



ETIP SNET

EUROPEAN
TECHNOLOGY AND
INNOVATION
PLATFORM

SMART
NETWORKS FOR
ENERGY
TRANSITION

PLAN.
INNOVATE.
ENGAGE.

Implementation Plan 2017-2020

October 2017

ETIP SNET Implementation Plan 2017-2020

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“INTEGRATED ENERGY SYSTEM - A PATHWAY FOR EUROPE”

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1 INTRODUCTION

1.1 CONTEXT

Europe's Strategic Energy Technology Plan (SET Plan) addresses the 5th dimension of the Energy Union with 10 Key Actions identified in September 2015 that address the whole innovation chain, from basic research to market uptake – see <https://setis.ec.europa.eu/>. Europe's energy transition is key to the European and global goals of reducing greenhouse gas emissions and keeping global temperature increases well below 2°C. To ensure this, more renewable and other carbon-neutral energy sources will be introduced into Europe's electricity, heating and cooling, and transport systems. The energy networks, especially stronger and smarter electricity grids interfaced with heating, gas and transport networks, play a key role in the energy transition while supporting security of supply and affordability¹. ETIP SNET – the European Technology and Innovation Platform “Smart Networks for Energy Transition” aims to make sure Europe's research and innovation (R&I) facilitates all energy customers and market actors to rely on optimally integrated networks, systems and markets.

The present Implementation Plan 2017-2020 (IP 17-20) has been elaborated in a very close collaboration with the ETIP-SNET Working Groups and submitted to public consultation from 3 July to 10 August 2017. It aims at listing the short-term priorities for R&I in ETIP SNET's scope and as defined in the DoI (Declaration of Intent) for key action 4 of the SET Plan (*Increase the resilience, security and smartness of the energy system*)². It is based upon the [ETIP-SNET R&I roadmap 2017-2026](#) which specifies the long-term R&I activities for the evolution of the European energy system. The roadmap was approved during the 4th Governing Board meeting of the ETIP-SNET (December 9, 2016).

The R&I activities specified in the roadmap are structured along 5 clusters (C1-C5) for transmission systems and 4 clusters (C1-C4) for distribution systems, as presented in Table 1.

Table 1. Clusters of the ETIP SNET roadmap 2017-2026

Transmission clusters	Distribution clusters
C1 – Modernization of the network C2 – Security and system stability C3 – Power system flexibility from generation, storage, demand and network C4 – Economic efficiency of power system C5 – Digitalization of power system	C1 – Integration of smart customers and buildings C2 – Integration of decentralised generation, demand, storage and networks C3 – Network operations C4 – Planning and asset management

Each cluster gathers functional objectives corresponding to a function of the energy system that R&I activities shall support (see detailed structure of the roadmap in Figure 1 next page).

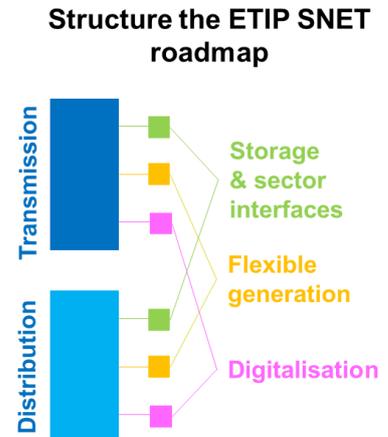
¹ Regarding electricity networks and more especially smart grids, the EC 27 islands will play a key role for the energy transition as living labs to test technologies, methodologies, market and governance schemes, etc. in different demonstration sites.

² The temporary Working Group 4 (TWGA4) of the SET PLAN is also elaborating an Implementation Plan (IP) which aims at identifying R&I activities related to Energy System.. The TWGA4 IP is different from the present document (ETIP SNET IP). It comes from a shared vision of the Members States (i.e. more related to national or transnational funding). Both IPs are complementary and necessary since the ETIP SNET IP covers a broader and a more holistic scope.

The main feature of the roadmap is to address flexibility by considering several options (cf. Figure on the side), both for transmission and distribution systems, such as sector interfaces (electricity-gas and electricity-heat for instance), flexible thermal and RES generation, and storage. Other flexibility means and enablers such as digitalisation are also covered.

Storage integration R&I activities have been mainly specified in two dedicated functional objectives for both the transmission and distribution systems. However, due to the cross-cutting dimension of storage integration, R&I activities have also been defined in other clusters and functional objectives when appropriate (cf. Figure 1 next page).

R&I activities related to digitalisation³, flexible generation and sector interfaces are also spread in the different transmission and distribution clusters as illustrated by the respective pink, yellow and dark green colours in Figure 1.



1.2 APPROACH TO ELABORATE THE PRESENT IMPLEMENTATION PLAN

The initial input to this Implementation Plan is the so-called “Initial integrated Implementation Plan of R&I activities: 2017-2019” delivered by the [Grid+Storage consortium](#) in December 2016. This initial IP was structured along transmission, distribution and storage topics in coherence with the Grid+Storage scope.

³ Digitisation of the energy system is a key driver that will allow the energy transition and a low-carbon economy. Digital developments (big data, IoT, 5G, AI, smart metering, , etc.) impact multiple aspects of the European energy policy and foster the evolution of the energy system.



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

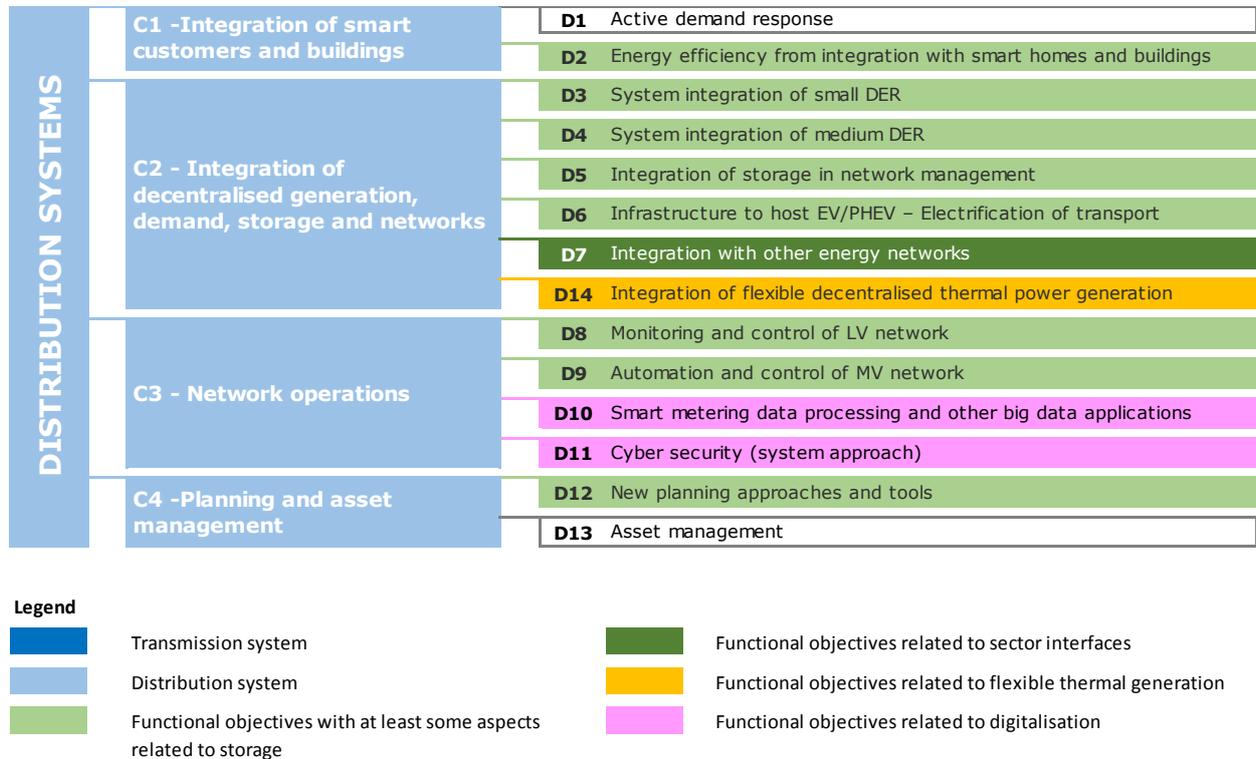


Figure 1. Structure of the ETIP SNET roadmap 2017-2026

The ETIP SNET Working Groups (WGs), especially WG1 to WG4, were invited to review this initial IP and to propose topics corresponding to the scope of the working groups:

- [WG1](#): Reliable, economic and efficient smart grid system,
- [WG2](#): Storage technologies and sector interfaces,
- [WG3](#): Flexible generation,
- [WG4](#): Digitisation of the electricity system and customer participation.

New topics have therefore been proposed along the structure of the four working groups.

Finally, after a thorough review of all topics proposed by the different working groups, cross-cutting topics have been identified as well as synergies between initial topics. The final structure for this IP has been adopted, highlighting the synergies and interfaces within the energy system. This is illustrated by Figure 2.

