrates the needs for improvements and the trends in tools and infrastructure solutions.
TRL range	Initial TRL 6-Final TRL 8
Proposed timeline	2017 - 2021
Estimated budget	6 M EURO
Funding Scheme	European Funding Research and innovation actions
Background/ State of the art	During the last ten years, the outcome from various EU projects pinpoints the needs for improvements, e.g: The EU project "Twenties" under the FP7, calls for more actions on the ICT arena and information security aspects. The EU project "GARPUR" under the FP7, calls for more advanced and improved algorithms for control applications.

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Topic N. 12 2017	Coordination on cyber-physical security within the energy sector
Cluster	C5
Main FO addressed	T21
Supported FO	
Specific Challenge	To overcome existing restraints and provide a coordinated response for improved cyber-physical security within the energy sector.
Content/Scope	Identify, evaluate and prioritize current and future risks for the European energy system, holistically addressing physical and cyber risks and the combination of both; Iteratively select, test and validate a set of high-potential innovative technologies, in order to deliver a first catalogue of proven innovative security technologies; Deliver the European Energy Security Distributed Assessment Centre EESDAC: a full-fledged framework for the validation of innovative cyber-physical security technologies. It will consist of virtual and physical testing facilities allowing prequalification and labelling paths aligned with the security scenarios identified in the project; Offer education capabilities and training opportunities for operators and related stakeholders, increasing knowledge basis and awareness to constantly developing threats and available solutions; Reach out, in Europe and beyond, to energy stakeholders and build a large scale community of suppliers and users that will support and use the EESDAC past the end of the project.
Expected results	Select, test and validate innovative technologies. Deliver a testing facility along with the development of education and training capabilities.
Expected Impact	A safe transition towards the digitalization of the Transmission system operation and asset management
Additional Information	TSOs, DSOs, Research institutes, Universities, Security organisms
TRL range	Initial TRL 5- Final TRL 7
Proposed timeline	2017-2020
Estimated budget	10 M EURO
Funding Scheme	European Funding Research and innovation action.
Background/State of the art	EU funded CIP projects

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Topic N. 13 2019	Smart asset management through use of Big Data
Cluster	C1
Main FO addressed	T2
Supported FO	
Specific Challenge	To revisit the lifetime prediction modelling based on extended parameters. To define new and reliable monitoring systems. To specify and develop new and relevant heuristics and approximations for integrated, realistic and workable frameworks. To demonstrate how these approaches can be implemented, scaled up and replicated at effective cost so that the expected benefits are realised.
Content/Scope	To integrate new sensors and new equipment condition monitoring approaches based on distributed technologies. To implement robotics for automated condition monitoring or diagnostic systems for incipient problem detection, as well as to intervene in hostile environments and avoid the need for human maintenance. Live line maintenance and working practises and the use of drones for network monitoring.
Expected results	New approaches for extending the lifetime of existing power components based on improved monitoring, measurements and models to determine ~~of~~ their health and remaining life time. New approaches for managing critical assets based on probabilistic risk assessment and optimization off maintenance planning that are shown to reduce operational costs while increasing network flexibility and ensuring adequate power quality.
Expected Impact	• Optimized costs for asset maintenance activities while increasing the life time of existing assets.
Additional Information	Involved entities: TSOs, DSOs, IT providers, Security organisations
TRL range	Initial TRL 6 – Final TRL 8
Proposed timeline	2018 – 2022
Estimated budget	8 M EURO
Funding Scheme	Preferably EC and national funding, if available

