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"Support to R&I strategy in the area of SET Plan activities in smart grids and energy storage"

Deliverable D2.2[1]

Integrated Implementation Plan of R&I activities: 2016-2018

by

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Quality check: ENTSO-E, EDSO, EASE

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Contents

Executive summary

The present document proposes the first integrated Implementation Plan (IP) for future R&I activities (2016-2018), constructed by the Grid+Storage consortium[2]. This integrated IP is based on:

- the IP 2016-2018 already published by ENTSO-E[3],
- the draft IP 2016-2018 provided by EDSO early 2015,
- R&I topics identified by EASE in its own R&D roadmap.
- A set of parallel analyses of:
    - the on-going R&I activities performed at European level by transmission and distribution system operators (the work already launched, and sometimes completed, in line with the priorities set within the previous EEGI R&I Roadmap 2010-2018 approved in June 2010)
    - the upgraded EEGI Roadmap approved by the EEGI in February 2013,
    - upgraded priorities which have emerged from the network operator joint activities in the past GRID+ support action which ended in late 2014
    - the past and on-going R&D activities on energy storage integration into energy systems, a scan of which was also performed during the GRID+ support action

The existing transmission and distribution operators IPs have been re-examined to identify the possible use of storage solutions which could enrich or complement the research and innovation topics pre-identified by ENTSO-E and EDSO. Moreover, new topics have been identified by EASE, on top of the topics pre-identified by ENTSO-E and EDSO,

The topics included in a draft version of the initial implementation plan 2016-2018 were submitted to public consultation, through an online questionnaire available on the Grid+Storage website[4]. The advent of Research and Innovation activities covering dedicated topics about **the grid integration of energy storage solutions** appears to be welcomed by the respondents to the public consultation. Their feedbacks have been analysed and integrated into the present final version of the implementation plan 2016-2018. Several of these stakeholders have insisted upon the needs for such R&I activities to be embedded into wider energy market considerations at EU level, including the role of market mechanisms and their remuneration in support of energy storage services. It is also worth mentioning that, beyond detailed R&I activities on current grid issues, the contributions of integrated storage solutions to the R&I devoted to "Asset management" and "Network Restoration" have been underlined, thus showing that storage integration into current network planning and operations must be approached in a systemic manner.

[2] See http://www.gridplusstorage.eu/partners
[3] See https://www.entsoe.eu/Documents/Publications/RDC%20publications/150330_RD_Implementation_Plan_2016-2018.pdf
[4] See http://www.gridplusstorage.eu/public-consultations

1 Introduction

1.1 The R&D component of the SET Plan

The EU28 energy policy sits on three pillars since the late 1990's, whatever the energy vector (electricity, gas, heat)[5]:

- a secure energy supply to ensure the reliable provision of energy whenever and wherever needed,
- a competitive environment for energy providers which ensures affordable prices for homes, businesses and industries,
- a sustainable energy system thus lowering greenhouse gas emission, pollution and fossil fuel dependence.

The SET Plan[6] aims at reinforcing the sustainability pillar, thanks to the faster deployment of **low carbon technologies**, while also promoting increased **energy efficiency** at any stage of the value chains of the impacted energy vectors (electricity, gas, heat). These are the two drivers of the research and innovation efforts across Europe, which result in cooperation programs amongst the European countries, industrial companies, research institutions and the EC.

Schematically, such research and innovation activities cover four technology levels, for any of the energy vectors (electricity, gas, heat) covered by the SET Plan:

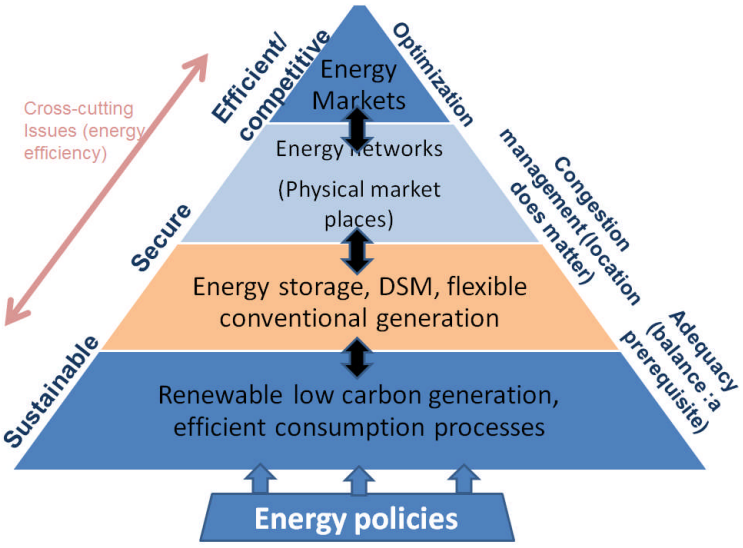

Figure 1 – The four technology levels covered by SET Plan research and innovation activities.

[5] See http://ec.europa.eu/energy/en/topics/energy-strategy
[6] See http://ec.europa.eu/energy/en/topics/technology-and-innovation

- **First level of technologies**, implementing renewable/low carbon generation and efficient conversion/consumption processes,
- **Second level of technologies**, ensuring the balance between supply and demand at system level,
- **Third level of technologies**, using networks to support the transmission/distribution of energy from generation to consumptions sites,
- **Fourth level of technologies**, implementing "smart" software-based solutions to optimise energy systems and energy market mechanisms within well-defined regulatory frameworks.

The present document is dedicated to the first short term (2016-2018) implementation plan of research and innovation activities integrating innovation on energy storage into the electricity system: it brings an integrated insight into the new knowledge needed to make electricity networks involve more energy storage options (level 2 and 3 of Figure 1) to the benefits of more competitive energy markets, including the gas and heat markets.

As depicted in Figure 2 below, there are other means to ensure energy balance at system level (including flexible conventional generation and DSM, -Demand Side Management-). However, they are herein given a less detailed attention than energy storage, since recent technology progresses may bring improved storage options to provide affordable flexibility solutions at different locations of the electric system.

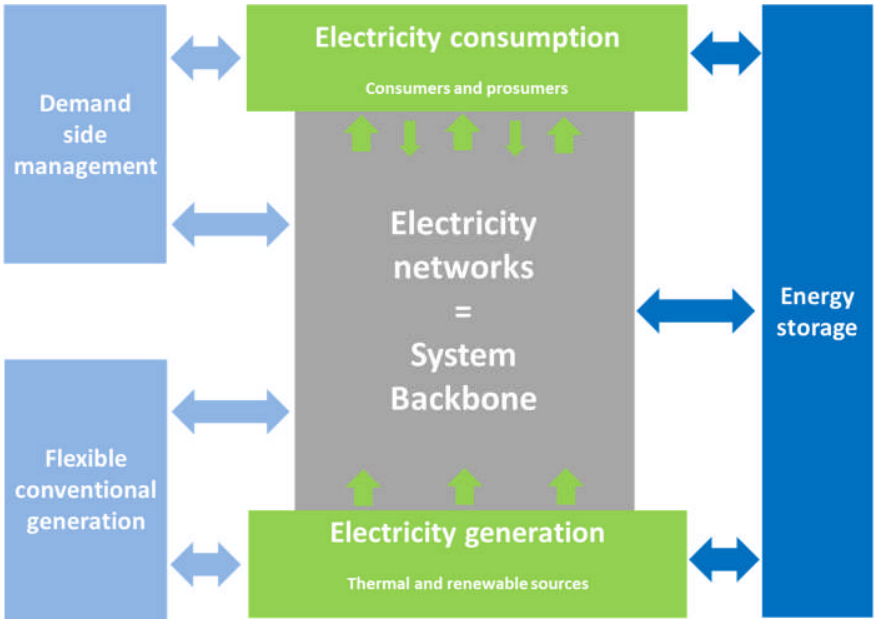

Figure 2 – The electricity networks as a backbone of the electricity system, and flexibility sources as muscles.

1.2 The integrated vision of the proposed implementation plan

Grid operators and storage players consider that the integrated aspects of their R&D efforts encompass three dimensions:

- **The functional integration within the energy system of storage-based solutions:** R&D activities address the optimal mixes of technological and application options, the interface definitions, studies under real life conditions and the provision of experimented data and numerical simulation studies to validate how more efficient end-to-end functionalities will be with the support of energy storage solutions. Such activities follow what has been developed by storage players and has already reached TRL 7 or 8[7]: they will cover activities to bring the TRL levels of the grid operator innovative solutions from 6 to 8 (see Figure 3)[8].
- **The temporal integration of storage-based solutions where R&D activities shape the life cycle of the integrated solutions in terms reliability and techno-economic performances as well as manufacturability.** These data appear critical when looking at evolving policies, changes in market designs and possibly new regulations which make the market uptake of the integrated solutions timely and economically efficient. These activities cover also the TRL 6 to 9 of grid operators.
- **The spatial and environmental integration into the most complex electricity system worldwide:** this requires a fine tuning of the optimal scale (where storage solutions are the most attractive, i.e. from the single home or the factory to districts in cities or pan Europe coverage?) and an adjustment to local climates (northern Europe for wind power versus Mediterranean regions for solar resources, seaside versus mountains) and to areas (mega-cities versus countryside, urban areas versus natural protected areas). These activities lie at TRL 9, with the assent of national regulatory authorities since part of a solution deployment.

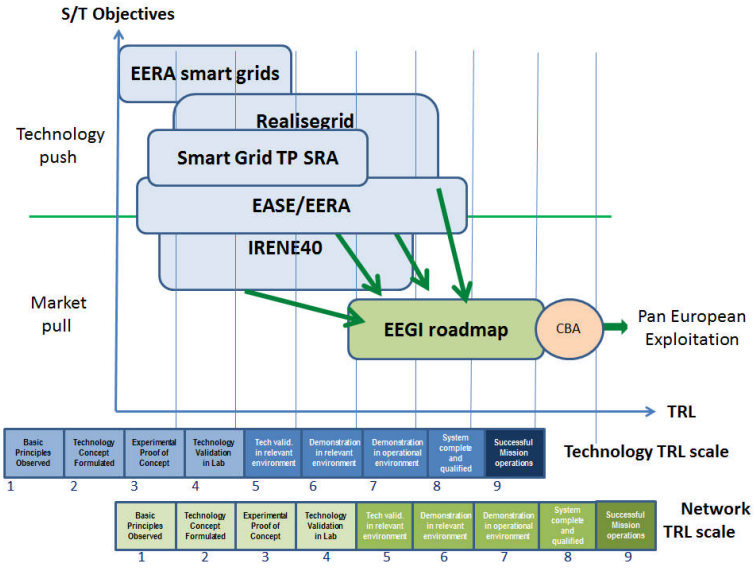

Figure 3 – Positioning of existing roadmaps according to the TRL scale of manufacturers and the TRL scale of network operators.

[7] TRL means "Technology Readiness Level". See the meaning of TRL1 to TRL9 levels in Figure 3.

[8] « Interaction between smart grids initiatives – comparison of roadmaps and implementation plans » GRID+ report D2.4 , October 2014

The R&D activities to be proposed in the present integrated implementation plan aim at addressing simultaneously the two first dimensions, i.e. **system integration of storage technologies** and **life cycle shaping of the integrated storage technologies**.

System integration of storage technologies encompasses:

- bringing together subsystem components to meet performances typical of an ambitious functional goal, in a reliable and economically efficient way,
- adding value to the overall electricity system, thanks to synergetic interactions between the newly connected storage subsystem and the local or global electric system,
- reaching hopefully a new global optimum at system level when deployed at full scale

Life cycle shaping of the integrated storage technologies deals with:

- matching appropriately the research, demonstration and market uptake to meet the deployment scenarios studied as results of the above integration R&D activities,
- matching the various agendas at policy, regulatory, market design and R&D investments levels

1.3 The methodology implemented to draft the integrated IP 2016-2018

The present document proposes the final version of the integrated Implementation Plan (IP) for R&D activities 2016-2018, constructed by the Grid+Storage consortium[9]. This integrated IP is based on:

- the IP 2016-2018 already published by ENTSO-E[10],
- the IP 2016-2018 provided by EDSO,
- R&D topics identified by EASE.