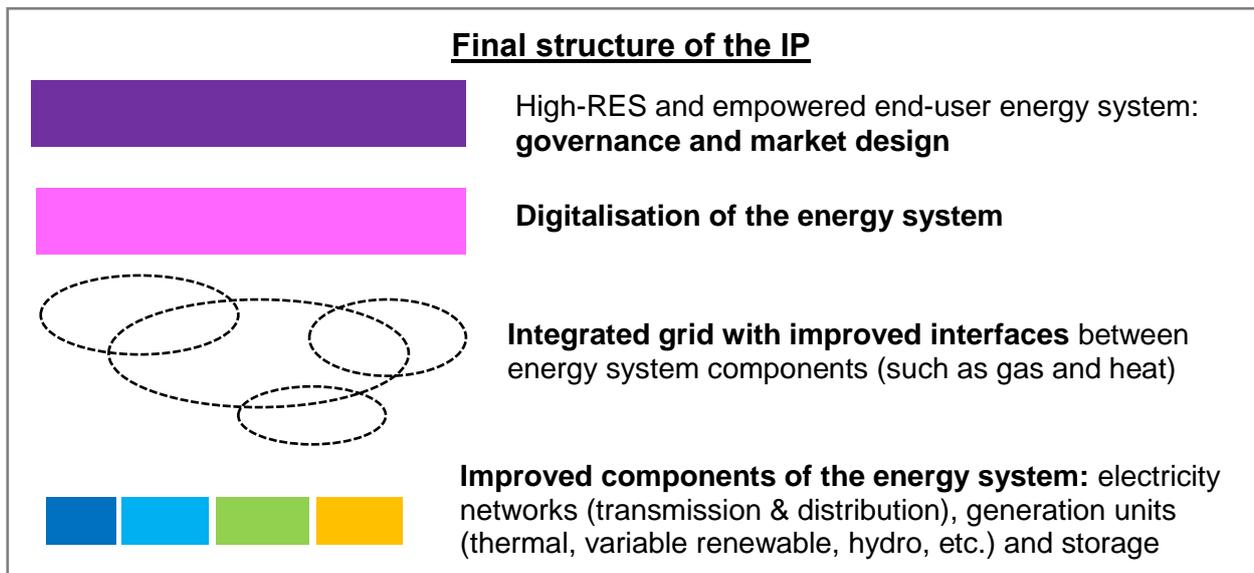


Figure 2 : Final structure of the ETIP SNET IP

Furthermore, it was decided by ETIP-SNET that the Implementation Plans should be released in coherence with the Work Programmes of the European Commission, every two years rather than every year as initially foreseen. The present Implementation Plan should thus cover years 2017 to 2020. The next Implementation Plan, which should be based on the next (updated) ETIP-SNET 10-year roadmap, should be released in 2020.

1.3 STATUS OF THE PRESENT DOCUMENT

The elaboration of this document has been coordinated by the INTENSYS4EU support team in close cooperation with the ETIP-SNET working groups (WG1 to WG4). The ETIP-SNET Governing Board has been regularly informed about the progress made and validated the new structure adopted and the detailed contents.

This document is an approved publication of the ETIP-SNET. It contains feedback from external stakeholders who have participated providing comments, remarks and suggestions during a public consultation held from 3 July to 10 August 2017. The ETIP-SNET Governing Board has adopted this final document by the beginning of October 2017 once the inputs coming from the public consultation have been evaluated and processed.

2 SELECTION OF THE TOPICS

2.1 PROCESS

2.1.1 GENERAL PROCESS

As previously explained, Implementation Plans have the purpose of specifying R&I topics to be addressed in the short-term, building upon the R&I activities listed in the 10-year R&I roadmap.

To define the topics to be included in a given IP, the following high-level principles have been adopted. These principles are aligned with the process implemented for the previous EEGI and Grid+Storage implementation plans. The process implemented is illustrated by Figure 3 (next page):

- The topics listed in the previous IP should be analysed following the criteria explained below:
 - Topics that are being addressed by new projects (for instance selected in the H2020 calls during the previous year or launched at national levels, as identified by the INTENSYS4EU monitoring and knowledge sharing exercises) should be excluded from the new IP (see ① in Figure 3).
 - Topics that are not addressed by new projects, or only partially addressed, should in principle be duplicated in the new IP, unless their relative level of urgency or importance has become lower (for instance if more urgent or more important topics have popped up – see below). This is represented by ② in Figure 3.
- The changing context in the energy system and the evolving status of ongoing R&I activities should allow the definition of new R&I priorities for the upcoming years:
 - These new priorities should be identified amongst the list of topics listed in the 10-year roadmap (see ③ in Figure 3).
 - The high-level vision from the ETIP-SNET working groups should be taken into account when updating the R&I priorities for the upcoming years. The main criteria to be considered should be:
 - *Urgency*: the agenda of integration challenges faced by energy system stakeholders (in particular the flexibility needs as seen by network operators);
 - *Timeliness for availability*: the time for system integration as estimated by system operators;
 - *System impact*: the expected impact on system planning, operation and maintenance once system integration has been successfully implemented.
 - Implementation Plans are also submitted to stakeholders' consultations. Proper considerations will have to be given to stakeholders' inputs.

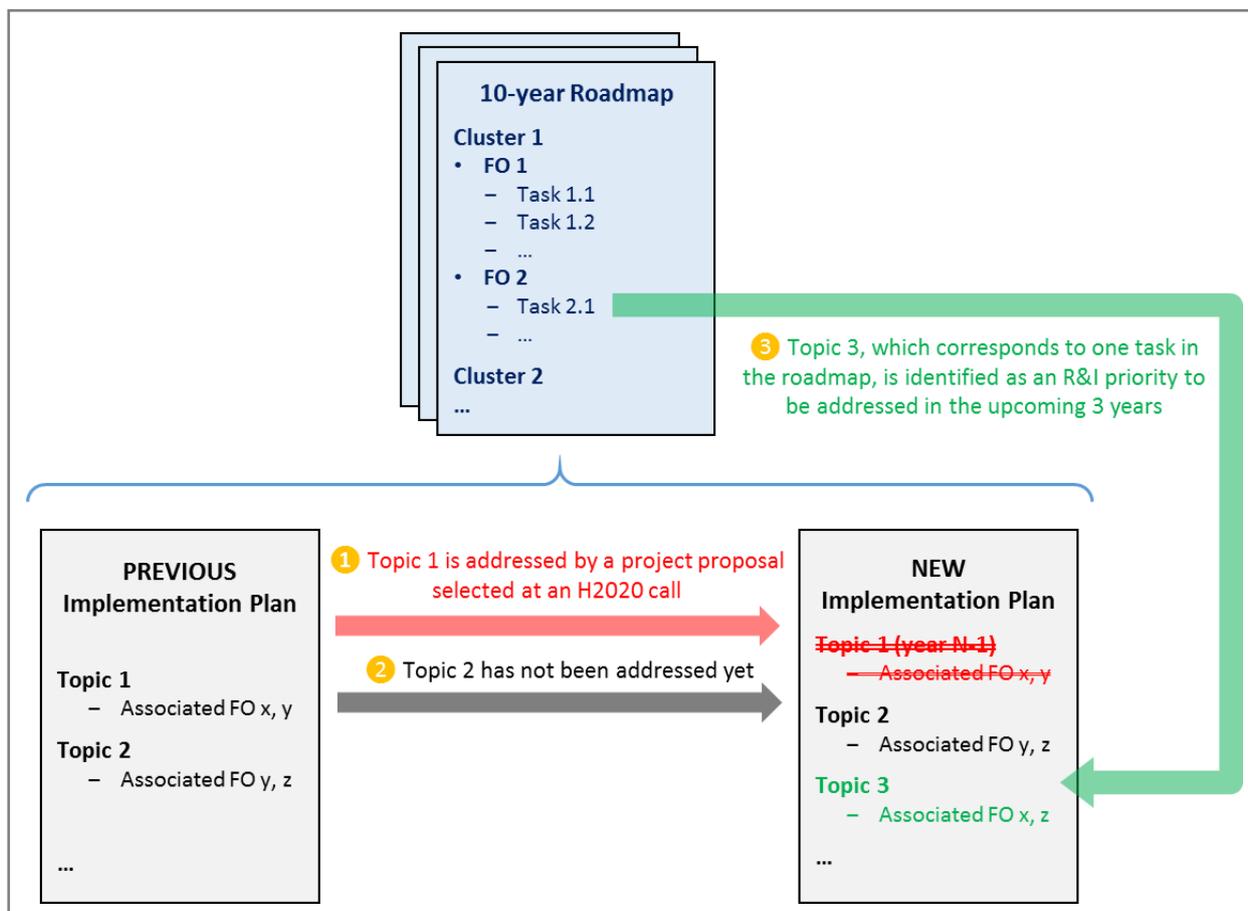


Figure 3. General process to prioritize topics in the Implementation Plans (IPs)

2.1.2 SPECIFICITIES OF THE PRESENT IMPLEMENTATION PLAN

The present Implementation Plan is the first one prepared in the framework of the ETIP-SNET gathering representatives of the energy system which were not involved in previous works conducted by the EEGI and the Grid+Storage project.

The current roadmap, adopted by the ETIP-SNET Governing Board, was elaborated prior to the creation of the ETIP-SNET Working Groups, therefore it does not fully reflect all R&I activities covered by the different members of the working groups.

This full coverage has been ensured in the present Implementation Plan: as a consequence, some of the R&I activities specified in the present Implementation Plan are not specified in the roadmap.

2.2 SELECTED TOPICS

2.2.1 HIGH-RES AND EMPOWERED END-USER ENERGY SYSTEM: GOVERNANCE AND MARKET DESIGN

The integration of the European energy system in a context of a high share of energy (electricity and heat) produced from renewables, together with the internal energy market, raise several questions regarding both governance (how to organize the operations of the energy system and the associated interactions between the different stakeholders) and market design (market rules supporting the development of renewables and empowering prosumers). The three proposed topics put forward R&I activities which should help answer these questions, viz.:

- Topic 1 (Preparing markets for flexibility) which should support the advent of a more efficient Internal Energy Market accounting for grid flexibility, market integration of RES and associated services, as well as an explicit modelling of uncertainties to increase cross-border exchange;
- Topic 2 (Market design for trading of heterogeneous flexibility products) which should help develop a flexibility market concept that allows the trading of ‘heterogeneous’ flexibility products (coupling electricity, heat and gas markets, both at the wholesale and retail level), taking into account the specific capabilities of each resource;
- Topic 3 (Holistic model and unified technical / functional architecture for smart power systems) which should help propose solutions to re-organize the respective roles and interactions of all stakeholders of the energy system (network operators, generators, aggregators, prosumers, etc.). The proposed solutions should also define the technical interfaces.