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Topic N.14 2018	Smart interfaces between generation and transmission
Cluster	C3
Main FO addressed	T14
Supported FO	T6,T8, T10,T12
Specific Challenge	Decarbonisation is essential for coping with long-term EU sustainability targets, and electricity is one of the main vectors leading this transition. From the demand-side perspective, electrification of the transport, heating and cooling sectors provides a pathway to fulfil this objective. On the generation side, it could be efficient for the energy system to coordinate and couple electricity generation with the gas supply for the combined cycles.
Content/Scope	The main focus will be on enabling energy systems to integrate (very) high shares of renewable generation with conventional generation, smart transmission and distribution grids and smart storage. This includes also power-to-X, enabler technologies (power electronics), batteries and other storage systems in order to increase the efficiency of power generation with higher flexibility and resilience. An additional priority will lie on smart digital management of energy systems to enable efficient exploitation of the combined capacities and flexibilities of the electricity, gas, heating and cooling, water and transport sectors. Cross-border energy systems will have to be enabled from a technical, economic, regulatory and legal point of view. Develop tools to analyse balancing and congestion issues across the entire energy system and to support the most efficient technologies in restoration plans. Data exchange applications facilitating the system operation, network planning and flexibility services
Expected results	Models and tools to manage balancing and congestion problems. Coordination actions and communication platforms with other system players.
Expected Impact	• Better and optimal decision making tools. • Holistic models that make use of the most cost effective solutions for supplying energy.
Additional Information	Research organizations
TRL range	Initial TRL 3 – Final 7
Proposed timeline	2018-2022
Estimated budget	7 M EURO
Funding Scheme	Mainly EC and national: Type of project: Research action
Background/State of the art	Projects: Real-Smart, GridTech

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Topic N. 15 2019	Optimal grid design and planning based on the use of most cost effective solutions/technologies to enable more flexibility
Cluster	C1
Main FO addressed	T1
Supported FO	T4,T10,T13
Specific Challenge	New planning methodologies involving variable RES and DER, integrating demand response, storage and the interface with other energy and transport/mobility networks as well as new technologies in the transmission network, European energy market and new business models.
Content/Scope	Grid planning within uncertainty framework, i.e., probabilistic approaches, no regret options and risk management. To develop planning methods that combine electricity market analysis, production capacities, DR capacities and infrastructure, storage and environmental constrains, both at the transmission and distribution levels. To account for coupling with other energy networks, specially gas but also heat and cold.
Expected results	Identification of most cost-effective technologies. Delivery of planning tools for network development, both for cross border and TSO-DSO system development, accounting for a broad spectrum of novel technologies.
Expected Impact	• Propose a tool to send investment signals to all stakeholders, not only technology developers but also to the responsibilities of building the infrastructure.
Additional Information	Universities and research centres, software developers, experts in the field of system operation, planning and markets. It is expected to develop pilot software, not at a commercial stage that enables to prove the concepts.
TRL range	Initial TRL 6- Final TRL 8
Proposed timeline	2019 - 2026
Estimated budget	10 M EURO
Funding Scheme	Research and innovation action
Background/ State of the art	E-Highway 2050, Realised grid, Umbrella, I Tesla, Garpur

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Topic N.16 2019	Public acceptance and stakeholders participation
Cluster	C1
Main FO addressed	T4
Supported FO	T1, T2,T3, T14 , T20
Specific Challenge	The realisation of a secure, sustainable and competitive European System requires the development of underlying transmission infrastructure. There is a need to improve public acceptance and stakeholder's participation in transmission infrastructure, while also reducing environmental impact.
Content/Scope	Increase communication campaigns, develop social impact studies and increase the involvement of local and territorial bodies in the early stage of planning of the infrastructure. Analyse new technologies that have reduced conductor visibility, propose new towers and station designs with less virtual visual impact, audible noise, EMF
Expected results	Guidelines on best practices to manage projects since the very beginning to minimize their negative impacts and promote stakeholders engagement and acceptance (for each situation/kind of project or asset)
Expected Impact	Minimize the number of projects/assets that could not be realised for public acceptance issues. Among those ones that can be realised: • Adoption of those technical solutions which bring higher return into socio-economical terms on a global scope (not linked to specific social groups) • Reduction of the realisation time of the selected technical solutions
Additional Information	
TRL range	Initial TRL-5-Final TRL7
Proposed timeline	2019-2026
Estimated budget	5 M EURO
Funding Scheme	
Background/State of the art	Best grid, Life ELIA, TWENTIES (results focused on interconnection links only)