The existing transmission and distribution operators IPs have been scanned to identify the possible use of storage solutions to enrich or complement the research and innovation topics pre-identified by ENTSO-E and EDSO,

- new topics have been identified by EASE, on top of the topics pre-identified by ENTSO-E and EDSO,
- a three-step methodology has been established and used to select these different topics,
- this process results in the Integrated IP 2016-2018

[9] See http://www.gridplusstorage.eu/partners
[10] See https://www.entsoe.eu/Documents/Publications/RDC%20publications/150330_RD_Implementation_Plan_2016-2018.pdf

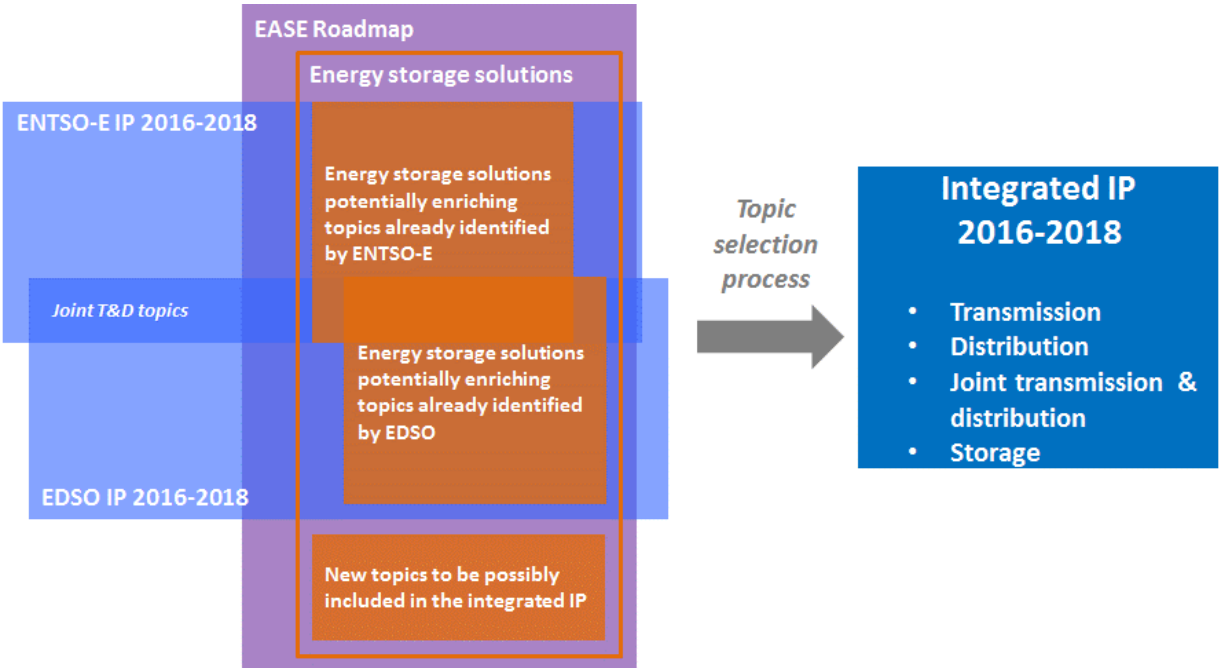

Figure 4 – Integrating energy storage solutions into existing network operators Implementation Plans.

1.4 The public consultation

The topics included in this initial implementation plan 2016-2018 were submitted to public consultation, through an online questionnaire available on the Grid+Storage website[11].

The feedbacks received through this public consultation were analysed by the Grid+Storage consortium and integrated into the present final implementation plan 2016-2018.

1.5 Structure of the present document

The present document is split into two main sections:

- Section 2 summarizes the joint approach implemented to select the different R&D topics where storage solutions are integrated into the implementation plans of grid operators;
- Section 3 depicts the final integrated implementation plan 2016-2018 based
- Section 4 concludes on the resulting R&I roadmap and proposes a first expected impact appraisal for energy storage manufacturers

[11] See http://www.gridplusstorage.eu/public-consultations

2 A three-step approach to merge R&I topics into a single integrated implementation plan

A three-step approach has been implemented under the coordination of TECHNOFI to filter and rank the portfolio of R&I topics which are to be integrated into the draft Implementation plan.

► **STEP 1: listing of storage functionalities able to enrich the network R&I topics**

- List available storage technologies
- Assess how they can enrich the existing TSOs and DSOs IPs 2016-2018
- Assess whether other R&I topics where storage is relevant in the present timeframe should be considered

► **Step 2: monitoring past and ongoing R&I projects**

- For each topic identified in step 1 (either from TSOs/DSOs IP, or from EASE), check whether past (since 2012) or ongoing projects have addressed or are addressing the topic:
  - The aim is to avoid double funding and generate the best value for money in terms of EC investments. The monitoring also includes a coherence analysis with other existing roadmaps and their own IPs if available.
  - In case a topic coming from step 1 is already sufficiently addressed by a past or ongoing project within the EU, it shall be excluded from the integrated IP 2016-2018.

► **Step 3: ranking according to needs coming from system operators**

- For the remaining R&I topics , a ranking is collectively performed according to three main criteria:
  - **Urgency:** the agenda of flexibility needs as seen by network operators (TSOs and DSOs),
  - **Timeliness for availability:** the time for system integration as estimated by networks operators (TSOs and DSOs) and EASE,
  - **System impact:** the expected impact on system planning, operation and maintenance once system integration has been successfully implemented

Upon completion of the public consultation and integration of the relevant improvements as described below, the Grid+Storage consortium proposes to introduce an industrial dimension into the final positionning of the retained list of R&I topics[12], this in order to pinpoint the expected impacts of the outputs from R&D topics onto the European industrial competitiveness of the storage industry.

[12] This list of R&I topics will have a de facto intrinsic European Added Value content when it comes to addressing challenges and producing a set of prototype solutions with the corresponding impacts (if the developed solutions reach market applications in EU28). This however means also that the corresponding R&I investments to perform the proposed R&I activities can come from several sources or combination of sources, including regional, national or European public funding, together with private funds from technology manufacturers and/or networks operators.

3 Integrated implementation plan 2016-2018

3.1 Summary of the results obtained from the initial integration process

The initial integration process coordinated by TECHNOFI with the joint involvement of ENTSO-E, EDSO and EASE has acknowledged three major conclusions:

1. The initial draft implementation plans of ENTSO-E and EDSO have already storage options addressed in several R&I topics
2. The same initial draft IP proposed either by ENTSO-E or EDSO may be enriched from new storage options brought by EASE
3. EASE brings new systemic R&I topics to be undertaken with impacts on the electricity system

The three conclusions are illustrated below with the conclusions of the integration process.

- **TSOs**

> Storage solutions already mentioned in the initial version of the ENTSO-E IP 2016-2018
  - *Topic 1-2016: Fast storage needed by TSOs*

> Storage solutions embedded in the draft integrated IP 2016-2018
  - *Topic 3-2017: Market modelling and system adequacy assessment for long-term planning (linked to EASE Topic ES04-2017: Long-term network planning tools involving storage for capacity firming, active demand and investment deferral)*

- **Joint TSO-DSO**

> Storage solutions embedded in the draft version of the draft integrated IP 2016-2018
  - *Topic 2-2017: Improved defence and restoration plan (linked to EASE Topic ES05-2018: Electricity storage for defence and restoration plans)*
  - *Topic 4-2016: Demand-Side Response: load control mechanisms and ancillary services at TSO and DSO levels (linked to EASE topic ES01-2016: Active demand at TSO level using centralised control (at DSO level) of small scale storage units for cross-border exchange)*

- **DSOs**

> Storage solutions already mentioned in the initial version of the EDSO IP 2016-2018
  - *Topic 3-2016: (D9) Network management tools (considering DER, storage and other new uses and players)*
  - *Topic 2-2016: (D6) Integration of infrastructure to host electrical vehicles*

> Storage solutions embedded in the draft version of the draft integrated IP 2016-2018
  - *Topic 3-2015: (D4) - Integration of DER at medium voltage /high Voltage using novel technologies (including storage) ((linked to EASE Topic ES03-2016: Technology and market conditions allowing electricity storage units to provide ancillary services including in cross-border modes)*

  - *Topic-5-2016: (D13) Novel approaches for market design addressing new grid operations (possibly linked to EASE Topic ES02-2016: Role of storage system to optimally integrate RES in short-term markets and EASE Topic ES06-2017: Market design allowing storage systems to join cross-border capacity markets)*

- **EASE**

> Storage options with impacts on the electricity system which deserve the introduction of R&I activities in the integrated IP 2016-2018
  - *Topic ES07-2016: P2X Storage involving the carbon intensive industrial sector (power, combined heat and power, process industries)*
  - *Topic ES8-2018: System integration of seasonal/large scale storage of energy involving cross-border exchanges*

3.2 The public consultation process and the respondents

The public consultation was opened via the GRID+STORAGE web site based on a set of questions organised on a per cluster basis (see section 4), according to5), and following the existing EEGI roadmap structure. It was relayed by the consortium organization web sites to maximize impacts.

It covered the period going from April 22-nd up to May 19-th 2015.

The table below lists the respondents with a short description of their organizations.

Organisation	Web site	Activity
CEDEC	www.cedec.fr	CEDEC is a European group which works since 1965 in the development and the evolution of business towards Management Excellence.
DHC+ TEchnology Platform c/o Euroheat & Power	www.euroheat.org	Euroheat & Power is the founding member of the DHC+ Technology Platform which aims at providing a European level framework for stimulating research and innovation for District Heating and Cooling.
EMIRI	https://emiri.eu/	EMIRI' covers the full Europe-based value chain from the lab (R&I on advanced materials) to the end-market development of various low carbon energy & energy efficiency technologies (pinpointing the strategic components for the competitive manufacturing of advanced materials and derived products).
ENGIE/Tractebel	www.engie.com/fr	ENGIE/Tractebel is active in electricity network planning and operations, worldwide
ETP for Smart Grids	www.smartgrids.eu/	The ***European Technology Platform for Electricity Networks of the Future***, also called ETP

		SmartGrids, is the key European forum for the crystallisation of policy and technology research and development pathways for the smart grids sector, as well as the link between EU-level related initiatives.
EUREC	www.eurec.be/en/	EUREC, created in 1991, is the leading association representing research centres and university departments active in the area of renewable energy.
EURELECTRIC	www.eurelectric.org/	EURELECTRIC is the electricity sector association which represents the common interests of the electricity industry at pan-European level.
EUROBAT	www.eurobat.org	EUROBAT gathers the European automotive, industrial and special battery industries (47 members from across the continent comprising more than 90% of the battery industry in Europe),
Highview Power Storage	www.highview-power.com	Highview Power Storage is a designer and developer of large-scale energy storage solutions for utility and distributed power systems, using liquid air as the storage medium,
Hydro Equipment Association	www.thehea.org	HEA – Hydro Equipment Association represents electro-mechanical equipment suppliers for hydropower globally
IK4-IKERLAN	www.ikerlan.es/en/	The Basque R&D technology center specialiing in embedded systems, power electronics, and energy
ITM Power	www.itm-power.com/	ITM Power is a manufacturer of integrated hydrogen energy solutions
NEW-IG	www.new-ig.eu/	The New Energy World Industry Grouping (NEW-IG) works to accelerate the market deployment of Fuel Cells and Hydrogen (FCH) technologies.
TAURON Polska Energia S.A.	www.tauron.pl/	TAURON Group is a energy utility covering hard coal mining, generation, distribution and supply of electricity and heat.
Younicos AG	www.younicos.com/en	Younicos is a global leader for intelligent storage and grid solutions

3.3 The final Implementation Plan 2016-2018

3.3.1 Level of acceptance of the proposed R&I topics

It can be claimed that the advent of Research and Innovation activities which cover dedicated topics about the grid integration of energy storage solutions is welcomed by the respondents to the public consultation.

Several stakeholders have insisted upon the needs for such R&I activities to be embedded into wider energy market considerations at EU level, including the role of market mechanisms and their remuneration in support of energy storage services.

This includes research and demonstration activities in support of the preparation of answers to questions such as:

- Who should have the right to own and operate storage facilities in EU28?
- How should the existing unbundling rules[13] be upgraded to favour electricity storage without creating potentially competitive distortions?
- How grid connection and access rules for storage should be designed EU-wide in order to ensure a level playing field which avoids any discrimination or competition distortion between storage solutions?
- What are the types of market rules which allow developing a level playing field between storage services and demand response or fast ramp up power generation?
- How R&I public support on grid integration will favour a fair competition between sources of flexibility to improve the energy system efficiency?

These activities are located in several of the topic descriptions below.