Table 2. Selected topics for the governance and market design of the high-RES and empowered end-user energy system

Topic #	Topic description	Main FOs	Year	Target TRL
1	Preparing markets for flexibility	T15, T17	2017-2018	6-8
2	Market design for trading of heterogeneous flexibility products	T17	2019	3-5
3	Holistic model and unified technical / functional architecture for smart power systems	T5, T13, T15	2017-2018	2-7

2.2.2 DIGITALISATION OF THE ENERGY SYSTEM

Smart networks should allow the enhanced monitoring, automation and control of the existing networks while ensuring that all involved stakeholders (regulated and market players) can interact: this will be made possible by a full digitalisation of the power system, and of the energy system as a whole. As of today, digitalisation is under implementation in transmission networks and distribution networks (mainly MV) but also for market applications. Still, a lot of work remains to be done to achieve a full digitalisation of the energy system. The following topics should help pave the way to a full digitalisation of the energy system allowing efficient markets, empowering customers, etc.:



- Topic 4 (Digital Technologies, Reference Architectures and Standards for a Scalable Energy Transition) for the overview of the development of a suitable ICT infrastructure, data availability and common standards for data exchange which will help to connect efficiently network operators and market players (including prosumers);
- Topic 5 (Demonstration of integrated IT-solutions for new markets and business models across the system) for the design and the demonstration of specific ICT solutions for market players;
- Topic 6 (Customer participation and New Markets and Business Models) for the design and the demonstration of specific ICT solution, with the associated business models, allowing the end-users' participation in energy markets;
- Topic 7 (Design and Demonstration of Grid digitalisation) to specify and demonstrate for the future energy system the digital technologies ensuring system reliability.

The full digitalisation of the energy system will bring new opportunities (e.g. Internet of Things -IoT) and challenges (e.g. cybersecurity) which are addressed in two topics:

- Topic 8 (Digitalisation and Big Data, IOT and IIOT) for example how to make use of IoT and data mining techniques (big data) to develop smart asset management strategies;
- Topic 9 (Cybersecurity of critical energy infrastructures) to assess in depth cybersecurity issues and propose solutions so as to maintain the system robust against possible cyber threats.

Table 3. Selected topics for the digitalisation of the energy system

Topic #	Topic description	Main FOs	Year	Target TRL
4	Digital Technologies, Reference Architectures and Standards for a Scalable Energy Transition	T15 to T19	2017	5-9
5	Demonstration of integrated IT-solutions for new markets and business models across the system	T16, T17, T19, T20	2017	5-9
6	Customer participation and New Markets and Business Models	T16, T17, T20	2017	5-9
7	Design and Demonstration of Grid digitalisation	T15	2017	5-8
8	Digitalisation and Big Data, IOT and IIOT	T18, T20	2017	5-9
9	Cybersecurity of critical energy infrastructures	T21, D11	2017	5-8

2.2.3 INTEGRATED GRID WITH IMPROVED INTERFACES BETWEEN ENERGY SYSTEM COMPONENTS

The integration of the different energy (electricity, gas and heat networks) to form of an integrated energy system creates specific challenges at the different interfaces, e.g. electricity-heat and electricity-gas and to some extent gas-heat (which is not covered by the present IP). This integration also creates specific challenges for new system components of the power system such as storage and renewable generation units.

2.2.3.1 SYNERGIES BETWEEN ELECTRICITY AND HEAT SYSTEMS

Heat networks will play a pivotal role in the future integrated energy system by providing additional flexibility. This additional flexibility needs to be optimised by better defining the role and interactions between the different stakeholders (regulated and market players) of the distribution grids and the heat networks (district heating and industry), taking into account the necessary technology-based integration issues (thermal storage and heat pumps for instance). This additional flexibility must also be provided in coherence with the energy and climate policies of the EC, e.g. integration of renewables and energy efficiency. The two proposed topics should support the development of this additional flexibility by:

- In Topic 10 (Coupling of electricity and thermal sectors) developing methodologies and tools to quantify and test the technical and cost performances of the coupling while addressing governance and market issues;
- In Topic 11 (Increase energy efficiency by utilising excess heat from other processes via heat networks and thermal storage) by investigating how to capture excess heat in an efficient way (energy efficiency and costs) so as to decarbonize the heat sector.

Table 4. Selected topics for the synergies between electricity and heat systems

Topic #	Topic description	Main FOs	Year	Target TRL
10	Coupling of electricity and thermal sectors	D7, T14	2020	5-8
11	Increase energy efficiency by utilising excess heat from other processes via heat networks and thermal storage	D7, T14	2018	4-6

2.2.3.2 SYNERGIES BETWEEN ELECTRICITY AND GAS SYSTEMS

Coupling gas and electricity networks (via power to gas technologies) at different spatial scales (transmission and distribution grids) provides additional flexibility options to manage the power system. At transmission level, gas networks can provide an alternative solution to perform large-scale storage (chemical energy) of renewable excess electricity. At distribution level, the existing gas networks, especially in cities, could be used to promote green fuels for thermal or transport applications.

The R&I activities described in Topic 12 (Coupling of electricity and gas sectors) explore all the dimensions of the coupling, from the technical, economic, market and regulatory viewpoints.

Table 5. Selected topics for the synergies between electricity and gas systems

Topic #	Topic description	Main FOs	Year	Target TRL
12	Coupling of electricity and gas sectors	D7, T14	2019	4-8

2.2.3.3 SYNERGIES BETWEEN ELECTRICITY TRANSMISSION NETWORKS, GENERATION AND STORAGE

The massive integration of renewable generation (wind and PV) in the power system challenges network operators in their daily operations when ensuring reliability at affordable costs. Flexibility options for transmission network operators can be provided at different interfaces, i.e. generation-grid and storage-grid. The following topic specify R&I activities which aim at improving the flexibility provided by such interfaces, i.e.



- Topic 13 (Smart interfaces between generation and transmission) with new technologies -power electronics- to improve the flexibility from thermal power generation;
- Topic 14 (Improve RES and demand forecasting and optimal capacity operation) with improved forecasting tools allowing to better predict RES generation and demand, this reducing the uncertainties on the forecast of the residual load;
- Topic 15 (Multiservice storage applications) with the demonstration of bulk storage integration options in the transmission system aimed to valorise the multi (ancillary) services offered by these technologies.

Table 6. Selected topics for the synergies between electricity transmission networks, generation and storage

Topic #	Topic description	Main FOs	Year	Target TRL
13	Smart interfaces between generation and transmission	T22	2018	5-7
14	Improve RES and demand forecasting and optimal capacity operation	T12	2019	5-8
15	Multiservice storage applications to enable innovative synergies between system operators and market players	T6, T10	2017	5-8

2.2.3.4 SYNERGIES BETWEEN ELECTRICITY DISTRIBUTION NETWORKS AND THEIR INTERFACES

The fast evolving environment of electricity distribution networks (growing share of distributed generation such as PV, distributed storage and new uses such as heat pumps and EVs that modify the load profiles) has resulted in an increased volatility of residual loads, directly impacting power flow and voltage control, fault detection, and power quality. As a consequence, there is still a major challenge for European DSOs to use all connected units (generation and load) to find flexibility options during operation and to fully equip their networks with advanced monitoring, automation and control technologies in order to better monitor and operate their MV and LV grids. The two following topics propose R&I activities which should help DSOs to better handle their fast evolving environment, viz.:

- Topic 16 (Increased control and observability of MV and LV networks in presence of DER, EV and storage systems), with methodologies/tools/technologies to control and operate MV and LV networks and associated market structures including new stakeholders with a focus on the integration of distributed storage, while taking into account all other flexibility means (distributed generation and loads).;
- Topic 17 (Integrated management of MV and LV networks based on DER). Topic 17 is similar to Topic 16 with a focus on DER (while taking into account all other flexibility means).

Table 7. Selected topics for the synergies between electricity distribution networks and storage

Topic #	Topic description	Main FOs	Year	Target TRL
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16	Increased control and observability of MV and LV networks in presence of DER, EV and storage systems	D5, D9, D8	2017-2018	4-8
17	Integrated management of MV and LV networks based on DER	D8, D9, D3, D4, D5	2018	4-8

2.2.3.5 COUPLING BETWEEN FLEXIBLE GENERATION AND STORAGE

Coupling generation units (thermal and RES) with a storage unit can help improve the flexibility provided by these units under satisfying techno-economic performances. R&I activities should focus on:

- Topic 18 (Integration of storage in thermal generation for increased flexibility): the design and demonstration of the integration of energy storage systems (electrical, thermal, mechanical or chemical) within thermal power plants including power-to-x (to power) solutions to couple with other energy networks.
- Topic 19 (Towards fully dispatchable RES: Variable RES with Storage): the demonstration of the local coupling of storage with solar and/or wind energy assets enabling renewable energy to be fully flexible and ensuring the sustainability of the future energy system.

Moreover, coupling non-dispatchable RES generation with dispatchable RES generation (CSP with thermal storage) can help improve the flexibility provided by solar-based generation with

- Topic 20 (Managing system flexibility with a smart balance between intermittent and dispatchable solar generation): the development and validation of design tools and operation strategies for a hybrid solar power plant (PV, CSP with thermal storage).

Table 8. Selected topics for the coupling between flexible generation and storage

Topic #	Topic description	Main FOs	Year	Target TRL
18	Integration of storage in thermal generation for increased flexibility	T22, D14	2018	4-7
19	Towards fully dispatchable RES: Variable RES with Storage	T10, D5	2019	4-7
20	Managing system flexibility with a smart balance between intermittent and dispatchable solar generation	D4, T22	2018	5-7

2.2.4 IMPROVED COMPONENTS OF THE ENERGY SYSTEM

2.2.4.1 ELECTRICITY NETWORKS

JOINT TRANSMISSION AND DISTRIBUTION ISSUES

The evolving environment of the electricity networks (renewables and new loads) modify the operating conditions of the existing assets (which were originally designed for rather steady and unidirectional power flows). New models/tools based e.g. big data, and new techniques (robotics, sensors, etc.) become available at affordable costs: this gives an opportunity to revisit the existing maintenance policies of network operators so as to extend the life time of the existing assets and improve the maintenance procedures of new assets within affordable costs (OPEX). Topic 21 (Smart asset management using innovative hardware and software technologies) addresses these issues.