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Topic N. 17 2019	Improve RES forecasting and optimal capacity operation
Cluster	C2
Main FO addressed	T12
Supported FO	T7, T10, T11, T13, T15, T16
Specific Challenge	Forecasting the production of RES with a high level of accuracy is key for optimising of the system, especially in situations of high penetration of high penetration of variable RES. Better forecasting can be achieved by improving the quality of meteorological inputs (such as wind speed, temperature, irradiation, etc) and utilising hybrid approaches that combine weather forecasts, local ad-hoc models, historical data, and on-line measurement.
Content/Scope	The goal is to determine the best method for deploying and demonstrating different concepts using ICT, ancillary services and models for reliable energy output so that clean energy can be integrated, forecasted and smart managed.
Expected results	Effective mechanisms, instruments and rules will be validated for the management of variable sources in system operation and power markets. Combining different approaches in the models should merge their strengths
Expected Impact	• More RES will be integrated into the pan-European system without impacting its reliability.
Additional Information	In RES production forecast models, meteorological inputs are the ones with the biggest room for improvement. Improving the meteorological models might have an impact in other forecast models apart from RES production, like demand forecasting in which minor improvements might have big impacts in the optimization of the system operation.
TRL range	Initial TRL 3 - final TRL 8
Proposed timeline	2019-2020
Estimated budget	10 M EURO
Funding Scheme	Research action
Background/State of the art	Optimate, Anemos, Safewind, Bestpaths, Grid Tech, Realisedgrid, Seetsoc, Windgrid, Ewis

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Topic n. 18	Probabilistic methods for generation adequacy planning
Cluster	C1, C2, C3 Inter-TSO cooperation
Main FO addressed	T1, T8, T13
Supported F	T10, T11, T12,
Specific Challenge	Increasing share of variable renewable energy in the system is precondition for critical situations in future and requires improving of current methods for assessing the risk in generation adequacy not only in peak load but taking into account the changing climate conditions (Pan-European Climatic Database (PECD) to 35 climatic years), available balancing reserve, demand side management potential and etc. All these combination of circumstances address the need of probabilistic methods which will assist the computing and assessing the risks and will display the possible weak spots and lead to potential solutions for operational and long term planning.
Content/Scope	The scope is to use probabilistic simulation methods to identify different combinations of uncertainties in the power system in average and critical conditions (stress situations, situations of scarcity of power generation, weather conditions etc.). Base on ENTSO-E Mid-term Adequacy Forecast (MAF) report for 2016 there is a need for continued development of the modelling tools and revision of used data assumptions for more accurate assessment of generation adequacy in the future. [1]
Expected results	Expected results are new and improved methods and tools for adequacy analysis that incorporate: • Overview and updated data for decommissioning of power plants complying European rules and regulations; • Use of the PECD to 35 climatic years; • Modelling of demand side response; • Use of flow-based market methodology; • Elaborating of cross-border interconnector assumptions and sensible assessment of cross-board support;
Expected Impact	• Improving and applying the methodologies used by ENTSO_E for assessment of generation adequacy at national, regional and pan-European level. • Good planning and assessing in operational reserve adequacy and load shedding risk will avoiding overinvestment in the network and will assist it flexibility. • Also improving the current method for assessing the generation adequacy will lead to better information about the generation reserves for operational planning and long term planning and will improve reliability and security at national and pan-European level.
Additional Information	Research questions could include e.g. • how to take demand response and short term energy storages into account in the adequacy analysis • how to take into account the correlation between short term and seasonal

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	weather variations and fault frequency of different power system components • how to manage the computational effort required by different calculation methods (e.g. monte-carol simulation)
TRL range	
Proposed timeline	2017- onwards
Estimated budget	
Funding Scheme	
Background/State of the art	All the listed recommendations and inspirations are based and in line with results of ENTSO-E Mid-term Adequacy Forecast (MAF) report for 2016.