3.3.2 Detailed description of ENTSO-E R&I topics with their storage dimension

TSO Topic 1-2016	**Highly responsive power and energy storage systems needed by TSOs TRL 5-6**
Main Functional Objectives	**T3 - DEMONSTRATION OF POWER TECHNOLOGY TO INCREASE NETWORK FLEXIBILITY AND OPERATION MEANS**
Supported Functional Objectives	T7 - INNOVATIVE TOOLS AND METHODS FOR COORDINATED OPERATION WITH STABILITY MARGIN EVALUATION
Specific Challenge	The European electricity systems are challenged by the high penetration of renewable electricity generation with fluctuating in-feeds. Interconnectors between power systems and market coupling ensure access to Day Ahead resources and demand in neighbouring regions, countries or power systems. Large-scale energy storage such as hydro power or power-to-gas facilities are contributing to the present and future need for storing vast amount of electricity in a comprehensive energy form. There is a growing challenge in balancing the power system in the short term (a few hours) and at a minute base (Intra Hour). Until now, fluctuations from wind turbines or solar units have been balanced by rotating reserves on traditional thermal power plants. These resources will decrease in the years to come while being supplanted by RES at an accelerating rate.

[13] which ensure fair competition across the energy system by guaranteeing non-discriminatory network access and avoiding conflicts of interest

Content/Scope	Activities should focus on storage systems that aim at supporting the power system with highly responsive power and energy storage. There are technical issues to overcome; many economic, regulatory, market and environmental aspects must be addressed. **The primary technical objectives** are optimal power-to-power cycles with optimal efficiency and minor losses or integration with other energy systems like thermal grids offering to use losses as valuable energy services such as heat or gas. It might be technically feasible to store electricity by converting it to other forms of energy, but this might not necessarily be desirable if conversion losses are too high or regeneration of electricity for the power system is not significant. **Secondary technical objectives** are focussed on the need to support the power system with ancillary services, and not just ensuring energy flow. Using highly responsive power and energy storage at different voltage levels in the power system calls for novel solutions where ancillary services are included in the storage facility. Swift power response, reactive power, voltage control, short circuit power and inertia should be included in a package of complete solutions provided by storage services to power systems. Future power systems with large amounts of inverter-based generation at all voltage levels require ancillary services from other sources. The advantage and business opportunities for highly responsive power and energy storage could be significantly higher if system operators would be able to harvest ancillary services from the storing systems, and, vice versa, if the storage facility needs ancillary services to operate. **The third technical objective** is to find the optimal size and position of highly responsive power and energy storage for operation in transmission systems as well as in distribution grids. This topic will address the issues from a technical perspective. However, results might provide the regulatory bodies with insights to deal with issues such as: - Who will own and/or operate such highly responsive power and energy storage facilities? - Is the storage facility to be included with system operations, or is it a fully market-integrated resource with optimisation potential in different electricity markets? - What are the investment incentives for large storage facilities with only a few hours of operation? - What tariffs should be developed to pay for these services? - How will storage facilities comply with varying national RES feeds? Potentials for servicing the power system with fast responding services should be examined and compared with other technical and/or market opportunities.
Funding Scheme	Innovation actions including RD&D activities.
Expected Impact	The proposals are expected to cover the general impacts with focus on: - Feasibility studies of several technologies being able to support the power system with highly responsive power and energy storage

	- Pilot demonstration(s) of highly responsive power and energy storage integrated at both transmission (HV) and distribution levels (LV) to show potentials for balancing, congestion management and/or support with ancillary services - Analyses and recommendations for the regulatory frameworks needed to favour opportunities for storage facilities - Deferred investments for transmission and distribution grids reinforcements and lower social costs associated with high penetration of fluctuating renewable power generation. - Impacts of couplings with heat and gas networks
Additional Information	The overarching benefit of the project is that it will help to develop a sustainable, efficient, secure and flexible Smart Cities solution with advanced integration of competitive low-carbon and renewable electricity generation.
Proposal Duration	3–4 years
Estimated budget	€ 20 million at least if pilots are implemented

TSO Topic 2-2016	**Control system of the future: real-time tools for control centres** **TRL 4 - 7**
Main Functional Objectives	**T6 - INNOVATIVE TOOLS AND METHODS TO OBSERVE AND CONTROL THE PAN-EUROPEAN NETWORK**
Supported Functional Objectives	T8 - IMPROVED TRAINING TOOLS AND METHODS TO ENSURE BETTER COORDINATION AT THE REGIONAL AND PAN-EUROPEAN LEVELS
Specific Challenge	The rapid evolution of the European power system presents control room operators with new challenges with respect to real-time control of transmission networks. The first challenge is related to the increase in system size to be controlled due to ever more components being connected. This is especially due to distributed production units being installed for the development of renewable production. The European electricity market has also increased cross-border exchanges and operators must now have access to more information on neighbouring systems. The second challenge is related to the increase of complexity with the emergence of active distribution networks, the insertion of new controllable components using power electronic (FACTS, HVDC links, and more) and the fast development of fluctuating generation from RES. This evolution also leads to changes in system dynamics due to additional fast close-loop control and fluctuating systems. A correct level of information synthesis should be given to the operators taking opportunities from new types of user interfaces. This will provide efficient access to more information from new monitoring systems including PMUs, smart meters, dynamic rating systems, local weather condition monitoring, and more. This presents another challenge in defining a new role for operators in the decision loop. We can see a move away from current control systems where operators have more or less direct control of the power system to a future control system that is more or less automatically controlled and highly responsive.
Content/Scope	Activities should focus on developing new real-time tools for control centres (SCADA enabling massive acquisition of information, EMS with advanced functions). The targeted time frame of these systems lies between 30 minutes ahead to real-time. Based on big data and machine learning techniques, development of prototypes of new tools for: - Automatic analysis functions improving the system observability (what is the current state of the system?), detection of security issues, alarms based on synthesis of detailed results from advanced security analysis tools[14] ("what if" analysis) providing contextual information and advice (guided analysis). Such analysis should help the operators to focus on critical contingencies or equipment, thus increasing awareness and accelerating decision-making processes. Another important issue is the detection of

[14] As proposed in the two ongoing FP7 projects Umbrella and ITesla

	real-time conditions needing specific attention such as novel conditions (i.e., conditions never before observed) or that were not studied during day-ahead preparations. - Decision support for adaptation of parameters and setting points of the transmission system controls (such as HVDC infrastructures, special protection schemes, voltage controls of SVCs, generator set points, a fast responding storage system and more). The objective is to help operators to increase or maintain stability in the context of a more complex and dynamic power system which will include fast responding reserve capabilities (mainly storage technologies) to offer dynamic response. Issues relating to optimal man-machine interfaces (i.e., between operators and transmission grid) are also covered by this topic. Various new technologies are available for synthesising information, easing navigation through huge quantities of information and accelerating the implementation of actions (such as touch-sensitive screens, head-up display, 3D, haptic technology, etc.). A question is raised on how operators can best interact with physical power systems.
Funding Scheme	Innovation actions including RD&D activities.
Expected Impact	The development of more advanced control centre tools will enhance European power system security and allow systems to be operated closer to their limits without increasing risk. The possibility to use more advanced controls will also have a positive impact on the possibilities of incorporating more active and distributed components such as RES generation. Finally, optimal usage of software should reduce the need for additional infrastructure (hardware).
Additional Information	Including RD&D activities with development of prototypes and demonstration in control centres (at least for some of the functions).
Proposal Duration	3–4 years
Estimated budget	€ 10-15 million

TSO Topic 3-2016	**Monitoring & observation tools for power network infrastructures** **TRL 6-7**
Main Functional Objectives	**T6 - INNOVATIVE TOOLS AND METHODS TO OBSERVE AND CONTROL THE PAN-EUROPEAN NETWORK** **T16 - DEVELOPMENT AND VALIDATION OF TOOLS WHICH OPTIMIZE ASSET MAINTENANCE AT THE SYSTEM LEVEL, BASED ON QUANTITATIVE COST/BENEFIT ANALYSIS**
Supported Functional Objectives	
Specific Challenge	The European power system faces major changes mainly associated with the massive integration of distributed and fluctuating RES generation. New types of transmission infrastructures must be added to the system: HVDC links, FACTS, offshore components, underground cables and more. This evolution is taking place on a grid that is already ageing and will require additional expenditures for maintenance and renewal. Sensors are to be used in the transmission grid mainly for real-time measurement of voltage and current. In order to operate the network, there is a need for additional real-time data on the European system that provides dynamic information on a growing number of components. For asset management issues, the classic approach consists in building asset management policies based on laboratory tests and measurements on a few samples of equipment. One challenge is linked with the capacity to use more information coming from equipment in the field. New sensors are needed in order to develop asset management policies based on risk evaluation. This must account for the life status of various equipment (based on previous conditions encountered locally by this equipment) and determine what the consequences for the system would be when a given piece of equipment fails.
Content/Scope	Activities should focus on new components and systems aimed at enhancing TSO awareness of network status either for operational activities (real-time and operational planning) or maintenance and long-term planning activities. “New” sensors are to be developed that allow for different kinds of measurements and applications (video, infra-red imagery, vibration detection, lasers and more). In summary: - Dynamic line-rating equipment including systems for overhead lines, underground or submarine cables - Monitoring systems for substation equipment (transformers, breakers, disconnectors and more) with real-time status and expected lifetime estimates - PMUs and associated local or wide-area monitoring systems - Vegetation monitoring - Presence detection around grid infrastructure (humans, animals, excavators, etc.).

	- Monitoring techniques for storage devices integrated into the electricity networks The various available communication networks should also be taken into consideration (depending on final applications): centralised vs. local system, cheap communication network with low reliability and low bandwidth vs. expensive communication network with high reliability and high bandwidth. The time synchronisation (acquisition and/or time stamping) requirement must be clarified for each application. This can be critical to finding correlations between different sets of measurement types in large systems. The targeted monitoring and observation tools can be static or mobile through "new" supporting devices (satellites, drones, robots).
Funding Scheme	Innovation actions including RD&D activities
Expected Impact	Improved real-time monitoring systems together with better knowledge of real constraints seen by components; operation of European system closer to physical limits with no increase in risk. Better knowledge of individual component life status; decisive impact on network performance in terms of power quality and security of supply and consequently on electricity market. This is also a prerequisite for smart asset management policies which will have a positive financial impact on OPEX (i.e., for grid maintenance) and on CAPEX (i.e., for grid renewal).
Additional Information	
Proposal Duration	3 years
Estimated budget	€ 10–20 million

TSO Topic 1-2017	**Advanced tools for new market models** **TRL 5-7**
Main Functional Objective	**T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION**
Supported Functional Objective	
Specific challenge	Pan-European power flows within a free energy market plus massive integration of variable RES resulting in local and regional bottlenecks, necessitating a fair charging mechanism for capacity use.
Content/Scope	The aim is to develop new capacity calculation methods for medium to long-term horizons (week, month, year, multi-year ahead) and congestion management approaches in accordance with a new comprehensive and reliable methodology being developed for the pan-European transmission network. Relevant tools should also be developed to support capacity allocation and congestion management. Stakeholders such as TSOs, market operators, regulators and market players have cooperated in establishing the broad lines of a target model for the European Electricity market. Many details and technical issues need to be further developed particularly for capacity allocation and congestion management. These must account for new approaches of combining preventative and corrective measures for reliability assessment, and allow more precise estimations of the system state due to accurate, wide-area, synchronised and high-sampling rate measurements. Other elements to ensure the market efficiency of electric systems with large share of RES ought to be considered: for instance, flexibility and grid services to be taken into account into new market designs. The consortium should include a relevant number of TSOs.
Funding Scheme	Collaborative project
Expected Impact	The results of this project should allow correct predictions of available capacities in transmission lines and cross-border interconnections so that they can be efficiently allocated to market actors. The completion of the internal market leads to increasing electricity flows and these are responsible for congestions particularly at cross-border connections. In view of the difficulty of building new lines, it is important to exploit existing connections to the maximum of their physical capacity. Advanced congestion management principles, methods and tools will correctly indicate to the market where true network congestions physically exist and should therefore minimise losses due to limited network capacity. Modelling techniques should also be able to account for Storage and Demand Side Response contributions to maximise the electricity system flexibility (see topic ES3 and ES6). It will then help assessing the role of the various market players and the costs and benefits of such solutions.