Table 9. Selected topic about joint transmission and distribution issues

Topic #	Topic description	Main FOs	Year	Target TRL
21	Smart asset management using innovative hardware and software technologies	T2, T18, D13	2019	6-8

TRANSMISSION NETWORKS

The fast evolving environment of electricity transmission networks (e.g. generation connected at distribution level, converter based power electronics in production and demand facilities, mix of AC and DC interconnectors) calls for increased system flexibility, stability and security. This can be achieved by several means, i.e.

- Topic 22 (Smart and flexible grid design and planning with probabilistic adequacy assessments in uncertain framework) planning tools able to optimise investments while taking into account the full environment of power system components and technologies (RES, storage, loads, interface with other energy networks, DLR, FACTS, etc.);
- Topic 23 (Public acceptance and stakeholders participation) public acceptance methodologies to decrease permitting duration (and project costs);
- Topic 24 (ICT systems and data handling for control chain) ICT systems able to handle huge data flows, control and storage of real-time information to feed the new tools, automation, etc., for operators;
- Topic 25 (Enhanced grid observability and assessment of pan European system stability) new technologies such as DLR, FACTS, WAMS, and PMU to operate closer to the physical limits of the grid with the existing assets;
- Topic 26 (Cross-border use of ancillary and flexibility services) an increased amount of ancillary services and flexibility resources made available across the interconnected borders and market zones;
- Topic 27 (Demand response engineering) an improved use of Demand Side Response (DSR) to provide innovative ancillary services;
- Topic 28 (Coordination and Measurement of System's flexibility mechanisms) methods to value flexibility product.

Table 10. Selected topics for the transmission networks

Topic #	Topic description	Main FOs	Year	Target TRL
22	Smart and flexible grid design and planning, asset management and system operation, with probabilistic reliability assessments in uncertain framework	T1	2019	4-8
23	Public acceptance and stakeholders participation	T4	2019	5-7
24	ICT systems and data handling for control chain	T5, T18, T19	2018	6-8
25	Enhanced grid observability and assessment of pan European system stability	T5, T6	2017	3-7



26	Cross-border use of ancillary and flexibility services	T9	2017	5-8
27	Demand response engineering	T11, T19	2017	5-7
28	Coordination and Measurement of System's flexibility mechanisms	T13, T16, T15, T17, D12	2017	3-8

DISTRIBUTION NETWORKS

As for transmission networks, the fast evolving environment of electricity distribution networks calls for innovative approaches for grid operation (allowing to increase system flexibility, while maintaining stability and security) while coping with new loads, in particular EVs with the advent of fast charging stations. The following topics address these issues:

- Topic 29 (Innovative approach for grid operation) by proposing R&I activities for the development and demonstration of integrated innovative approaches (new software - algorithms- and hardware -power electronics- with the associated ICT infrastructure) for reliable network operations;
- Topic 30 (EV/PHEV charging infrastructure and integration in smart energy systems) by proposing R&I activities for the speed-up of EV roll-out and in particular fast charging stations (demonstration, planning, business models).

Table 11. Selected topics for the distribution networks

Topic #	Topic description	Main FOs	Year	Target TRL
29	Innovative approach for grid operation	D10	2018	5-8
30	EV/PHEV charging infrastructure and integration in smart energy systems	D5, D6	2017	5-8

2.2.4.2 STORAGE UNITS

Storage units are a major source of flexibility today (mainly pumped-hydro storage to store electricity at a very large scale) for energy balancing. In the near future (solutions are already available and some demonstrations are on-going) storage units, of different sizes and possibly located in specific areas of the electricity grid, will provide multiple services in different markets. Yet there are still major issues to be addressed, namely

- Topic 31 (Advanced energy storage technologies for energy and power applications) the validation in demonstrations of different technological options, together with R&I activities related to integration issues and business models (degradation and failure mechanisms which impact profitability) and with a focus on multiservice business models which might be a solution for profitability provided that the system services brought by storage are valued on a fair basis;
- Topic 32 (Coupling of electricity and transport networks) how to unlock the potential of V2G (vehicle to grid) applications by e.g. testing new business models and market mechanisms.

Table 12. Selected topics for storage units

Topic #	Topic description	Main FOs	Year	Target TRL
31	Advanced energy storage technologies for energy and	D5, T10	2020	4-8

PLAN. INNOVATE. ENGAGE.

	power applications			
32	Coupling of electricity and transport networks	D6	2020	4-6

2.2.4.3 GENERATION UNITS

THERMAL GENERATION

The ever increasing penetration of RES in electricity production has changed the operating conditions of thermal power generation (TPG). TPG must increase its flexibility, e.g. at full and partial load with possibly different fuels, at the lowest emission level as possible. New concepts are needed, viz.:

- Topic 33 (Developing the next generation of flexible thermal power generation) to achieve a robust, sustainable, flexible and efficient TPG fleet, able to meet the future (electricity) system needs at an affordable cost.

Regarding fuel flexibility, for “green” synthetic liquid or gaseous fuels produced from excess RES electricity and which can be used in TPG as well as to couple the electricity grid with the transport and gas sectors (large-scale electricity storage solution), the main challenges are the adaptation of the existing combustion technologies, viz.

- Topic 34 (Adaptation and improvement of technologies to novel Power-to-Gas and Power-to-Liquid concepts) combustion systems able to handle hydrogen mixtures (up to 100% H₂) while remaining flexible (partial loads) with low emissions.

Table 13. Selected topics for thermal generation

Topic #	Topic description	Main FOs	Year	Target TRL
33	Developing the next generation of flexible thermal power generation	T22, D14	2018	3-7
34	Adaptation and improvement of technologies to novel Power-to-Gas and Power-to-Liquid concepts	T22, D14	2018	3-6

VARIABLE RES

As mentioned above, the increasing penetration of RES in electricity production has changed the operating conditions of TPG but also sets new constraints on RES generators which must be designed to provide flexibility (ancillary services) with no (or very few) rotating machines, viz.:

- Topic 35 (Improved flexibility and service capabilities of RES to provide the necessary ancillary services in scenarios with very large penetration of renewables) to design RES generators able to ensure all needed ancillary services for system reliability when reaching 100% RES penetration;
- Topic 36 (Enhanced smart RES flexible solutions and control strategies for Power Electronic Converter (PEC) dominated grids) to develop the RFM (Renewable Flexible Modules) concept so as to make sure that the enhanced power electronics of each RES generator are able to fulfil all needed functions.

Table 14. Selected topics for variable RES

Topic #	Topic description	Main FOs	Year	Target TRL
35	Improved flexibility and service capabilities of RES to	T6, T13	2018	3-6



	provide the necessary ancillary services in scenarios with very large penetration of renewables			
36	Enhanced smart RES flexible solutions and control strategies for Power Electronic Converter (PEC) dominated grids	T6	2018	7

HYDRO PLANTS

Existing medium to large-scale hydro power plants have not been designed to fulfil today’s flexibility needs (e.g. ramp rates imposed by the balancing of wind and solar power). There is therefore a need to refurbish existing reservoirs/ PHS facilities with e.g. variable-speed turbines connected to the electricity network through power electronics interfaces.

- Topic 37 (Refurbishment and upgrade of existing hydropower with the purpose of increased flexibility and expanded storage capacity): the proposed R&I activities cover the development of tools and models to engineer the refurbishment design and works (new components), and demonstration projects to assess the techno-economic performances of the upgraded hydropower plants.

The enhanced flexibility of the refurbished hydropower plants (new operating conditions) will lead to changes, at different time scales, in the fluctuations in reservoir water levels and the state of downstream water bodies and fish population.

- Topic 38 (Environmental impact assessment of hydropower projects): the proposed R&I activities focus on the development of new tools (methods and models) for environmental impact assessments in sensitive areas in order to improve public acceptance.

Table 15. Selected topics for hydro plants

Topic #	Topic description	Main FOs	Year	Target TRL
37	Refurbishment and upgrade of existing hydropower with the purpose of increased flexibility and expanded storage capacity	T9	2018	5-7
38	Environmental impact assessment of hydropower projects	T4	2018	5-7

CROSS-CUTTING TOPIC

The digitalisation of generation units is key to improve design methods and tools (techno-economic performances) and operating conditions (better efficiency and extended lifetime resulting in higher profitability). Digitalisation, e.g. HPC (high-performance computing), IoT (new sensors), big data (data mining techniques and data analytics), etc., will allow the development of:

- Topic 39 (Digitalisation of flexible, dispatchable generation technologies): simulation methods and tools to assess the future techno-economic performances (reliable lifetime predictions) and improve operating conditions, as well as monitoring systems for optimised maintenance.