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Topic N. 19	High impact low probability events
Cluster	Inter-TSO cooperation
Main FO addressed	
Supported FO	
Specific Challenge	The complexity and uncertainties of the power system have been ever increasing since its creation, a trend that will continue with the introduction of more smart devices, new technologies, renewables and distributed energy resources, and more extreme weather. Even in the present power system the mechanisms behind extraordinary events are not well understood. Regardless of the root cause of the extraordinary events, the resulting consequences will be of such a magnitude that society will incur great losses. Consequently, both the transmission system operators as well as the society need increased knowledge and methods for assessing extraordinary events.
Content/Scope	Develop methods and tools for analyzing risk and vulnerability related to extraordinary events in the power system, including: 1. Qualitative framework for analyzing extraordinary events 2. Quantitative methodology for analyzing extraordinary events 3. Methodologies for quantification and interpretation of uncertainties related to extraordinary events. Ensure that the developed methodologies are applicable to real systems, through case studies performed on real transmission systems in collaboration with TSO-partner
Expected results	The anticipated results will be methodologies and prototyped tools for analyzing extraordinary events.
Expected Impact	• The primary goals of assessing the reliability of electricity supply is to provide decision support for the TSOs to help them make a reasonable trade-off between reliability and investment costs. The methodologies developed within this project will generate value for the participating TSOs through improved system reliability and knowledge base on extraordinary events in particular.
Additional Information	The project has been granted support from the Norwegian Research Council as a "Knowledge-building Project for the Industry"
TRL range	Initial TRL 2 – Final TRL 5
Proposed timeline	2017- onwards
Estimated budget	1,3 MEUR
Funding Scheme	National funding
Background/State of the art	Extraordinary events comprise complex mechanisms involving various parts of the power system, requiring knowledge of many disciplines within the field of power system studies. The consequences of power system events are traditionally estimated through contingency analyses. Traditionally, relevant contingencies have been selected by experts, or by screening techniques utilizing approximate power flow techniques. In recent years, probabilistic techniques using fault and event trees have been proposed. Studying extraordinary events requires more

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	than merely running a power flow calculation. For instance, there are many complex chains of events that will have to be correctly modelled to be able to estimate consequences accurately. In this regard, there has in later years been progress in modelling of cascading outages[6]. Important factors involved in cascading failures include dependent faults, hidden faults, and corrective actions[9]. The effect on the reliability taking the probability of unsuccessful corrective actions into account is among the aspects investigated in the GARPUR project. To capture the dynamics of a blackout, detailed dynamic data may also be needed.

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Topic N. 20	Optimal usage of Storage plants
Cluster	C3; Inter-TSO cooperation
Main FO addressed	T10
Supported FO	T8, T9, T13
Specific Challenge	Use of existing Storage Lab facilities for demonstration of typologies and added value from storage technologies.
Content/Scope	The integration of storage facilities in Transmission systems is a promising solution for advanced grid services implementation as well as an effective way to increase system flexibility. Scope of the topic is to analyse the performances of different storage technologies for ancillary services provision.

Expected results	• Scenarios identification related to storage penetration:
	  ◦ Evolution of distributed storage in European network, considering e-Mobility development, renewables integration and Plug-and-Play architectures diffusion.
	  ◦ Large Storage development in transmission and distribution systems for regulation services.
	• A review on the state-of-the art and a critical comparison between different available storage technologies (Battery Energy Storage Systems, CAES systems, Flywheels, Super-capacitors).
	• An exhaustive analysis of possible services obtainable with storage technologies:
	  ◦ Fast frequency regulation services, FCR, FRR or congestion management.
	  ◦ RES curtailment reduction.
	  ◦ System security increase: integration of storage systems in TSOs restorations plans during black-out and for the black-start of traditional generating groups.
	• Aging models definitions for several technologies according to the operating conditions and required regulation services.
	• Identification of some key-factors that would determine a broader penetration of storage in electrical systems.
	• Definition of communication tools, platforms and devices for increased observability/controllability of the resources and measurement acquisition.
	• Virtual storage implementation: technological and regulatory conditions.
	• Impact of the Cloud-storage model on power system management.
	• Definitions of specific regulatory frameworks that would enhance storage distribution.

Expected Impact	Large storage projects would have the following positive impacts: • Provide a significant flexibility to TSOs that will have the possibility to exploit innovative ancillary services and higher availability of resources. • Push National Authorities towards new regulatory frameworks. • Development of new business models related to dispatching services provision for electrical market operators.
Additional Information	Thanks to the possibility to provide enhanced ancillary services (T9) and the increased reliability (T8), Large Storage development can be considered in the broader perspective of flexible grid use (T13).