Additional Information	
Proposal Duration	TBD
Total Budget	TBD

TSO Topic 3-2017	**Market modelling and system adequacy assessment for long-term planning TRL 3-5**
Main Functional Objective	**T2 - PLANNING METHODOLOGY FOR FUTURE PAN-EUROPEAN TRANSMISSION SYSTEM**
Supported Functional Objective	T1 - DEFINITION OF SCENARIOS FOR PAN-EUROPEAN NETWORK EXPANSION, T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION
Specific challenge	Need for a better modelling and simulation approaches to address the uncertainties in the future energy mix and market mechanisms for long-term planning purposes
Content/Scope	Based on the outcomes and lessons learned from e-Highway2050 project, a methodology and associated tool is to be developed that integrates long-term market scenarios and simulations for grid planning purposes. The tasks are: • Design and demonstrate new methods, tools and processes for assessing long-term market scenarios and system adequacy. • Build on existing experiences and tools (PSM, SPARK, ANTARES, etc.) to anchor know-how and lessons learned in the business while designing new market models to reflect the future EU market framework for grid planning purposes • Account for the impact of growing technologies such as Demand Response, electric vehicles, Battery-based Electric Vehicles, Fuel Cell Electric Vehicles and energy storage on consumption and generation; , and on grid planning from a market point of view; • Develop forecasting techniques including correlation effects (wind, solar, DR, storage, etc.). • Build on these experiences and more specifically deal with the trade-off between a bottom-up approach and a top-down approach when identifying gaps and to find the best approach of filling gaps (including the challenges involved in collecting data). • Account for the role of innovative storage solutions (such as power2X) in optimising the use of the energy mix • Account for existing and future market mechanisms (such as capacity markets) to quantify their impacts on system adequacy
Funding Scheme	Collaborative project
Expected Impact	• Methodology and prototype tool for better incorporation of market modelling in long-term planning and decision-making processes • Ability to quantify the benefits of storage solutions for different services such as enabling capacity firming, active demand and investment deferral... • Link with large scale demonstration activities where the role of the storage in long term planning simulation tools can be assessed.

Additional Information	Link with e-Highway 2050
Proposal Duration	4 years
Total Budget	€ 20–30 million

TSO Concept 1-2018	**Data and information management for system operation and asset management** **TRL 5**
Main Functional Objective	**T15 - DEVELOPING APPROACHES TO DETERMINE AND TO MAXIMIZE THE LIFETIME OF CRITICAL POWER COMPONENTS FOR EXISTING AND FUTURE NETWORKS**
Supported Functional Objectives	T6 - INNOVATIVE TOOLS AND METHODS TO OBSERVE AND CONTROL THE PAN-EUROPEAN NETWORK T16 - DEVELOPMENT AND VALIDATION OF TOOLS WHICH OPTIMIZE ASSET MAINTENANCE AT THE SYSTEM LEVEL, BASED ON QUANTITATIVE COST/BENEFIT ANALYSIS T7 - INNOVATIVE TOOLS AND METHODS FOR COORDINATED OPERATION WITH STABILITY MARGIN EVALUATION T9 - INNOVATIVE TOOLS AND APPROACHES FOR PAN-EUROPEAN NETWORK RELIABILITY ASSESSMENT
Specific challenge	Necessity for a new approach of managing enormous volume of information and data generated throughout the electricity system
Content/Scope	• Set out a methodology for managing the information and data currently available: technical specifications of different assets including storage systems, lifetime characteristics, maintenance and operational practices, data and information coming from measurements, protection and monitoring devices, as well as from metering devices (generation and demand connection points, storage connection points, measurements on interconnection tie-lines, including metering for contracted and activated reserves). • Data acquisition, data management (updates, storing/archiving and cleaning methodologies, data security) as well as data mining; statistical inference and heuristic algorithms should be investigated so that high-quality data and information can be used for different applications, e.g., for dynamic simulations and security assessments, helping system operators in decision-making processes and for asset management purposes, both at the component and system level. • Experience feedback methods should be proposed in order to learn from best data and information management practices.
Funding Scheme	Collaborative project

Expected Impact	Increase the quality and reliability of the data and information that TSOs use to manage their assets and operate their systems.
Additional Information	Link with iTesla, Umbrella, Garpur
Proposal Duration	4 years
Total Budget	€ 20–40 million
TSO Concept 2-2018	**Realisation of ultra-high-voltage lines with partial underground cabling TRL 6**
Main Functional Objectives	**T14 - TOWARDS INCREASING PUBLIC ACCEPTANCE OF TRANSMISSION INFRASTRUCTURE**
Supported Functional Objectives	T2 - PLANNING METHODOLOGY FOR FUTURE PAN-EUROPEAN TRANSMISSION SYSTEM T3 - DEMONSTRATION OF POWER TECHNOLOGY TO INCREASE NETWORK FLEXIBILITY AND OPERATION MEANS
Specific Challenge	TYNDP indicates the urgent necessity of expanding the current pan-EU transmission grid in order to meet European energy policy goals. The main driver of grid expansion is the huge increase in production from RES. Since RES are often situated far away from consumers, this results in large power flows through transmission networks. Furthermore, public acceptance of infrastructural projects is another issue for Member States. This induces public expectance to minimise the visibility of infrastructure. Cable links for EHV/UHV do not yet ensure adequate capacity at a reasonable cost. For the reasons stated above, TSOs require new transmission technologies that: • Can provide greater capacities • Can be easily integrated into existing grids, especially in existing corridors • Can be utilised in densely populated areas • Can take into account the technology progress made on storage technologies
Content/Scope	R&D is necessary to investigate and demonstrate the integration of high-capacity technologies in meshed networks and in densely populated areas. Even though ultra-high voltage AC and DC transmission lines have already been demonstrated around the world, R&D is still necessary to learn how to confront the challenges stated above. This concept will provide new knowledge and experience of the advantages offered by new technologies for the densely meshed European transmission system. It will also lead to new and improved equipment for urban applications and demonstrate the benefits of high-capacity corridors from the technical and

	public acceptance points of view. The potential of bundling with existing infrastructures will also be investigated. Tasks: • Launch the implementation of UHV transmission in Europe (foster political discussion, create public acceptance, trigger necessary legal additions, technical standardisation) • Technical development and demonstration of UHV AC solutions (500 kV to 750 kV) • Development of new OHL tower designs for UHV applications (flexible for AC/DC and various voltage levels, optimised electro-magnetic fields, compact design etc.) • Development of new conductors for UHV applications (in contrast to worldwide applications, special focus shall be placed on noise reduction as well as high capacities) • Develop concepts for UHV applications in existing routes and their combination with electricity storage to optimise the operation of UHV lines • For the integration of Gas and possibly thermal grids with the storage capabilities they offer to optimise the whole energy systems • Implement demo projects • Develop cable solutions for partial cabling in densely populated areas o XLPE cables for DC +/- 500 kV o Reduction of losses o Reduction of trench width to gain space compared to OHL o Technological development to increase reliability and reduce costs o Innovative maintenance concepts for cable with quick reaction times • Implementation of AC UHV pilot project in meshed network including maintenance concepts for AC UHV • Development of solutions for bundling line routes with existing infrastructure o E.g., using GIL or partial cabling o Demonstrate applicability of new innovative transmission technologies (super-conducting cable etc.)
Funding Scheme	Collaborative project
Expected Impact	Readiness for application solutions with strong energy transmission links useable in meshed networks, densely populated areas, improved public acceptance

Additional Information	Links to other projects with a focus on similar FOs will be considered. The focus will be on innovation and demonstration, i.e., new knowledge and technology.
Proposal Duration	4 years
Total Budget	€ 50 million

3.3.3 Detailed description of joint TSO and DSO R&I topics with their storage dimension

TSO/DSO Topic 1-2016	**Demand-Side Response: load control mechanisms and services at TSOS and DSOs levels for system level TRL 5-7**
Main Functional Objective	**TD2 - THE INTEGRATION OF DEMAND SIDE MANAGEMENT AT DSO LEVEL INTO TSO OPERATIONS**
Supported Functional Objectives	TD3 - ANCILLARY SERVICES PROVIDED THROUGH DSOS T10 - ADVANCED PAN-EUROPEAN MARKET TOOLS FOR ANCILLARY SERVICES AND BALANCING, INCLUDING ACTIVE DEMAND MANAGEMENT
Motivation/challenge	Consumption-based flexibility from distributed sources is another route to give network operators the capability to better manage power and energy flows within the electricity system, where growing volumes of variable generation have to be taken care of. TSOs can obtain consumption flexibility from several stakeholders, including through Demand Side Response which could be offered by DSOs thanks to the aggregation of distributed resources: end-consumers (residential and others), prosumers, distributed storage, aggregators, …. Yet, the attractiveness of the resulting business models need to be checked via large scale demonstrations in order to understand the main barriers to be overcome before full deployment can be decided.
Topic 2-2017 Content and scope	**Improved defence and restoration plan** • **TRL 4-6**Develop processes, profiles, platforms and standards for the real demand curves coming from different types of customers. • Requirements of TSOs towards market stakeholders and DSOs in order to trigger consumption-based flexibility offers, with or without energy storage options, with specifications about the related data and telecommunications needs as well as response time constraints to impact the electric system management when deployed at large scale • Modelling of short-term electricity markets (day-ahead, intraday and balancing), able to account for energy storage options, with the proper segmentation of the flexibility providers (with or without energy storage solutions) • Specifications of sustainable business models for different types of stakeholders (DSOs, aggregators, residential and larger consumers, storage operators, …) based on the modelling trends obtained when looking at different business configurations • Definition of a set of a few regional large scale demonstrations which will take into account past or on-going experience in several Member States [15] to test and validate under real-life conditions/regulations the sustainability perspectives of the selected business models, this in order

[15] Demonstrations in Member States where examples of TSO-DSO cooperation is already taking place (like Italy, UK, Denmark, …..)

	to monetize the value of the consumption-based flexibility targets within the involved local electricity markets • Performance of the demonstrations and analysis of the experimental data obtained from the set of regional demonstrations with a broad coverage to show the impact of different flexibility solutions (DSR, storage etc….) at pan European level. The impact on system stability and market efficiency can be assessed, leading to the requirements for implementing such programs at a wide scale. • Recommendations for deployment based on scaling-up and replication rules which have been validated experimentally
Funding Scheme	Collaborative project with a predominant innovation component involving large-scale demonstrations
Expected Impact	• Validation of effective load control options involving a spectrum of stakeholders (DSOs, aggregators, storage operators,…) according to the tested local electricity market conditions • Valorisation of technologies such as smart metering, online reading and feedback, and consumer awareness, currently in place within the distribution network, in order to make the system more secure and the markets more efficient • Flexibility in planning and operations of the electricity networks, which in turn facilitates RES integration at pan European level • Enhanced coordination between system operators to ensure that DSOs can offer new services (for instance frequency services) to TSOs, in view of ensuring improved system integrity and stability • Increased security of supply based on sustainable business models which promote EU28 technology manufacturers[16] with large deployment perspectives of the validated solutions in EU28 and beyond • Novel business relationships between TSOs and DSOs helping the implementation of cost-effective solutions to make the electricity system more stable and secure • Load control provided by distributed resources, which allows TSOs and DSOs planning and operating the network more efficiently and economically • Improved management of grid congestions both at transmission and distribution levels
Additional Information	The main contributors will be TSOs, DSOs, manufacturers, ICT and storage solution providers, electricity consumers/prosumers, aggregators, energy service providers, regulatory authorities and academia/research centres
Proposal Duration	4 years
Total Budget	At least € 60 million

[16] Power control technologies, smart appliances, telecommunication solutions, etc…

TSO/DSO Topic 2-2017	**Improved defence and restoration plan** **TRL 4-6**
Main Functional Objective	**TD4 - IMPROVED DEFENSE AND RESTORATION PLAN** **TD5 - METHODOLOGIES FOR SCALING-UP AND REPLICATING**
Supported Functional Objective	T9 - INNOVATIVE TOOLS AND APPROACHES FOR PAN-EUROPEAN NETWORK RELIABILITY ASSESSMENT T7 - INNOVATIVE TOOLS AND METHODS FOR COORDINATED OPERATION WITH STABILITY MARGIN EVALUATION T6 - INNOVATIVE TOOLS AND METHODS TO OBSERVE AND CONTROL THE PAN-EUROPEAN NETWORK
Specific challenge	Storage and demand technologies to participate actively in defence and restoration plans, not only centralised generation, but also DER and DR.
Content/Scope	• To develop a methodology of assessing the risk of breakdowns during reconnection, for different kinds of technologies, in order to maintain an appropriate level of security. • To investigate the impact of micro-grids and islanding capabilities into defence and restoration plans. • To investigate the contribution of DER including storage solutions for system restoration and its contribution to immediate power reserves; this is relevant from the TSO perspective (e.g., black start capability and coordination of wind turbine generators). • To develop simulation tools for interactive system restoration including advanced forecast tools developed in TD1 for wind, solar PV and other variable RES. • To propose operational procedures regarding defence and restoration plans with DSOs in the presence of high volumes of DER and /or storage solutions • To train operators on the evolution of national regulatory schemes in order to foster coordination efforts. • To address regulatory and technical challenges that implement restoration plans at the pan-European level. • To Asses the cost effectiveness of the various studied options
Funding Scheme	Collaborative project
Expected Impact	New operational procedures for improved defence and restoration plans will reduce the economic impact of major disturbances and threats.
Additional Information	Links with Garpur, After, eHighway 2050 and MIGRATE
Proposal Duration	2 years
Total Budget	€ 20–30 million