Table 16. Cross-cutting topic for flexible generation

Topic #	Topic description	Main	Year	Target
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		FOs		TRL
39	Digitalisation of flexible, dispatchable generation technologies	T7	2018	5-7



3 DETAILED DESCRIPTION OF THE TOPICS

3.1 HIGH-RES AND EMPOWERED END-USER ENERGY SYSTEM: GOVERNANCE AND MARKET DESIGN

Topic 1	Preparing markets for flexibility
Main FOs	T15 - Market/grid operation integration T17 - Flexible market design
Supported FOs	T9 - Enhanced ancillary services T12 - RES forecast
Specific Challenge	<p>Pan-European power flows within a liberalised energy market, plus massive integration of variable RES, have resulted in local and regional bottlenecks. The specific challenge lies in the management of congestions and deviations from planned operations resulting from such solutions.</p> <p>The market design should enable the integration of wholesale and retail markets through the use of distributed flexibility resources and of new market services based on the market signals. Consumers should be empowered so that they can participate freely in all the markets, directly or through various market players. The market arrangements should enable consumers to benefit fully from a reinforced competition that allow them to have at the same period of time various retailers, aggregators, and to value their services in the most efficient way. The new technologies enable these disruptions in energy exchanges (Block Chain, peer to peer platforms, IOT for energy, etc.).</p> <p>Three important aspects should be considered when addressing market design. 1. The solutions developed should ensure an efficient risk-sharing between the stakeholders. 2. They should not be too “complicated” in order to be usable for the consumers. 3. They should keep the transactions costs as low as possible.</p>
Content/Scope	<p>This will require the identification of scarcities at high RES supply and the need to design new products and services which should cope with these scarcities. This should take into account the issues such as non-priority dispatch and balancing responsibility. Consumers should be able to benefit both from local and global opportunities. The choices should be market-based driven, with a short-term horizon. All the solutions based on a priori split between local and global should be banned.</p> <ul style="list-style-type: none"> • Incentives for the market participants to react to system conditions according to the location and time. There is a need to consider different price components such as capacity and energy components and the various taxes. The economic rationale for cost allocation to the prices components needs to be defined. Owing to the structure of tariff for the end-user consumers, it is relevant to consider all the components and not only the energy part. • Study the detailed impact of scalable and replicable solutions for RES integration, using not only power markets but also system services. • Market based distribution congestion management will be assessed and market signals and their impact on the whole supply chain needs to be estimated.



	<ul style="list-style-type: none"> • Development of new tools and algorithms for market and network analysis which aim to integrate retail and wholesale markets in a global modelling of the major energy carriers, able to account for different roles and players involved. • Test the new market design and tools/algorithms based on new energy system requirements and assess the social welfare for the customers.
Target TRL	6-8
Funding Scheme	IA
Expected outcomes	<ul style="list-style-type: none"> • Innovative market design and tools/algorithms based on new energy system requirements addressing the social welfare for the customers • New tools and algorithms for market and network analysis. • Interoperable solutions involving different market actors. • Innovative and interoperable market tools and platform that integrate also market signals. • Evaluation of scalability and replicability potential of the most promising solutions
Expected Impact	A more efficient Internal Energy Market that takes into account grid flexibility, market integration of RES and associated services, as well as an explicit modelling of uncertainties to increase cross-border exchange. This new internal energy market should reinforce the role of the consumers.
Possible partners	Stakeholders: TSOs, DSOs, aggregators, storage, generation companies, research institutes, service providers (e.g. ESCOs), regulators, consumers' representatives.
Reference projects	Existing studies and projects such as OPTIMATE, EUSYSFLEX, Flexitranstore, Market4RES.
Proposal Duration	2017-2021
Estimated Budget	At least 50 M€

Topic 2	Market design for trading of heterogeneous flexibility products
Main FOs	T17 - Flexible market design
Supported FOs	T15 - Market grid integration T14 - Interaction with non-electrical energy networks D7 - Integration with other energy networks D5 - Integration of storage network management
Specific Challenge	There is a growing need for flexibility products (such as energy storage, cross-border interconnectors, electric vehicles, DR, interfaces between energy networks and novel market products) in the energy market to balance intermittent renewables, to provide short-, medium- and long-term flexibility, to provide black-start reserve power and to address balancing market failures. Nowadays, balancing services are still mainly provided through conventional fossil-fuel based generation units. To help achieve the EU emission and climate targets, other flexibility products should be introduced in the balancing market. Given that 'flexibility' is a heterogeneous product operating in and relevant to e.g. different locations in the network, applicable



	<p>to different end-users and operational in different time scales, and potentially affecting several energy markets, a new market design needs to be developed. This new design should allow the trading of the different flexibility products. Of particular relevance is to assess how the commercialisation of these products affects the different energy markets (electricity, gas and, where existing, heat) when there is a conversion in the energy carriers, e.g. the impact in the electricity and gas price at wholesale and, especially, retail level on a windy day when a lot of electricity coming from wind farms is pulled into the gas network through P2G technologies. To facilitate and increase the liquidity of the flexibility market and increase the demand for flexibility, all heterogeneous flexibility users and products could be combined under a new flexibility market concept.</p>
Content/Scope	<p>Developing a flexibility market concept and design for the various markets (electricity, heat and gas markets) that allows the trading of 'heterogeneous' flexibility products, taking into account the specific capabilities of each resource. This research topic involves the following steps:</p> <ul style="list-style-type: none"> • developing a flexibility market concept for the multi-resource balancing market that allows the trading of 'heterogeneous' flexibility products and determine how to market and commoditise heterogeneous flexibility; • translating the markets concept into a dynamic simulation model of the system to understand their coordinated behaviour and enable implementation, • integration of the new concept in the energy markets across the EU, and • analysing the impact of the flexibility provided by energy sector coupling in the wholesale and, particularly, retail energy markets <p>ICT activities for developing platforms and other tools for the trading of flexibility products and interconnection of the energy markets are not within the scope of this topic.</p>
Target TRL	3-5
Funding Scheme	RIA
Expected outcomes	Expected project outputs are flexibility market concept ready for integration and implementation within the current energy markets across the EU
Expected Impact	<ul style="list-style-type: none"> • Increase market participation of a wide range of flexibility products, both short and long term, through remuneration in multiple balancing/flexible markets. • Improve market conditions of flexibility products at both supply and demand sides to ensure balancing and ancillary service provision in the markets. • Improve the integration and cooperation between the different energy markets (electricity, gas and heat)
Possible partners	Network operators, market operators, retailers and aggregators, generators, BRPs, equipment manufacturers, ICT solution providers, regulatory bodies, R&D institutes, end-user associations, organizations promoting standards.
Reference projects	GARPUR
Proposal	3-5 years



Duration	
Estimated Budget	10 M€
Topic 3	Holistic model and unified technical / functional architecture for smart power systems
Main FOs	<p>T5 - Grid observability T13 - Flexible grid use T15 - Market/grid operation integration</p>
Supported FOs	<p>T6 - Grid controllability: frequency and voltage stability, power quality, synthetic inertia T8 - Reliability and resilience T11 - Demand response T16 - Business Models D3 – System integration of small DER D4 – System integration of medium DER</p>
Specific Challenge	<p>For more than 15 years, different smart grid solutions have been implemented on individual model regions, but up to now none of them has crossed the boundaries of their own model region. The many already developed solutions do not fit to each other and do not offer a reasonable solution for the smart power system as a whole. The final solution is not in sight, because none of the individual solutions have considered the highly complicated interdependencies between the different parts of power systems - i.e. interdependencies between generation/storages, transmission, distribution and consumers/prosumers -. A holistic model and the resulting unified technical/functional architecture of power systems are the cornerstones to reach a complete smart power system solution.</p>
Content/Scope	<p>Proposals should focus on a reliable, secure and economical, environmentally friendly holistic model and unified operation architecture for smart power systems by putting all stakeholders - i.e. TSO, DSO, generation and storage (both regardless of size and technologies), market players and prosumers - under the same umbrella. The policy makers and regulators should accompany actively the projects. The solution may be based on Virtual Power Plants, Microgrids, Cellular approach, <i>LINK</i>-paradigm, in any other newly conceived concept/paradigm or in their combination. It should fulfil the severe requirements for data privacy and cyber security. The solutions should enable a complete smart grid solution. The proposed architecture (e.g. capacity markets) should facilitate the execution of all processes, which are necessary for a reliable, secure and economical operation of a smart power system, –i.e. load-generation balance under market consideration, volt/var assessment, static (N-1 criteria and the proposed probabilistic reliability management criteria) and dynamic stability (angle and voltage), demand response (emergency and price driven), etc. –. The solution should define technical and market oriented interfaces and describe the interactions between the same and different stakeholder types, precise or define their roles. The harmonization of the grid code with the new designed operational architecture should assure the elaboration of the solution. It should enable a smooth transition from the traditional operation of</p>



	power systems to the smart one. Demonstration of at least one operation process in a model region, which includes high-, medium- and low voltage grid with large DER share –i.e. distributed generation and storage- and customer plants should guarantee the quality of the developed applications, which run in real time.
Target TRL	2-7
Funding Scheme	RIA and IA
Expected outcomes	<ul style="list-style-type: none"> • An applicable, complete solution for smart power systems as a whole including prosumers and market. • Real time applications needed for the operation of the smart power system. • Upgraded grid code conform the smart power system behaviour. • Reliable transition plan from the traditional to the smart power systems.
Expected Impact	<ul style="list-style-type: none"> • First-time realisation of a sustainable, secure, economic and environmentally friendly solution for smart power systems, customers and electricity market simultaneously. • It will set the framework for successful, sustainable solutions in management system (application) level. • It will facilitate the large scale integration of distributed energy resources and realisation of demand response by setting in the same flow the grid, consumers and market. • Definition of a new technology –i.e. real time applications- which enables and facilitates the operation processes of a smart power system.
Possible partners	TSOs, DSOs, Generation companies, Storage companies, Aggregators, Industry partners, Retailers, ESCOs, Research institutions, Market players. Regulators and policy makers should accompany the project.
Proposal Duration	2017-2023
Estimated Budget	60 M€

3.2 DIGITALISATION OF THE ENERGY SYSTEM

Topic 4	Digital Technologies, Reference Architectures and Standards for a Scalable Energy Transition
Main FOs	<p>T19 - Standardization, protocols for communication, and data</p> <p>T20 - New technologies, Internet of Things</p> <p>T18 - Big Data Management</p> <p>T15 - Market/grid operation integration</p> <p>T16 - Business Models</p> <p>T17 - Flexible Market Design</p>
Supported FOs	<p>D1 - Active Demand Response</p> <p>D2 - Energy efficiency from integration with smart homes and buildings</p> <p>D10 - Smart metering data processing and other big data applications</p> <p>D12 - New planning approaches and tools</p> <p>T7 - Expert systems and tools: expert systems, decision-making support tools and advanced automatic control</p>