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TRL range	Initial TRL 7, Expected TRL 8
Proposed timeline	Ongoing activity
Estimated budget	
Funding Scheme	Own TSOs resources
Background/State of the art	According to Bloomberg's Global Energy Storage Forecast, between 2016 and 2024 storage market will experience an exponential increase in its volume, both considering large applications for system operators and domestic distributed storage facilities. Terna (IT) has installed 35 MW of Energy-intensive storage for congestion management and a Storage Lab for the evaluation of different battery technologies and aging models definitions under different operating conditions.

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Topic N. 21	Best practices exchange in cyber-security
Cluster	C5 Inter-TSO cooperation
Main FO addressed	T21
Supported FO	C5 / T18
Specific Challenge	Ensure company IT systems security, including protection of: - hardware from theft or damage - software from contamination and malfunctioning - data from undue access and misuse - entire system from disruption or misdirection Controlling physical access to the hardware, as well as protecting against harm that may come via network access, data and code injection, and malpractice by operators, whether intentional, accidental, or due to being tricked into deviating from secure procedures. This field is of growing importance due to the increasing reliance on computer systems in most industrial sectors and societies. Computer systems now include a wide variety of "smart" devices, including smartphones, televisions and tiny devices, as part of the IoT, and networks include the Internet and private data networks.
Content/Scope	• ITC security standards and architecture • Security measures, monitoring, detection and reactions • Organisation of Security and governance models • External threats, risk level analysis • Real cases examples and scenarios for fast resolution • Security agenda and security initiatives, periodical and on demand • Prevention procedures and employees education and behaviour • Early spotting and identification of threats • On-site resolution of attacks
Expected results	Exchange of experiences, case-studies analysis, risk analysis models, ITC disaster recovery procedures, cyber security strategies, ITC defence plan, data protection systems
Expected Impact	Increase safety and security of IT systems and therefore of all the company processes and technical operations.
Additional Information	Topic addressed multilaterally or bilaterally under the *inter-TSO cooperation* pillar of ENTSO-E Roadmap
TRL range	Not applicable
Proposed timeline	2017- onwards
Estimated budget	
Funding Scheme	TSO Own resources and EU funding
Background/State of the art	Starting point is, for each TSO, its own security systems, to be benchmarked against European peers.

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Topic N. 22	Partially insulated OHL conductor
Cluster	C1 Inter-TSO cooperation
Main FO addressed	T3
Supported FO	
Specific Challenge	Partially insulated OHL Conductor: operate a 400kV circuit on a 110 kV tower
Content/Scope	To engineer, set-up and test the optimal insulation level to cater for utilisation of 110 kV infrastructure at 400 kV To generalise the use-case, identify the optimal upgrade rate of voltage level and define criteria for possible voltage upgrade cases of different OHL
Expected results	Proof the viability of such original scheme; assess the savings achievable and the transformation costs; assess the performances and drawbacks
Expected Impact	Avoid or delay new investments in OHL lines Reduce Capex for attaining higher transmission capacities Increase public acceptance of more powerful corridors
Additional Information	
TRL range	From 7 to 9
Proposed timeline	2018 – 2019
Estimated budget	1 M EURO
Funding Scheme	TSO Own resources
Background/State of the art	N.A. – original research topic

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Topic N. 23	Developing tools for better system awareness based on Big Data analysis
Cluster	Inter-TSO cooperation
Main FO addressed	T18
Supported FO	
Specific Challenge	Inadequate use of already existing big data: measurements from power system (from PMUs, from AMR devices and any sensors) weather forecasts (temperature, wind solar, rain), Electricity market data (volumes and prices) etc.
Content/Scope	Exploring the capabilities of Big data for performing/improving risk analysis and system operation.
Expected results	Methods and tools applicable for TSO to fully utilize their data for having better trends and power system state awareness in general
Expected Impact	Better system awareness enables actions (planning and operation) in time. Real time awareness for control and quantitative information on long term trends occurring in the power system changes (planning)
Additional Information	• External specialists required (e.g. mathematicians understanding data mining techniques etc.)
TRL range	Initial TRL 4 – Final TRL 6
Proposed timeline	2018-2021
Estimated budget	2 M EURO
Funding Scheme	TSO Own resources
Background/State of the art	N.A. – original research topic

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