3.3.4 Detailed description of EDSO R&I topics with their storage dimension

DSO Topic 2-2016	**SMART METERING DATA PROCESSING**
Main Functional Objectives	**D10 - SMART METERING DATA PROCESSING**
Supported Functional Objectives	None
Specific Challenge	By 2022, all EU member states will have to complete their smart metering roll out. Besides, the distribution networks will become increasingly instrumented (lines, substations, generation units). Therefore, a huge amount of data will be potentially available. Many benefits are expected by the different stakeholders of the electric distribution system: improvement of network real time observability, improvement of planning methods and tools, visibility of the power quality in the network, integration of electrical vehicles and distributed generation, methods for asset optimisation (predictive maintenance, etc.), possibilities of new services in the area of efficient energy uses. Many scientific and technologic issues have to be addressed to fully exploit the potential of data made available to DSOs A technical and academic approach is necessary to acquire the knowledge needed for further technical developments. Large data mining processes, development of mathematical approaches to describe consumption behaviour, mathematical models of the network using data from smart meters, data protection, efficient communications for large amounts of data, standardisation of data models, new IT solutions to process large data streams are topics that should be addressed. On the other hand, the final customers are waiting for new and unknown services from Smart Grids. Data publishing systems, new energy related services, and customised services in the area of efficient energy uses, possibility to define power quality at customer site and other possibilities should be studied and consequently, some recommendations for new regulations to provide personalised services and tariffs to individual customers may be necessary to develop the above mentioned services.
Content/Scope	The overarching objective is to develop scalable solutions to address large-scale data management issues in the electric distribution systems, which implies the standardisation of data models, methods and tools for data storage, data mining techniques, and data editing solutions. Furthermore, the R&I activities have to address data communications issues, including data privacy and cyber security. The following R&I activity components should be considered: • Novel data mining approaches applied to smart metering data in view of aggregating consumer profiling.

	• Novel data processing techniques for the publication of smart metering data for market participants and customers. • Ways and means to reduce the transaction costs for active demand operations. • Improved mining of generation data in view of the forecasting of DG and consumption • Identification of efficient data filtering processes to serve electricity market stakeholders. • Developing integrated solutions involving efficient communications and data processing. • Standardisation and interoperability of system architectures, protocols and data models. • Standardisation of data publishing systems towards different stakeholder interfaces. • Solutions to address data privacy issues. • Solutions to address cyber security issues. • Construction techniques to address load data for aggregated consumer profiling and energy efficiency measures • Addressing different smart meter data management models.
Funding Scheme	Collaborative project, Research and innovation
Expected Impact	• More efficient solutions to optimise data management • Greater real time observability of the electricity system • Novel and effective hardware and software architectures needed to manage and process the data contributing to increased system, observability • Enabling new business models and stimulating electricity market competitiveness • Improving the behaviour of energy consumers to promote more efficient uses of energy energy • Improved collaboration and knowledge sharing among European DSOs, researchers and technology/IT manufacturers.
Additional Information	The consortium should include DSOs with a large amount of Smart Meters deployed to deal with large amounts of real data, IT system and solution providers, universities and research centres specialised in big data analytics
Proposal Duration	3 years
Estimated budget	Approximately 15M€

DSO Topic 2-2017	**NETWORK MANAGEMENT TOOLS (Considering DER, storage and other new uses and players)**
Main Functional Objectives	**D9 - NETWORK MANAGEMENT TOOLS**
Supported Functional Objectives	
Specific Challenge	Novel tools for network management are needed to provide better observability and therefore improved control of distribution networks. Such networks face intermittency of DER units connected to DSO networks which in turn lead to variable generation and consumption loads at the MV and LV levels. Network management tools should then take into consideration, on the one hand the multiple network constraints that will occur and, on the other hand, new opportunities for controllable load that will be possible. Therefore, DSOs should guarantee the quality of electricity supply within appropriate stability boundaries, while increasing the hosting capacity of the MV and LV network for RES and new usages, and also considering new players such as aggregators or storage operators together with new market rules.
Content/Scope	The objective is to integrate into existing network management procedures and tools of the DSO new functionalities for grid observability, this in order to identify constraints coming from the increased PV generation as well RES disconnection due to voltage instability or unexpected islanding situations. Achieving these objectives requires to implement the following R&I activities: • Implementation of tools for the optimal load flow calculation into the grid taking, into account DRES, storage and other new uses, and the optimal location of storage solution in the grid • Integration of modules for a better PV generation and consumption forecast • Implementation of tools and methodologies for voltage regulation including the interface with RES generators using all potential technologies (storage, SVCs, auto-transformers, etc.), including storage and grid topologies to be used for the grid state optimisation • Integration of tools for flexibility prequalification and validation (storage, aggregators, etc.) and the assessment of the flexibility activation together with the real impacts on removing grid constraints. • Identification of methods and rules for information exchange with TSOs • Development for training tools for emergency management (coordination under emergency situations) • Interface with other grids (heat, gas)
Funding Scheme	Collaborative project, Research and Innovation

Expected Impact	The procedures and tools will provide enhanced observability and controllability of distribution networks while facilitating their secure and efficient operation with the continuously increasing DRES connection and more active users. It will also encourage market participation of new players such as aggregators and storage operators
Additional Information	The consortium should include DSOs with a strong involvement of universities and research centres. TSOs may also participate.
2-3 years	2-3 years
Estimated budget	20M€.

DSO Topic 3-2017	**Integration of DER at medium voltage /high Voltage using novel technologies (including storage)**
Main Functional Objectives	**D4 - SYSTEM INTEGRATION OF MEDIUM DER**
Supported Functional Objectives	
Specific Challenge	With the substantial rise of distributed generation, the EU is facing the challenge of finding new ways of integrating more distributed resources in the MV/HV networks. This will require an increase in the network hosting capacity and the ability to cope with several different types of DER (PV, wind, biomass, small hydro, mini-cogeneration, storage, CHP, VPP) within different network topologies (rural vs urban, radial vs meshed, different voltage levels).
Content/Scope	The overarching objective is to increase the secure penetration of medium DER in the MV networks using Active Control: this will help distribution networks becoming more flexible thanks to advanced network operations, the integration of storage services and energy management capabilities, in view of making conventional ways of increasing the DG hosting capacity by networks more efficient. Storage may become one of several solutions that are currently being developed to address problems such as grid congestion and violation of voltage limits on MV network levels caused by increasing levels of renewable generation on the distribution network[17]. Possible applications that contribute to solve problems in the grid should be investigated (testing a decentralized approach and the possibility of balancing performed by DSOs). Achieving such a goal requires completing the following series of R&I activities: • Define metrics for operation flexibility and system adequacy involving the identification of day-ahead security margins and their impacts on the definition of new ancillary service markets

[17] Other candidate solutions include OLTC transformers, controlling the DG at the inverter, installing new cables

	• Develop a new ancillary services market (like reserves, congestion management) to deal with the variability and grid location of the renewable sources: it requires extending the time horizon of such markets and the adoption of regional markets to deal with local problems • Identify the impacts of flexibility and of the adoption of advanced market solutions on distribution / transmission planning • Studying new demand response approaches, combining renewable (small hydro, biomass, solar, wind...) and storage system solutions to increase grid hosting capacity. • Develop tools and methodologies to determine the most adequate size of each element participating in the solution. • Define tools and methodologies for sizing flexibility resources • Identify what are the regulatory conditions and new standards needed to reach the expected benefits of such solutions • Propose cost/benefit analysis to evaluate the large scale deployment potential of the solutions and/or to determine the target cost of the new technology that would be required to make the studied solutions economically viable • Address regulatory matters for the provision or the management of ancillary services on DSO level should also be considered.
Funding Scheme	Collaborative project with a predominant innovation component.
Expected Impact	• the development of a risk-based approach to validate the implementation and test of such markets, involving tools based on probabilistic or fuzzy logic which able to provide a risk measure to system operators and help them managing the system and defining the required level of ancillary services • account of the specificity of the different grids / generation systems and climate conditions based on large scale demonstration projects where the ICT infrastructure associated to the deployment of the Smart Grid concept allows performing these tests • The response of DER (DG units, storage and responsive loads) needs to be taken into account in the modelling, namely regarding the probabilities or fuzzy distributions assigned to each one of the responses of these components. If possible, these implementation tests should be based in large scale regional demonstrators where the ICT infrastructure associated to the deployment of the Smart Grid concept allows performing these tests.
Additional Information	The consortium should be led by European DSOs, and where necessary the involvement of TSOs. Involvement of Research Centres, Customers,

	Aggregators, ICT solution providers, and Manufacturers should also be considered if necessary.
Proposal Duration	3 years
Estimated budget	Approximately 40M€

DSO Topic 4-2017	**NOVEL APPROACH TO ASSET MANAGEMENT**
Main Functional Objectives	**D12 - ASSET MANAGEMENT**
Supported Functional Objectives	
Specific Challenge	The investment costs of distribution infrastructures and related assets (including storage if part of the network) are very high with very long operational life times. With hundreds of thousands of components at different stage of their lifecycle and working under very different conditions (including very extreme climatic conditions), the complexity of maintenance and operation of distribution systems becomes an increasingly complex burden for al distribution operators. The growth in intermittent generation source connections, the advent of mobile loads and the integration of distributed low power sources do change the working conditions of existing infrastructures: ways and means to operate and maintain the grid assets must improve. The improvements made in ICT technologies, and the starting transition to smart grids offers an opportunity to improve the efficiency in operation and maintenance, by possibly introducing new methodologies and technologies for asset management. This will probably imply the need to improve field crew competences and work organisation (mobility tools, etc.). Moreover, new knowledge is needed about the critical parameters which impact the ageing of infrastructures and the evolution of asset characteristics. New inspection methods, new sensors, local controllers, and telecommunication services are needed to collect the relevant operational parameters which will enhance grid asset management. DSOs need to better appraise the capabilities and limits of differently aged infrastructure, this in view of supporting the loads appearing on the network and making well informed decisions about asset operations, preventive replacements and new investments.
Content/Scope	The objective is to expand the lifetime of existing assets and to reduce the costs of operation and maintenance, while ensuring the necessary quality of service levels. R&I activities are needed to study policies and methods for maintenance, existing asset renewal and reinforcement. A better understanding of assets' ageing mechanisms should be developed: a better specification and test of methods, tools, sensors and other monitoring and inspection systems, is required. Ageing forecasting techniques may be needed to smartly face the end of life of different network components. Reaching the above objective requires completing the following R&I activities: • Development, testing and sharing of knowledge on ageing process of assets (including storage assets if part of the network).