	T9 - Enhanced ancillary services for network operation T11 - Demand response, tools for using DSR, load profile, EV impact
Specific Challenge	This is an umbrella topic for digitalisation of the energy networks. <ul style="list-style-type: none"> • Verification of topics 5, 6, and 7; • Safeguard coherence of topics 5, 6, and 7.
Content/Scope	The following aspects must be addressed: <ul style="list-style-type: none"> • TECHNOLOGIES: <ul style="list-style-type: none"> ○ Overview and future outlook Methodologies and Tools. Emerging technologies, new communication solutions such as 5G and more electrically related such as DC; ○ Latency and reliability (“ultra-reliable”) of communication infrastructure for critical applications for energy distribution networks (e.g. for automatic fault detection, isolation and restoration -FDIR- systems based on logic discrimination/zone sequence interlocking). • ARCHITECTURE: Role of centralized, versus decentralized/distributed, open standards; • STANDARD: based on the existing recommendations (see http://smartgridstandardsmap.com, identify gaps that could block technology applications. Explore beyond electricity related standards, emerging in areas such as e-mobility for example. Explore the ETSI new activities around CIM (not to be confused with CIM coming from IEC standards).
Target TRL	5-9
Funding Scheme	RIA and IA
Expected outcomes	Articulation of digitalisation and customer participation by design in energy networks.
Expected Impact	<ul style="list-style-type: none"> • Enabling new Digital Use Cases and Services supporting the energy transition while maintaining the quality of service in the energy provision. • Significant economic benefits related to the digitalisation of the assets and customer services. • Enabling a full functioning Smart Grids system across the energy value chain. • A large-scale demonstrator for specific use cases should demonstrate the feasibility of disruptive real-time services. • Articulation and involvement of the customer and end user in digitalisation of energy supply.
Additional Information	Should be focusing on forward looking to explore the emerging technologies and the technologies of the future that will change the way we operate and run the overall Smart Grids system.
Possible partners	Utilities, DSO, TSO, knowledge institutes
Additional information	The Smart Grid Architecture Model (SGAM) and the IEC 61850 standard should be used in the R&I activities to be carried out.
Proposal Duration	2017-2020



Estimated budget	20 M€
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Topic 5	Demonstration of integrated IT-solutions for new markets and business models across the system
Main FOs	T19 - Standardization, protocols for communication, and data T20 - New Technologies, Internet of Things T16 - Business Models T17 - Flexible Market Design
Supported FOs	D1 - Active Demand Response D2 - Energy efficiency from integration with smart homes and buildings D12 - New Planning approaches and tools T7 - Expert systems and tools: expert systems, decision-making support tools and advanced automatic control T9 - Enhanced ancillary services for network operation T11 - Demand response, tools for using DSR, load profile, EV impact T17 - Flexible Market Design
Specific Challenge	The development of the IT solutions must be performed at affordable costs
Content/Scope	Demonstration in use cases of: <ul style="list-style-type: none"> Advanced IT, Telecommunications, 5G Digital enablers. Digital flexible generation.
Target TRL	5-9
Funding Scheme	RIA and IA
Expected outcomes	Proven technology in pilot projects. Experience and knowledge of IT solutions in (new) markets, articulation of markets and business models
Expected Impact	<ul style="list-style-type: none"> Demonstration of IT solutions Demonstration of small scale projects optimize energy balancing with digitalisation between households and SME
Possible partners	Utilities, DSO, local communities
Proposal Duration	2017-2020
Estimated budget	16 M€

Topic 6	Customer participation and New Markets and Business Models
Main FOs	T20 - New Technologies, Internet of Things T16 - Business Models T17 - Flexible Market Design
Supported FOs	D1 - Active Demand Response D2 - Energy efficiency from integration with smart homes and buildings D10 - Smart Metering data processing and other big data applications D12 - New Planning approaches and tools T7 - Expert systems and tools: expert systems, decision-making support



	tools and advanced automatic control T11 - Demand response, tools for using DSR, load profile, EV impact
Specific Challenge	<p>Digitalisation of the energy system and customer participation. Open standards and principles for open markets. The following questions will play a role in the new markets based on the customer participation principle.</p> <ul style="list-style-type: none"> • What is a customer-centric model and who is the customer? • Which technologies are available? • Why do we need new business models? • What is the timeframe we are looking at? • Which is the main focus/market of those business models? • Are we looking for services or products? • Regarding electricity: congestion or energy market? • Blockchain: Is there a business case? Who benefits? • Why would consumers participate? • Who owns the problem? Maybe DSO/TSO? • Necessary regulative changes for business models?
Content/Scope	<p>Use cases, demonstration projects</p> <ul style="list-style-type: none"> • Cross-sectoral heat, gas, power modelling for optimal supply and demand balancing. • Customer participation by design. Models for new operational markets.
Target TRL	5-9
Funding Scheme	RIA and IA
Expected outcomes	<ul style="list-style-type: none"> • Digitalisation of energy networks. • Customer participation by design in energy networks. • Supporting the energy transition while maintaining the quality of service in the energy provision. • A large-scale demonstrator for the lighthouse use cases should demonstrate the feasibility of disruptive real time services.
Expected Impact	<ul style="list-style-type: none"> • Digitalisation of the energy network. • Digital flexible generation. • Articulation and involvement of the customer and end user in digitalisation of energy supply. • Integration of the heat and electricity grid at local level.
Additional Information	<p>In scope:</p> <ul style="list-style-type: none"> • End of End Value Chain Digital Use Cases specification; • Digital Plants, DER, TSO and DSO Networks (Digital twin); • Digital Smart Meters; • Digital Aggregation, ESCOs and Retail; • Digital Customer Services.
Possible partners	Utilities, DSO, TSO, knowledge institutes local communities
Proposal Duration	2017-2020
Estimated budget	24 M€



Topic 7	Design and Demonstration of Grid digitalisation
Main FOs	T15 - Market/grid operation integration
Supported FOs	T19 - Standardization, protocols for communication, and data D1 - Active Demand Response D10 - Smart Metering data processing and other big data applications D12 - New Planning approaches and tools T7 - Expert systems and tools: expert systems, decision-making support tools and advanced automatic control T9 - Enhanced ancillary services for network operation T11 - Demand response, tools for using DSR, load profile, EV impact
Specific Challenge	Identify which digital use cases may enable the vision of the grid of the future. Identify digital scenarios that will enable the energy transition maintaining the quality of service in the energy provision and addresses customer participation.
Content/Scope	<ul style="list-style-type: none"> • Data Science Models, Predictive Analytics Digital enablers • Intelligent power routing • Grid operator systems • Intelligent demand and response assets and appliances
Target TRL	5-8
Funding Scheme	RIA and IA
Expected outcomes	Proven and demonstrated technology
Expected Impact	<ul style="list-style-type: none"> • Significant economic benefits related to the digitalisation of the assets, customer services and overall system. • Enabling a full functioning of the next generation of the energy system across the value chain.
Possible partners	Utilities, DSO, knowledge institutes, equipment parties
Additional Information	Should be focusing on forward looking to explore the emerging services of the future that will change the way we operate and run the overall Smart Grids system
Proposal Duration	2017-2020
Estimated budget	24 M€

Topic 8	Digitalisation and Big Data, IOT and IIOT
Main FOs	T20 - New Technologies, Internet of Things T18 - Big Data Management
Supported FOs	D8 - Monitoring and control of LV network D9 - Automation and control of MV network D10 - Smart metering data processing and other big data applications
Specific challenges	Identification of possibilities, digital issues and market opportunities related to big data and IOT and the energy system



Content/Scope	<ul style="list-style-type: none"> • Development of the interface tools to intensify the IIoT (Industrial IoT) and the IoT to anticipate on markets and changes. • Big Data, IOT and IIOT, Blockchain, Exchange Platforms Digital enablers
Target TRL	5-9
Funding Scheme	RIA and IA
Expected outcomes	Understanding and development of technologies, related to Big data, IOT , IIOT and interfaces, enabling full functioning smart grid system
Expected Impact	<ul style="list-style-type: none"> • Significant economic benefits related to the digitalisation of the assets and customer services. • Enabling a full functioning Smart Grids system across the energy value chain.
Additional Information	It is about sensing in the grid in combination with IoT and IIoT. Identify which technologies may enable the vision of the grid of the future. Identify technologies that will enable the energy transition maintaining the quality of service in the energy provision.
Possible partners	Utilities, DSO, TSO, knowledge institutes
Proposal Duration	2017-2022
Estimated budget	20 M€

Topic 9	Cybersecurity of critical energy infrastructures
Main FOs	T21 - Cybersecurity D11 - Cybersecurity (system approach)
Supported FOs	T18 - Big Data Management
Specific Challenge	<ul style="list-style-type: none"> • NIS Directive will be active by May 2018 – implications on sharing of information across borders, across companies, defining many points of contact POC (Points of Contact). Support relevant parties in this picture. • Is processing in data centres with centralized processing power environmentally outweighing sensitivity concerns.
Content/Scope	<ul style="list-style-type: none"> • Safety interconnection to security concerns. • ECSO: State of the art & progress. • The progress of computer power and energy use. • Newfound cryptography solutions. • Quantum Processing as a game changer. • Sensitivity and priority of data categories. • Cost / Benefits methodologies. • Global database for best practices sharing. • Societal impact.
Target TRL	5-8
Funding Scheme	RIA and IA



Expected outcomes	Full functioning robust next generation of the energy system
Expected Impact	<ul style="list-style-type: none"> • Supporting the energy transition while maintaining the system secured and robust. • Significant economic benefits related to cybersecurity secured system against costly attacks. • Enabling a full functioning robust next generation of the energy system across the value chain. • A large scale demonstrator for “What if Scenarios” preventing against cyber-attacks.
Additional Information	<p>Identify cybersecurity risks, prevention solutions and how to make the overall infrastructure and services running on a robust secured platform.</p> <ul style="list-style-type: none"> • Evaluating current approaches for security. • Vision 2050: centralized => decentralized. • Analyse new technologies. • Identify security challenges in usage of data streams versus databases. <p>Should be focusing on forward looking to explore the emerging cybersecurity technologies of the future that will change the way we operate and run the overall Smart Grids system The Smart Grid Architecture Model (SGAM) should be used in the R&I activities to be carried out.</p>
Proposal Duration	2017-2020
Estimated budget	24 M€

3.3 INTEGRATED GRID WITH IMPROVED INTERFACES BETWEEN ENERGY SYSTEM COMPONENTS

3.3.1 SYNERGIES BETWEEN ELECTRICITY AND HEAT SYSTEMS

Topic 10	Coupling of electricity and thermal sectors
Main FOs	<p>D7 - Integration with other energy networks T14 - Interaction with non-electrical energy networks</p>
Supported FOs	<p>D3 - System integration of small DER D4 - System integration of medium DER D5 - Integration of storage in network management T10 - Increase the integration of storage in network management T11 - Demand response T16 – Business models D14 - Integration of flexible decentralised thermal power generation</p>
Specific Challenge	<p>Heating and cooling in buildings and industry accounts for half of the EU's energy consumption. A major part of this heating and cooling is generated with fossil fuels. While the transition towards a decarbonised electricity system is on a good track, further efforts are needed in the heating & cooling sector. Coupling the electricity and the thermal energy system is a way to reduce fossil fuel consumption in the thermal sector, even if the production of</p>



	<p>heat or cold from electricity means a downgrading of the theoretical energy value.</p> <p>The targeted coupling can be achieved through Combined Heat and Power plants, with and without thermal storage, district heating networks, electric heaters, and heat pumps. The technology development is however not the focus here as it is addressed by other initiatives.</p> <p>The coupling will provide additional flexibility, offers capacity to store excess renewable electricity production, optimize planning and enable the connected networks to be operated in a more efficient way.</p> <p>Challenges addressed here are:</p> <ul style="list-style-type: none">• The management and the efficient operation of these energy networks as an integrated system (methodology and tools allowing this coupling in both steady states and dynamic configuration);• The organisation of interactions between stakeholders (DSO, DH operators, energy suppliers, the networks owners and end users);• The development of market places for energy exchange (peer to peer exchange and concept of energy block chain, improvement of heat market, new job opportunities, extended concept of prosumer to multi energy-carriers, ...);• Associated business models, e.g. the response of the heat price is of importance and must be set in a dynamic heat market;• Regulatory issues.
Content/Scope	<p>This topic contains different aspects which need to be developed, improved and solved:</p> <ul style="list-style-type: none">• Technologies, as long as the development focus is on cross-sectoral integration and not covered by other calls:<ul style="list-style-type: none">○ New large-scale thermal storage techniques, for example phase changing materials or thermochemical solutions,○ Combined district heating and cooling systems together with heat pumps and thermal energy storage (e.g. in aquifers),○ Active components for heat and cold generation at high efficiency (e.g. heat pumps, absorption cooling) and different scales (residential, commercial, industrial).• Methodology and modelling tools for Energy Management:<ul style="list-style-type: none">○ Demonstration of synergies among different energy sectors reducing costs for integration,○ Control, optimization (including the dynamics of each energy network),○ Robustness of the interaction between district heating and electric grid,○ Energy information for optimal multi-scale energy flows,○ Measurement of improvements in robustness of the integrated system and economic balance.• Economics:<ul style="list-style-type: none">○ Improvement or further development of heat market,○ Integrated market design,○ Local energy markets,○ Business case investigation,○ Energy and Blockchain,



	<ul style="list-style-type: none"> ○ Regulatory aspects. ● Stakeholders: <ul style="list-style-type: none"> ○ Interaction mechanisms, ○ End user as multi energy prosumers. ● Case studies and system optimization depending on demand profile for thermal energy, presence of a district heating network. <p>When the above-mentioned R&I activities have been successfully completed, demonstration projects can be initiated.</p>
Target TRL	5-8
Funding Scheme	RIA and IA, because the topic contains preliminary research and then demonstration.
Expected outcomes	Demonstration and objective measurements of the benefits of integration of electricity and heat networks.
Expected Impact	<ul style="list-style-type: none"> ● Increase in the amount of sustainably generated heat. ● Integration of the heat and electricity grid at local level. ● Reduction of costs for the final user of energy networks. ● Fostering of the mutual benefits of multi energy-carrier integration regarding energy savings, CO₂ emissions and economics.
Possible partners	Industry (e.g. power, heat, cold, chemical, food, paper), network operators, retailers and aggregators, ESCOs, generators, BRPs, equipment manufacturers, regulatory bodies, R&D institutes, end-user associations, organizations promoting standards.
Proposal Duration	3-4 years
Estimated Budget	20-30 M€ including 2 demonstration projects

Topic 11	Increase energy efficiency by utilising excess heat from other processes via heat networks and thermal storage
Main FOs	D7 - Integration with other energy networks T14 - Interaction with non-electrical energy networks
Supported FOs	-
Specific Challenge	There is currently more excess heat being wasted around Europe from power plants, industry, and waste incineration than is required to heat all buildings in Europe. However, only a small amount of this excess heat is currently being utilised (~10%), so the aim is to create projects that accelerate the use of excess heat and by doing so, replace the use of fossil fuels such as oil and natural gas.
Content/Scope	Excess heat is a bi-product from other sectors in the energy system. For example, the primary focus for most power plants is electricity generation, for industry it is their final product (e.g. cement, glass, and steel), and for waste incineration it is waste treatment. Excess heat is created indirectly by these sectors. To use it, two components are essential: heat networks and thermal storage. Projects in this topic should identify where it is possible to develop these heat networks and thermal storage facilities near sources of excess heat, for



	the energy system today and in the future. Geographical information systems can be used to map the demand near a potential excess heat source to establish if a heat network is technically and economically feasible. Similarly, advanced energy models should also be supported to calculate the capacity and operation of different thermal storage facilities on the new heat network, which will ensure that this excess heat can be absorbed by the heat network, rather than wasted.
Target TRL	4-6
Funding Scheme	RIA Projects
Expected outcomes	<ul style="list-style-type: none"> • Energy and carbon dioxide savings by replacing fossil fuels with excess and renewable heat • Improved security of supply due to a reduction of fossil fuel imports • Faster deployment of proven thermal storage technologies by identifying, designing, and promoting new projects around Europe
Possible partners	Industry, heat network operators, generators, equipment manufacturers, regulatory bodies, R&D institutes.
Expected Impact	<ul style="list-style-type: none"> • Increase the coupling between the heat sector and other sectors (electricity, industry, waste) • Increase overall efficiency of energy system by reducing waste heat • Decarbonize the heat sector
Additional information	This proposal is centred on the heat sector and the possible interfaces of this sector with others. The budget proposed will not be sufficient to build a heat network or thermal storage, so these projects will be desktop studies such as modelling, planning, knowledge-sharing, capacity-building.
Proposal Duration	3-4 years
Estimated Budget	10 M€

3.3.2 SYNERGIES BETWEEN ELECTRICITY AND GAS SYSTEMS

Topic 12	Coupling of electricity and gas sectors
Main FOs	<p>D7 - Integration with other energy networks</p> <p>T14 - Interaction with non-electrical energy networks</p>
Supported FOs	<p>T10 – Storage integration</p> <p>T11 – Demand response</p> <p>D3 - System integration of small DER</p> <p>D4 - System integration of medium DER</p>
Specific Challenge	In many countries, households are supplied with natural gas for heating, hot water, cooking, through connection with the local gas distribution network. However, it is more and more common in the development of new housing areas to plan without gas distribution network. This means that the existing gas network could become obsolete. In some places, parts of the gas network have already been dismantled with progressive dismantling steps foreseen in the medium-term. It would be very beneficial if a new purpose could be given to the existing network as part of a Power-to-gas solution



	<p>(methane, hydrogen, etc.). Upgraded biogas is one further example of renewable gas.</p> <p>In addition, Power-to-gas offers an additional coupling between energy sectors which has significant benefits in terms of increased renewable integration, flexibility options, optimized operation, long-term large-scale storage possibilities. The coupling and interaction of the 3 sectors power, heat and gas sectors is also targeted.</p> <p>A study of the possibilities for utilizing the existing gas network would show the benefits and problems associated with re-using this network for a Power-to-gas solution. The network would function as a large vessel and, as it does now, transport the fuel to houses.</p>
<p>Content/Scope</p>	<p>The following R&I activities should be addressed:</p> <ul style="list-style-type: none"> • Technical challenges and adjustments needed to be made to prepare an existing network from a gas delivery system to a component of a sustainable energy solution • Economic and capacity feasibility studies to transfer a gas transport and distribution network to a network with a different purpose • Market aspects for the gas network to become a key player in sector coupling • Analysis of the cross coupling electricity, gas and heat sector through extension and adaption of energy models to cover the gas sector in an appropriate way • Regulatory issues to overcome • Investigate the volume that can be stored and how fast the system can react to changes in energy demand. • Scope for cost reduction of Power-to-Gas on a per energy unit delivered basis. • How realistic is the goal for different types of cities to make a transition towards a society without the need for a supply of natural gas? How much energy needs to be available in alternative ways? Is such a gas network competing with district heating? How flexible should the energy demand be? • Small and medium scale demonstration projects using new or blended fuels.
<p>Target TRL</p>	<p>4-8</p>
<p>Funding Scheme</p>	<p>RIA and IA, because the topic contains preliminary research and a demonstration.</p>
<p>Expected outcomes</p>	<ul style="list-style-type: none"> • Estimation of market size, opportunities. • Economic and technical feasibility. • Business models. • Demonstration of this type of storage. Network operators can use the results to promote generation with storage, so the investments in the electricity grid can be reduced.
<p>Expected Impact</p>	<p>The proposals are expected to have impact on:</p> <ul style="list-style-type: none"> • A new alternative for the storage of electric energy; • A new purpose for existing gas transportation infrastructure. • Optimise the value from the existing gas transport and distribution networks.