	• Autopsy tests on parts of the real networks and innovative analysis of assets to validate the ageing process evaluation • Developing and experimenting new asset management methodologies, sensors, tools, and systems based on the above knowledge, accompanied by appropriate field tests • Improving the management efficiency of the network components' maintenance and their resulting lifetime. • Developing and experimenting new algorithms for ageing and failure prediction, with the development of appropriate simulation tools • Introducing asset management methodologies that address both hardware and software issues. • Improvements in maintenance effectiveness associated to reduction of environmental risks. • Education and training of operators to acquire the new requested skills. • Study of the impact of energy storage systems which can extend the life of network assets and reduce losses, by relieving congestion and reducing network stress, by storing energy at times of low demand and releasing it at peak times, provided that storage services are located near large centres of demand. • Dedicated asset management processes for storage services (whether within the network or connected to the network) in relation to storage management.
Funding Scheme	Collaborative project, Research and Innovation
Expected Impact	It is expected that these novel methods and tools will extend life-time of assets, maintaining or even improving system reliability at a lower cost. It is also expected strong collaboration and intensive knowledge sharing among European utilities and researchers.
Additional Information	The consortium should include DSOs and a strong involvement of universities and research centres.
Proposal Duration	3 years.
Estimated budget	Approximately 20M€

DSO Topic 5-2018	**Monitoring and control of LV networks**
Main Functional Objectives	**D7 - MONITORING AND CONTROL OF LV NETWORK**
Supported Functional Objectives	
Specific Challenge	Currently several projects in the EU have addressed the need to monitor and control grids at the LV level. The need for better observability of the LV part of the grid has arisen as a reaction to the wider introduction of intermittent non-dispatchable resources which, to a large extent, have changed the usual approaches of grid operations. This is why the LV network is given increased importance. The future EU regulatory environment will provide additional needs for enhancing the monitoring of the LV grid. Currently debated rules on grid operation (grid codes) will promote new approaches towards cooperation between DSOs and TSOs, notably in terms of ancillary services or demand side response (DSR). These new roles which individual DSOs are expected to take will require a more detailed insight into the control of the LV grid. Present projects involved in the LV grid control or operation also show the need to reconsider some solutions since not reliable or cost efficient.
Content/Scope	The overarching objective is to demonstrate, under real operating conditions, new cost-effective solutions which will improve LV network monitoring and control. Moreover, new market models and operation schemes need to be developed allowing direct operation of LV grid connected components as an integral part of grid management (for instance Temperature Controlled Devices and their potential as DSR). • Load and generation control using islanded modes of operations in the presence of RES electric vehicles and storage capacities • Reliable wireless communications in LV automation schemes • AMM involvement in LV operations • Participation of aggregated demand facilities in the DSR concept including the impact of energy storage control strategies for DSR. • Semi-automated LV network compared with full automated grid approaches • Grid modelling techniques • Data protection and cyber security approaches • Integrated communication solutions • Schemes to implement selected protection schemes within automated LV networks • Information model aggregation • ”Smart“ inventions and their role in the DSR scheme or prosumer storage where the proper monitoring and control of customer, DER

	and storage may contribute to improved LV grid reliability and power quality. • Reliability of the available wireless connection between automated LV street cabinet (substation) and SCADA (protection functions preventing jamming or interferences) • AMM as an operation grid component in the LV automation architecture: wider participation of the AMM would enable more accurate balancing in the closed island area, thus providing better quality of supply.
Funding Scheme	Collaborative project, Research and Innovation
Expected Impact	• more efficient integration of renewables and better acceptance by the consumer • Wider engagement of "prosumers" in providing electricity generation • Better environments for more reasonable load patterns • Impact of prosumer electricity storage on LV Grid control strategies and stability
Additional Information	The consortium should be composed and led by European DSOs. Involvement of Research Centres, Customers, Aggregators and Manufacturers should also be considered.
Proposal Duration	3 years
Estimated budget	Approximately 50 M€

DSO Topic 6-2018	**NOVEL APPROACHES FOR MARKET DESIGN ADDRESSING NEW GRID OPERATIONS**
Main Functional Objectives	**D13 - NOVEL APPROACHES FOR MARKET DESIGN ANALYSIS**
Supported Functional Objectives	
Specific Challenge	Changing regulatory frameworks poses new challenges to DSOs since they might be required to perform new duties in terms of grid operations as a consequence of the integration of large amount of dispersed generation into the grid. The main issue is then to support market evolutions while meeting new technical and/or contractual constraints in terms of load/voltage and eventually (for TSO-related services) frequency. Challenges could be basically identified in three areas: 1) Demand Side Response (DSR): the central to ability of DSOs to maintain grid stability through the active participation of the customers. New market models need to be developed to make customers willing to accept alternative consumption schemes which allow different delivery patterns according to actual grid condition. 2) Ancillary services: new and different electricity generation schemes, including aggregating and storage services which create new opportunities for DSOs. New approaches towards grid operationscreate capacities to deliver ancillary services to be provided to the TSOs. 3) Island operation: dispersed energy generation may as well reduce the dependency of the customer upon DSOs. The customer/prosumer could operate on his own using DSO services to a very limited extent (basically a spare energy source). Business strategies must be developed providing compelling incentives for the customers to remain connected to the DSO.
Content/Scope	The overarching objective is to developed business scenarios exploring new grid operation schemes from the business/market point of view. The most important issue remains the engagement of the consumer as an active part of grid management. • Islanded operations as a market opportunity provided for major industries (e.g. spare energy capacities for emergency situations) • Creating market models for the integration of small islanding schemes, DSR, ancillary services, curtailment, storage, etc. WhereWhereWhere the most efficient and cost-effective solutions and the right balance among them are analysed and compared. • Involvement of the vendors in the DSR concept. • DSO and customer related approaches towards DSR in view of creating active demand strategies including aggregators and storage servicesservicesservices to increase grid flexibility.

	• AMM and data gathering as an opportunity for DSO (creating new business models, enabling better asset management etc.) • Ancillary services and practical consequences of their implementation (including storage at different voltage levels and adapted small Hydro plants ...). DSOs have new opportunities to provide ancillary services through energy storage units, hydro plants, etc. Regulatory changes, market design issues and investment activation programs ought to be addressed. • Small hydro may require upgrade of the existing fleet that is designed to supply energy and not regulate power. • Creating active demand strategies including aggregators and storage operators to increase grid flexibility
Funding Scheme	Collaborative project, Research and Innovation
Expected Impact	• The development of new market schemes and new approaches to address and solve challenges stemming from the changing environment in grid operation and management. • Better involvement of consumers with better awareness about his/her behaviour to take appropriate means to react to radical changes in the field of energy sector. • Preparation to even more radical changes resulting from the maturing of technologies in the field of renewable or aggregation.
Additional Information	The consortium should be composed and led by European DSOs. Involvement of Research Centres, Customers, Aggregators and Manufacturers should also be considered.
Proposal Duration	2-3 years.
Estimated budget	20M€.

DSO Topic 7-2018	**INTEGRATION OF INFRASTRUCTURE TO HOST ELECTRICAL VEHICLES**
Main Functional Objectives	**D6 - INFRASTRUCTURE TO HORST EV/PHEV**
Supported Functional Objectives	
Specific Challenge	The topic is related to the mass roll out of the Electric Vehicles which requires addressing the impacts of different types of charging options on the distribution grids (and generally onto the whole electric system). EV demand for charging points in domestic areas will be at LV and in certain countries single-phase. Given the existing LV networks planning procedures, massive adoption of EVs could stress the network infrastructure in terms of: • Overloads • Power quality (i.e. harmonics, voltage profiles) not in line with international agreed standards (e.g. EN 50160) Hence the development and implementation of methods and tools to cope with the impact on the network of massive charging of electrical vehicles are needed.
Content/Scope	Reaching the above overarching objective requires implementing the R&I activities below, while taking care of existing activities at network and EU level: • Integration of the EV charging infrastructure into the distribution network management systems to host Electrical Vehicles, with a special focus on fast charging infrastructures and their impact on Distribution grid operation. • Charging control (both centralised to exploit integration of the control intelligence with DSO legacy systems, and decentralised or distributed control, in order to verify that it could be effective and less costly than centralised approaches). • Understanding the limitations of different technologies of the charging stations in order to validate their implementation constraints • Novel control techniques in charging technologies (in order to allow for a higher penetration of micro-generation in LV such as PVs) • Research on the consequences of different charging control strategies under different reinforcement scenarios. • Methods and tools proposed to cover the following functionalities: o New planning and operation procedures for LV networks; o Enabling of V2G services; o Ancillary services linked with the availability of distributed storage; o Smart charging and load shaping;

	○ Forecasting of available resources to face the demand. • Role of local storage to smooth charging loads onto the electricity networks • Research impacts to develop new charging stations
Funding Scheme	Collaborative project, Innovation with an important demonstration component.
Expected Impact	New funding schemes of changing infrastructures will support the market growth of the electric vehicles.
Additional Information	The consortium should include DSOs, and TSOs if necessary, and a strong involvement of universities and research centres.
Proposal Duration	3 years
Estimated budget	approximately 40 M€

Detailed description of EASE R&I topics addressing several electric system issues

Topic ES01-2016	**Active demand at TSO level using centralised control (at DSO level) of small scale storage units for cross-border exchange**
Main functional objectives	**TD2 - THE INTEGRATION OF DEMAND SIDE MANAGEMENT AT DSO LEVEL INTO TSO OPERATIONS** **T3 - DEMONSTRATION OF POWER TECHNOLOGY TO INCREASE NETWORK FLEXIBILITY AND OPERATION MEANS**
Supported functional objectives	
Specific challenge	Renewable energy sources are rapidly penetrating the European scene for electricity generation. However, the intermittency of those energy sources implies a still stronger need for important grid operation services. Such services were formerly provided by central power plants, which are now taken permanently out of operation or in other cases operated only periodically. Ancillary services – like primary reserves – are purchased by grid operators on a minimum quantity basis. For primary reserves the minimum acceptable quantity is often in the range around 1 MW. Enhanced coordination between system operators is becoming increasingly necessary to ensure that Distribution System Operators (DSO) can offer new services (i.e. frequency services) to Transmission System Operators (TSO), ensuring system integrity and stability. Flexibility services related to load control is one option available that must be studied further.
Content/Scope	Small energy storage facilities in households, light industry or elsewhere are usually at a power level far below 1 MW - often in the range of a few kW – and they are thus not eligible for provision of e.g. primary reserves. However, by aggregating many small energy storage units a power capacity of the entire aggregation can be obtained, which fully qualifies for taking part in the ancillary service market. Intelligent control and operation of such aggregates require development of advanced IT and communication solutions based on reliable, optimised mathematic algorithms. Solutions should acknowledge and remunerate the consumers making the physical storage facilities available as well as the business of the aggregator and at the same time maximise comfort and convenience for consumers´ use of their storage facility. Efforts are expected to bring technologies from TRL 3-4 to TRL 5-6
Funding scheme	Innovative actions including RD&D activities
Expected impact	• Better market conditions for ancillary services on the European level including cross border exchange of services • Improved grid security by improved security for timely provision of important ancillary services

	• New pathways for provision of ancillary services
Additional information	This research topic combines with the following topics supported by ENTSO-E and EDSO: • Topic 4-2016 of ENTSO-E • Topic 1-2016 of EDSO
Proposal duration	3-4 years
Estimated budget	20 MEUR

Topic ES02-2016	**Role of storage system to optimally integrate RES in short-term markets**
Main functional objectives	**T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION**
Supported functional objectives	TD3 - ANCILLARY SERVICES PROVIDED THROUGH DSOS T11 - ADVANCED TOOLS FOR CAPACITY ALLOCATION AND CONGESTION MANAGEMENT
Specific challenge	Participation of variable RES (mainly wind and solar) generation plants in global energy markets is still an exception, their access to ancillary services and balancing is largely excluded. Various technology demonstration projects have investigated the different solutions to enable a better integration of variable RES from a technical point of view. They include very often storage as one of the solutions to enable a more predictable, stable and reliable delivery of energy (i.e. firm capacity), provide ancillary services and balancing (respectively, reduce the forecasting error and hence balancing needs). Yet, the corresponding market designs and technical rules are far from being implemented in Europe. Existing market mechanisms and technical rules are designed around conventional power generation, and do not take into account specifics of RES.
Content/Scope	- Determine state of the art of the technical capabilities of RES when associated with Energy Storage and other technologies to participate effectively in energy and ancillary services markets. This action should namely consist in synthesising the outcomes of different demonstration projects in Europe and elsewhere, characterising the technical capabilities, the specifics of such solutions and necessary boundary conditions. - Elaborate a set of proposed market mechanisms, respectively the adaptation of existing regulations and specifications to enable RES to participate to such markets in an effective, non-discriminatory manner. - Propose appropriate remuneration schemes
Funding scheme	Innovative actions including RD&D activities
Expected impact	The proposals are expected to have impact on: • Increased level of RES integration = higher contribution to the mix, minimisation of curtailment. • Capacity firming • Higher value of RES for the system: remuneration of services improves economic feasibility of RES plants and their level of deployment • Effects of combined services
Additional information	This topic combines with the topic 1-2017 of ENTSO-E
Proposal duration	3 years

Estimated budget	20M€
Topic ES3-2016	**Technology and market conditions allowing electricity storage units to provide ancillary services including in cross-border modes**
Main functional objectives	**T10 - ADVANCED PAN-EUROPEAN MARKET TOOLS FOR ANCILLARY SERVICES AND BALANCING, INCLUDING ACTIVE DEMAND MANAGEMENT** **T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION**
Supported functional objectives	
Specific challenge	Larger amounts of RES into the grids make their operation more complex and increase the needs for ancillary services. Up to now they were provided by Market participants, mainly power generators, but in the next future energy systems, new assets should be included. Moreover, with an urgent and minimum target of 10% of existing electricity interconnections for 2020 and 15% by 2030, the TYNDP addresses both targets via the implementation of Project of Common Interest (PCIs) and by prioritising cross border actions. Energy storage technologies, and more the ones linked to power electronics, can provide many ancillary services at any level of the network including the transmission grids, and they should be taken in account in the market operation and schedule. Technical capabilities of Energy Storage must be proved in real operation and quantified in order to deploy new business models to demonstrate their competitiveness both technically and economically in the future markets and energy management tools should also include energy storage as ancillary services providers.
Content/Scope	The crucial goals of the activities include demonstration of technical capabilities of storage technologies to provide ancillary services at any network level, quantification of profits derived from these services and business models development including multiple income streams. Among all ancillary services, a special attention will be given to study the benefits that fast storage could bring to the primary and secondary reserve markets (higher reaction time and accuracy than conventional generators) Other activities should include supporting to new pan-European market schemes development including storage, regulatory issues and standardisation (Network codes & Guidelines).
Funding scheme	Innovative actions including RD&D activities
Expected impact	The proposals are expected to have impact on:

	• Effects of combined services (ancillary services, balancing capabilities, supply security, congestion management, power quality enhancement, etc) • New storage & power electronics functionalities demonstration • New pan-European Market Schemes, Multiple Business Models and CBAs • Integrated markets for electricity and gas/heat • Cross-border issues (management tools, market, regulation, infrastructures, etc.)
Additional information	This topic combines with the topic 4-2016 of ENTSO-E
Proposal duration	3-4 years
Estimated budget	50 M€

Topic ES04-2017	**Long-term network planning tools involving storage for capacity firming, active demand and investment deferral**
Main functional objectives	**T2 - PLANNING METHODOLOGY FOR FUTURE PAN-EUROPEAN TRANSMISSION SYSTEM**
Supported functional objectives	T1 - DEFINITION OF SCENARIOS FOR PAN-EUROPEAN NETWORK EXPANSION T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION
Specific challenge	Need for better tools and procedures to address the uncertainties in the future energy mix for long-term network planning purposes
Content/Scope	On the background of earlier experience – e.g. from the e-Highway2050 project - methodologies and related operational tools need to be developed for optimising long-term integration of storage technologies in network planning processes. Proposals should • Design and demonstrate new methods, tools and processes including energy storage for assessing long-term technical and market scenarios and system stability • Build on detailed technical insight into application aspects of energy storage technologies • Thoroughly include the potential impact of energy storage on consumption and generation and subsequent grid operation as well as market conditions • Include economical characteristics of energy storage technologies Activities are anticipated to bring technology from TRL 2-3 to TRL 4-5
Funding scheme	Research and Innovation Action
Expected impact	Activities would allow network operators and network planners to generate more reliable technical and economic planning and decision tools for assessing future network scenarios including energy storage capacities.
Additional information	Link with earlier projects on network planning tools This topic links with the topic 2-2017 of ENTSO-E and EDSO
Proposal duration	3-4 years
Estimated budget	20 MEUR

Topic ES05-2018	**Electricity storage for defence and restoration plans**
Main functional objectives	**TD4 - IMPROVED DEFENSE AND RESTORATION PLAN** **TD5 - METHODOLOGIES FOR SCALING-UP AND REPLICATING**
Supported functional objectives	T9 - INNOVATIVE TOOLS AND APPROACHES FOR PAN-EUROPEAN NETWORK RELIABILITY ASSESSMENT T6 - INNOVATIVE TOOLS AND METHODS TO OBSERVE AND CONTROL THE PAN-EUROPEAN NETWORK T7 - INNOVATIVE TOOLS AND METHODS FOR COORDINATED OPERATION WITH STABILITY MARGIN EVALUATION
Specific challenge	There is a need for new types of generation and demand technologies to participate actively in defence and restoration plans, not only centralised generation, but also DER. Grid operational conditions have changed dramatically during the last years in many European countries. The penetration of DER in the electrical grids continues to grow. The capacity for "island mode of operation" is gaining importance, especially in the countries or regions where the stability of the grid is an issue. The amount of possibilities arising from these changes makes it necessary to study, simulate and apply new technologies for improved defence and restoration plans:
Content/Scope	• To develop simulation tools and methods to integrate storage on a pan-European level in defence and restoration plans, and to evaluate the impact of its participation. • To study the potential capacity of black-start from different systems (types of generation and storage considering a high penetration of renewables) and regions/countries in a pan-European scenario. • To analyse the cost-effectiveness of storage solutions in comparison with traditional approaches. • To address regulatory and technical challenges associated with energy storage technologies that implement restoration plans at the pan-European level. Technologies are expected developed from TRL 3-4 to TRL 5-6
Funding scheme	Collaborative project
Expected impact	New operational modes including energy storage for improved defence and restoration plans will allow reduction of economic impacts of disturbances and threats. It will lead to more efficient strategies, reduction of grid recovery time after incidences and improved simulation tools.
Additional information	Links with earlier projects (Garpur, After, eHighway2050 and InCoPro)
Proposal duration	2-4 years
Estimated budget	20 MEUR

Topic ES6-2017	**Market design allowing storage system to join cross-border capacity markets**
Main functional objectives	**T10 - ADVANCED PAN-EUROPEAN MARKET TOOLS FOR ANCILLARY SERVICES AND BALANCING, INCLUDING ACTIVE DEMAND MANAGEMENT**
Supported functional objectives	T11 - ADVANCED TOOLS FOR CAPACITY ALLOCATION AND CONGESTION MANAGEMENT T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION
Specific challenge	Several studies have shown in Europe the weaknesses of the *energy only* model that is today used in European countries. This model guarantees the security of supply for citizens by including in the market price a margin to pay for capacities that have lower utilisation along the year but are needed to cover the peak demand occurring for a few hours during a year. In the last decades this model has shown imperfections that could cause in the future a lack of capacity because the market signals do not trigger the investments to allocate the right amount of capacity in the energy market. Many EU countries have put in place a new capacity market to better account for capacity flexibility in both generation and demand. Storage systems are resources capable to provide capacity in two directions (generation and demand) and should be eligible to participate in these new markets. The challenge of this project would be to study and propose mechanisms for the participation of storage systems in capacity markets in the same way that generation or demand resources. This participation could be in an autonomous way or as a pool of generation, demand and storage capacities. The project should also address how storage could improve the usage of cross border capacities among countries when the transfer capacity is limited (interconnections).
Content/Scope	R&D activities of this project would deal with 3 main items: 1. Develop models to study technical aspects about storage in capacity markets under different scenarios • Renewable plants with storage • Virtual power plants • Smart communities 2. Evaluate benefit of storage to optimise the use of cross-border capacities available among EU countries. 3. Elaborate a set of proposed market mechanisms to take into account energy storage characteristics and define remuneration schemes that accounts for performance of resources in a fair manner.
Funding scheme	Innovative actions including R&D activities
Expected impact	The proposals are expected to have impact on:

	• Define technical requirements and remuneration schemes in capacity markets in a way that storage can coexist with generation and demand resources • New pan-European Market Schemes dealing with cross-border issues (management tools, market, regulation, infrastructures, etc.)
Additional information	This topic combines with the topic 4-2016 of ENTSO-E
Proposal duration	3 years
Estimated budget	20 M€

Topic ES07-2016	**P2X Storage involving the carbon intensive industrial sector (power, combined heat and power, process industries)**
Main functional objectives	**T3 - DEMONSTRATION OF POWER TECHNOLOGY TO INCREASE NETWORK FLEXIBILITY AND OPERATION MEANS**
Supported functional objectives	T10 - ADVANCED PAN-EUROPEAN MARKET TOOLS FOR ANCILLARY SERVICES AND BALANCING, INCLUDING ACTIVE DEMAND MANAGEMENT T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION
Specific challenge	The high shares of variable renewable energy sources feed in to the European power system entail the need for large scale energy storage to balance the production and consumption of large quantities of electricity during longer time periods. “P2X” concepts (“Power to X”, whereas “X” is used for Power / Heat / Fuel / Gas) have been identified in the recent years as promising solutions towards large scale energy storage. Pilot scale demonstration projects on several “P2X” storage options have been carried out in the recent years. Therefore, first of its kind large scale demonstration projects in real industrial scale environment shall be the next development step. However, the development of these first of its kind large scale demonstration projects still faces several challenges in technical and non-technical terms. In technical terms optimised thermal cycle and process integration of energy storage in existing infrastructures is required towards maximising overall plant efficiency and achieving the set CO_2 emission reduction targets. In parallel, constraints and special boundary conditions applied in every particular case shall be considered. Furthermore, non-technical development steps for large scale projects, such as the permit process, require a considerable time and effort and can have a duration of several years. Several studies and analysis work is usually required (e.g. environmental impact assessment, risk analysis), while possible implications in permitting have a direct impact on the project plan. Based on the above facts, no decision for a project execution is taken before the completion of the permitting process and a positive technical and financial project evaluation. All the above hinder the realisation and execution of large scale demonstration projects within a timeframe of one typical R&D project. In this sense the present topic intends to support the development of large scale energy projects integrated into existing industrial infrastructures from the initial concept and project identification phase until the completion of the permittingpermitting procedure and the preparation of relevant tender documents.
Content/Scope	- Support the identification and valuation of most promising Large Scale Energy Storage projects in Europe

	- Address projects with particular synergies in the large scale power, combined heat and power and carbon intensive industrial sector and chemical process industry - Front to End Engineering and Design (FEED) studies for new large scale energy storage projects integrated in the power, combined heat and power and process industry - Projects have to also include relevant milestones related with the permission process of the planned large scale project - Basic technical and financial information required in future tender documents shall be also included as project deliverables - Full technical and financial assessment for investment decision
Funding scheme	Research and Innovation Action
Expected impact	The proposals are expected to have impact on: - Supporting the preparation and development of full scale, first-of-a-kind demonstration projects in line with the B.2.1 Call ("*Supporting first-of-a-kind, commercial-scale industrial demonstration projects in the field of competitive low carbon energy through InnovFin FDP Energy Facility*"). - Enabling the developments of product to take technology from TRL 5-6 to the TRL 8 level. - Preparing the roll-out of advanced low carbon technologies to TRL 8. - Contributing to the Energy Union objectives, by enabling the introduction of low carbon energy technologies in the power and process industry - Strengthen European industrial initiatives for reindustrialisation of Europe with focus on the Low Carbon Energy technologies. - Understanding and minimising risks in investments on advanced Low Carbon Energy technologies related with first of its kind demonstrations.
Additional information	TheThe topic feeds in system approaches to several ENTSO-E topics: • Topic 1-2016 • Topic 1-2017 • Topic 3-2017 • Concept 2-2018 • Topic 2-2017
Proposal duration	2-3 years
Estimated budget	25 M€

Topic ES8-2018	**System integration of seasonal/large scale storage of energy involving cross-border exchanges**
Main functional objectives	**T3 - DEMONSTRATION OF POWER TECHNOLOGY TO INCREASE NETWORK FLEXIBILITY AND OPERATION MEANS** **T12 - TOOLS AND MARKET MECHANISMS FOR ENSURING SYSTEM ADEQUACY AND EFFICIENCY IN ELECTRIC SYSTEMS INTEGRATING VERY LARGE AMOUNTS OF RES GENERATION**
Supported functional objectives	D1 - ACTIVE DEMAND FOR INCREASED FLEXIBILITY TD3 - ANCILLARY SERVICES PROVIDED THROUGH DSOS
Specific challenge	Still deeper penetration of renewable energy sources in the European electrical power system leads to rapid changes of system operational conditions. Energy production from renewable energy sources closely correlates with regional/local weather conditions whereas energy demand varies independently on a cyclic daily, weekly or seasonal basis. Heat accounts for approx. 50% of European final energy demand and heat demand shows a clear dependence on season. Heat is maximally demanded in the winter season, where solar influx is at its minimum and installed wind power is often insufficient to secure supply of demand. Similarly demand for air conditioning or cooling shows a clear seasonal dependence as well. Seasonal or large-scale energy storage can play an important role in matching energy demand with supply at the same time preventing installation of generation overcapacity. Power-to-gas technologies and large scale heat or cold storage technologies represent possibilities for seasonal and storage, which can be of significant economic and technical benefit to the future electricity grid of Europe.
Content/Scope	Activities should aim at supporting the electrical power system in smoothing out mismatching, seasonal variations in energy demand and supply. The crucial goals of the activities include power-to-heat as well as full-cycle power-to-power technologies, but more important is the displacement of requests for primary supply in periods, where primary supply is not sufficiently accessible as illustrated above by the example of demand for heat. Power-to-power technologies can be economically optimised by utilisation of heat released in inherent conversion processes and such aspects could ideally be addressed.
Funding scheme	Innovative actions including RD&D activities
Expected impact	The proposals are expected to have impact on: • Interacting and harmonised markets for electricity and gas/heat • Investment deferral in transmission as well as distribution grids • Effects of combined services (seasonal storage in combination with ancillary services, balancing capabilities, supply security, etc. • Curtailment minimisation • Generation capacity firming

Additional information	Power-to-gas technologies including storage of chemical fuels in gaseous or liquid forms hold interesting technology components potentially reaching also into the future powering of transport, e.g. heavy truck transport, marine transport and aviation. This topic feeds in system approaches to several ENTSO-E topics: • Topic 1-2016 • Topic 1-2017
Proposal duration	3-4 years
Estimated budget	50 M€

4 Conclusions

The present document is the final version of the short-term integrated Implementation Plan (IP) 2016-2018, constructed by the Grid+Storage consortium[18]. This integrated IP is based on:

- the IP 2016-2018 already published by ENTSO-E[19],
- the IP 2016-2018 provided by EDSO,
- R&DI topics identified by EASE and embedded in the above two IPs with more details about the detailed R&I activities to be addressed when considering storage integration challenges
- The inputs of a public consultation where 15 respondents gave inputs and recommendations

It can be claimed that the advent of Research and Innovation activities which cover dedicated topics about **the grid integration of energy storage solutions** is welcomed, at least by the respondents to the public consultation. Several of these stakeholders have insisted upon the needs for such R&I activities to be embedded into wider energy market considerations at EU level, including the role of market mechanisms and their remuneration in support of energy storage services.

Last, but not least, apart from detailed R&I activities on current grid issues, it must pointed out that the contributions of storage solutions to the R&I devoted to "Asset management" and " Network Restoration" have been underlined, thus showing that the storage integration into current network operations must be approached in a systemic manner.

Overall, the summary table below proposes a first qualitative appraisal of the expected competitiveness impacts that such successful R&I activities would have onto the European energy storage manufacturers.

[18] See http://www.gridplusstorage.eu/partners
[19] See https://www.entsoe.eu/Documents/Publications/RDC%20publications/150330_RD_Implementation_Plan_2016-2018.pdf

TSO topics

		Expected impact on the storage manufacturer competitiveness		
		Low	**Average**	**High**
TSO Topic 1-2016	**Fast storage needed by TSOs - TRL 5-6**			**High**
Main functional objectives	T3 - Demonstration of power technology to increase network flexibility and operation means			
TSO Topic 2-2016	**Control system of the future: real-time tools for control centres - TRL 4 - 7**		**Average**	
Main Functional Objectives	T6 - Innovative tools and methods to observe and control the pan-European network			
TSO Topic 3-2016	**Monitoring & observation tools for power network infrastructures - TRL 6-7**		**Average**	
Main Functional Objectives	T6 - Innovative tools and methods to observe and control the pan-European network T16 - Development and validation of tools which optimize asset maintenance at the system level, based on quantitative cost/benefit analysis			
TSO Topic 1-2017	**Advanced tools for new market models - TRL 5-7**			**High**
Main Functional Objective	T12 - Tools and market mechanisms for ensuring system adequacy and efficiency in electric systems integrating very large amounts of res generation			
TSO Topic 3-2017	**Market modelling and system adequacy assessment for long-term planning - TRL 3-5**			**High**
Main Functional Objective	T2 - Planning methodology for future pan-European transmission system			
TSO Concept 1-2018	**Data and information management for system operation and asset management - TRL 5**		**Average**	
Main Functional Objective	T15 - Developing approaches to determine and to maximize the lifetime of critical power components for existing and future networks			
TSO Concept 2-2018	**Realisation of ultra-high-voltage lines with partial underground cabling - TRL 6**		**Average**	
Main Functional Objectives	T14 - Towards increasing public acceptance of transmission infrastructure			

TSO/DSO topics

		Expected impact on the storage manufacturer competitiveness		
		Low	**Average**	**High**
TSO/DSO Topic 1-2016	**Demand-Side Response: load control mechanisms and services at TSOS and DSOs levels for system level TRL 5-7**		**Average**	
Main Functional Objective	TD2 - The integration of demand side management at DSO level into TSO operations			
TSO/DSO Topic 2-2017	**Improved defence and restoration plan - TRL 4-6**		**Average**	
Main Functional Objective	TD4 - Improved defence and restoration plan TD5 - Methodologies for scaling-up and replicating			

DSO topics

		Expected impact on the storage manufacturer competitiveness		
		Low	**Average**	**High**
DSO Topic 1-2016	**Smart metering data processing**		**Average**	
Main Functional Objectives	D10 - Smart metering data processing			
DSO Topic 2-2017	**Network management tools (considering der, storage and other new uses and players)**			**High**
Main Functional Objectives	D9 - network management tools			
DSO Topic 3-2017	**Integration of der at medium voltage /high voltage using novel technologies (including storage)**			**High**
Main Functional Objectives	D4 - system integration of medium DER			
DSO Topic 4-2017	**Novel approach to asset management**		**Average**	
Main Functional Objectives	D12 - Asset management			
DSO Topic 5-2018	**Monitoring and control of LV networks**		**Average**	
Main Functional Objectives	D7 - Monitoring and control of LV network			
DSO Topic 6-2018	**Novel approaches for market design addressing new grid operations**			**High**
Main Functional Objectives	D13 - Novel approaches for market design analysis			
DSO Topic 7-2018	**Integration of infrastructure to host electrical vehicles**			**High**
Main Functional Objectives	D6 - Infrastructure to host EV/PHEV			

Storage topics

		Expected impact on the storage manufacturer competitiveness		
		Low	**Average**	**High**
Topic ES01-2016	**Active demand at TSO level using centralised control (at DSO level) of small scale storage units for cross-border exchange**		**Average**	
Main functional objectives	TD2 - The integration of demand side management at DSO level into TSO operations T3 - Demonstration of power technology to increase network flexibility and operation means			
Topic ES02-2016	**Role of storage system to optimally integrate RES in short-term markets**			**High**
Main functional objectives	T12 - Tools and market mechanisms for ensuring system adequacy and efficiency in electric systems integrating very large amounts of res generation			
Topic ES3-2016	**Technology and market conditions allowing electricity storage units to provide ancillary services including in cross-border modes**			**High**
Main functional objectives	T10 - Advanced pan-European market tools for ancillary services and balancing, including active demand management T12 - Tools and market mechanisms for ensuring system adequacy and efficiency in electric systems integrating very large amounts of res generation			
Topic ES04-2017	**Long-term network planning tools involving storage for capacity firming, active demand and investment deferral**			**High**
Main functional objectives	T2 - Planning methodology for future pan-European transmission system			
Topic ES05-2018	**Electricity storage for defence and restoration plans**		**Average**	
Main functional objectives	TD4 - Improved defence and restoration plan TD5 - Methodologies for scaling-up and replicating			
Topic ES6-2017	**Market design allowing storage system to join cross-border capacity markets**			**High**
Main functional objectives	T10 - advanced pan-European market tools for ancillary services and balancing, including active demand management			

Topic ES07-2016	**P2X Storage involving the carbon intensive industrial sector (power, combined heat and power, process industries)**			**High**
Main functional objectives	T3 - demonstration of power technology to increase network flexibility and operation means			
Topic ES8-2018	**System integration of seasonal/large scale storage of energy involving cross-border exchanges**			**High**
Main functional objectives	T3 - Demonstration of power technology to increase network flexibility and operation means T12 - Tools and market mechanisms for ensuring system adequacy and efficiency in electric systems integrating very large amounts of res generation			

5 Annex 1: Questions for the public consultation about the INITIAL VERSION OF THE INTEGRATED IP 2016-2018

CLUSTER TSO1 - GRID ARCHITECTURE

- ***ENTSO-E Topic 3-2017 "Market modelling and system adequacy assessment for long-term planning"***

    1. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

        ☐ **YES** ☐ **NO** ☐ **NO OPINION**

    Please explain:

- ***ENTSO-E Concept 2-2018 "Realisation of ultra-high-voltage lines with partial underground cabling"***

    Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

    ☐ **YES** ☐ **NO** ☐ **NO OPINION**

    Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

    Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

    ☐ **YES** ☐ **NO** ☐ **NO OPINION**

    Please explain:

CLUSTER TSO2 - POWER TECHNOLOGIES

- ***ENTSO-E Topic 1-2016 "Fast storage needed by TSOs"***

    Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

CLUSTER TSO3 - NETWORK OPERATION

- ***ENTSO-E Topic 2-2016 "Control system of the future: real-time tools for control centres"***

  Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***ENTSO-E Topic 3-2016 "Monitoring & observation tools for power network infrastructures"***

  Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

CLUSTER TSO4 - MARKET DESIGNS

- ***ENTSO-E Topic 1-2017 "Advanced tools for new market models"***

  Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

CLUSTER TSO5 - ASSET MANAGEMENT

- ***ENTSO-E Concept 1-2018 "Data and information management for system operation and asset management"***

  Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

JOINT TSO/DSO CLUSTER

- ***ENTSO-E Topic 2-2017 "Improved defence and restoration plan"***

2. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?
   ☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

- ***ENTSO-E Topic 4-2016 "Demand-Side Response: load control mechanisms and ancillary services at TSO and DSO levels"***

3. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?
   ☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

- ***EDSO Topic 1-2014: Demonstration of demand side management mechanisms at DSO level into TSO operations***

Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

CLUSTER DSO1 - INTEGRATION OF SMART CUSTOMERS

Based on your organisation's experience within this field, do you think that energy storage integration shall be addressed in the R&I activities of this cluster during the 2016-2018 period?

☐ **YES** ☐ **NO** ☐ **NO OPINION**

Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

CLUSTER DSO2 - INTEGRATION OF DER AND NEW USES

- ***EDSO Topic 3-2015 "Integration of DER at medium voltage /high Voltage using novel technologies (including storage)"***

  4. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***EDSO Topic 2-2016 "Integration of infrastructure to host electrical vehicles"***

  5. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

CLUSTER DSO3 - NETWORK OPERATIONS

- ***EDSO Topic 3-2016 "Network management tools (considering DER, storage and other new uses and players)"***

    6. Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

        ☐ YES ☐ NO ☐ NO OPINION

    Please explain:

- ***EDSO Topic 4-2014 "Smart metering data processing"***

    Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

        ☐ YES ☐ NO ☐ NO OPINION

    Please explain:

- ***EDSO Topic 4-2015 "Monitoring and control of LV networks"***

    Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

        ☐ YES ☐ NO ☐ NO OPINION

    Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

    Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

        ☐ YES ☐ NO ☐ NO OPINION

    Please explain:

CLUSTER DSO4 - NETWORK PLANNING AND ASSET MANAGEMENT

- ***EDSO Topic 3-2014 "Novel approach to asset management"***

    Based on your organisation's experience within this field, would you consider that R&I activities regarding energy storage integration should be included within this topic?

        ☐ YES ☐ NO ☐ NO OPINION

    Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain

CLUSTER DSO5 - MARKET DESIGN

- ***EDSO Topic-5-2016 "Novel approaches for market design addressing new grid operations"***

  Do you consider that the activities related to energy storage have been appropriately integrated into this topic?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

- ***Integration of technologies other than energy storage into the R&I activities of this cluster***

  Would you consider that technologies other than energy storage are able to bring more advantageously flexibility into electricity networks through proper R&I activities about their integration?

  ☐ **YES** ☐ **NO** ☐ **NO OPINION**

  Please explain:

NEXT ROUND OF CONSULTATION: INTEGRATED 10-YEARS R&I ROADMAP

- ***The Initial Integrated Implementation Plan 2016-2018 has been built within the framework of the current 2013-2022 EEGI roadmap. By contrast, the upcoming Grid+Storage consultation (foreseen by December 2015) will deal with a full revisit of the R&I EEGI roadmap, together with more R&I activities dedicated to storage integration, this in order to shape the construction of a full Integrated R&I roadmap covering the period 2016-2025.***

  How do you intend to contribute to this integrated roadmap?