	<ul style="list-style-type: none"> Optimising and saving costs of removal of the gas network.
Possible partners	Network operators, retailers and aggregators, ESCOs, generators, BRPs, storage equipment manufacturers, ICT solution providers, regulatory bodies, R&D institutes, end-users, organizations promoting standards, technical consultancy and operation algorithm developer
Proposal Duration	3-5 years
Estimated Budget	30 M€

3.3.3 SYNERGIES BETWEEN ELECTRICITY TRANSMISSION NETWORKS, GENERATION AND STORAGE

Topic 13	Smart interfaces between generation and transmission
Main FOs	T22 - Flexible thermal power generation
Supported FOs	T5 - Grid observability T7 - Expert systems and tools T8 - Reliability and resilience
Specific Challenge	<p>As the power generation landscape changes in the European energy systems, namely with the integration of variable RES, a further flexible operation of power generation is needed. This poses additional challenges in the interaction between generation and transmission networks calling for smarter interfaces between them.</p> <p>Flexible thermal power generation needs to further support transmission networks and system operators in meeting increasingly demanding requirements to ensure grid stability and security of supply with higher levels of RES in line with EU sustainability targets.</p>
Content/Scope	The main focus will be on enabling energy systems to integrate higher shares of renewable generation backed by more flexible thermal power generation. The target is to improve existing and develop new technologies to leverage greater flexibility from thermal power generation units to support and better interact with transmission networks.
Target TRL	5-7
Funding Scheme	RIA and IA
Expected outcomes	Faster response from thermal turbines; shorter ramping time (up and down); lower technical minimum power; optimisation of thermal inertia.
Expected Impact	<ul style="list-style-type: none"> Improved flexibility from thermal power generation and variable renewable energy (pitch control -wind power-, hybrid systems combined with energy (e.g. batteries) storage, etc.) Smarter interface between generation and transmission networks in coping with grid stability and security of supply Development of new decision-making support tools
Possible partners	Thermal generation companies, utilities, TSOs, turbine manufacturers.



Proposal Duration	2018-2020
Estimated Budget	7 M€

Topic 14	Improve RES and demand forecasting and optimal capacity operation
Main FOs	T12 - RES forecast
Supported FOs	<p>D1 – Active demand response D2 – Energy efficiency from integration of smart homes and buildings D3 - System integration of small DER D4 - System integration of medium DER T7 - Expert systems and tools T10 - Storage integration T11 - Demand response T13 - Flexible grid use T15 - Market-grid integration</p>
Specific Challenge	<p>The use of forecasting tools addresses the challenge of uncertainty in RES power generation. Forecast RES production with a high level of accuracy is key for the system optimisation in terms of its integration. They are usually divided into day ahead (DA) forecasting and hour-ahead (intra-day) forecasting, which differ from the perspective of accuracy, and applicability. In general, with the current penetration of RES, day-ahead schedules are applicable, while intra-day forecasts are currently of smaller economic value. However, in a scenario with increasing RES penetration and the expected accuracy improvement of intra-day compared to DA forecasts substantial new opportunities will likely materialize.</p> <p>Depending on data availability, prediction models can either be fitted to historical data or be based on manufacturer specifications. For very short-term forecasts, stochastic learning techniques without exogenous input have been proven very competitive in accuracy and relatively easy to setup. However, there is still a high potential lying in the inclusion of relevant exogenous data, as well as data from other meteorological databases, which could significantly increase accuracy and forecasting skill, thus contributing to increase RES availability and their contribution to a flexible energy network system.</p> <p>Improvements can be achieved applying generation forecasting models based on neural networks algorithms and utilising hybrid approaches that combine weather forecasts, local ad-hoc models, historical data, and real time measurements.</p> <p>Nonetheless, to perform a better balancing between supply and demand forecasting the demand is also crucial, especially in a context where new consumption profiles will be shaped in the future with the advent of new loads such as EVs, residential battery-based storage systems, etc. Demand response will also play a relevant role in the future, introducing variability in demand behaviour. Therefore efficient forecast of demand (and residual loads) accounting for the new loads and the demand-response activities of</p>



	new market players need to be tackled.
Content/Scope	<ul style="list-style-type: none"> To improve forecasting accuracy, new ensemble models considering individual forecasting models for power generation and meteorological conditions should be developed. Forecasting methods should include both linear models and nonlinear models. Moreover, the integration of the new forecasting tool with grid management tools, such as adaptive plan controllers, should be explored to improve the control and management of the grid. Improve RES forecast accuracy by testing hybrid approaches that combine weather forecasting, local ad-hoc models, historical data, and on-line measurement. Develop and demonstrate methods for dynamic capacity management and reserve allocation that support system operations with large amounts of RES integration. Estimate secondary/tertiary power reserves against RES forecast accuracy/error. Improve RES forecast accuracy by developing probabilistic methods.
Target TRL	5-8
Funding Scheme	RIA/IA
Expected outcomes	<ul style="list-style-type: none"> More accurate forecasting tools New casting techniques and cloud evolution and satellite data information should be implemented in the advanced forecasting tools Demonstration of innovative tools and techniques for dynamic capacity management and reserve allocation Analysis of scalability and replicability potential of the selected solutions
Expected Impact	<ul style="list-style-type: none"> To decrease the standard deviation of forecast errors w.r.t. the state of the art More efficient balancing market decreasing the costs for the whole energy system Increase the RES penetration in electricity system without affecting the reliability standards
Possible partners	TSOs, DSOs, RES generators, technology providers, Research institutes.
Reference projects	GARPUR
Proposal Duration	2019-2021
Estimated Budget	15 M€

Topic 15	Multiservice storage applications to enable innovative synergies between system operators and market players
Main Functional Objectives	T6 - Grid Controllability T10 - Storage integration, use of storage services
Supported	T8 - Reliability and resilience



Functional Objectives	<p>T9 - Enhanced ancillary services T13 - Flexible grid use T16 – Business models D3 – System integration of small DER D4 – System integration of medium DER D5 – Integration of storage in network management</p>
Specific Challenge	<p>Storage facilities in transmission systems is a promising solution for advanced grid services implementation as well as an effective way to increase system flexibility and decrease the requirements of back-up conventional energy while ensuring the supply. They are also crucial to integrate renewable electricity.</p> <p>Storage is also a key factor for new market players to manage balance responsibility and to access the Ancillary Service Market with innovative resources.</p> <p>Therefore, the investigation of models for a multiservice usage of single or aggregated energy storage system can increase the value for both the whole System and market players.</p>
Content/Scope	<p>Activities should focus on storage integration in the electric system that aim to valorise the multi services offered by storage facilities, including network requirements and energy market parameters. There are technical issues to overcome and many economic, regulatory, market and environmental aspects must be addressed. The goal is: (i) to provide a significant flexibility to TSOs that will have the possibility to exploit innovative ancillary services and higher availability of resources and (ii) the development of new business models related to dispatching services provision for electrical market operators.</p>
Target TRL	5-8
Funding Scheme	RIA/IA
Expected Outcomes	<ul style="list-style-type: none"> • Scenarios related to storage penetration identified. • An exhaustive analysis of possible services obtainable with storage technologies, including the most effective and profitable combinations among services, conducted. • Aging models definitions for several technologies according to the operating conditions and required regulation services. • Definition of communication tools, platforms and devices for increased observability/controllability of the resources and measurement acquisition. • Virtual storage implementation: technological and regulatory conditions. • Recommendations for a new regulatory framework and market design that enable recognition of the full value of storage, technologically neutral in order to allow the most cost-effective way solutions to emerge
Expected Impact	<ul style="list-style-type: none"> • Broader penetration of storage in electrical systems. • Impact of the cloud-storage model on power system management. • Reduced demand for network enforcement • New opportunities for extended installation of RES on subordinate



	<p>network levels</p> <ul style="list-style-type: none"> • Provision of ancillary services to the grid
Additional Information	<ul style="list-style-type: none"> • Pilot demonstration of highly responsive power and energy storage integrated at both transmission (HV) and distribution levels (MV, LV) to show potentials for balancing, congestion management, ancillary services and new system services. • Tools and platform for operation that enable to mutualize the flexibilities offered by storage facilities and those offered by other resources
Possible partners	DSOs, TSOs, utilities and manufacturers (storage, power electronics, ICTs, etc.) as well as academia (technological centres & universities)
Proposal Duration	2017-2022
Estimated budget	35 M€

3.3.4 SYNERGIES BETWEEN ELECTRICITY DISTRIBUTION NETWORKS AND STORAGE

Topic 16	Increased control and observability of MV and LV networks in presence of DER, EV and storage systems
Main FOs	<p>D5 – Integration of storage in network management D9 – Automation and control of MV networks D8 – Monitoring and control of LV networks</p>
Supported FOs	<p>D3 – System integration of small DER D4 – System integration of medium DER T5 – Grid observability</p>
Specific Challenge	<p>Increasing integration in the MV and LV networks of new generation technologies based on renewables, storage systems, EVs and smart loads is modifying the operation of the network. As a consequence, new challenges related to power quality, bidirectional power flows, energy balancing at local level, congestion issues, etc., arise.</p> <p>Storage systems can support the improvement of control at MV and LV levels impacting the quality of service as well as the integration of distributed renewable energy sources. A deeper analysis of the appropriate conditions to exploit the possibilities brought by storage in the grid needs to be performed. Smart automated solutions integrated in the dispatching systems need to be tested. The developed systems should be able to utilize also other types of controllable resources taking into account the different properties of different types of resources i.e. should not concentrate solely on possibilities of storage but have a holistic view on system operation.</p>
Content/Scope	<p>Proposals should focus on developing and demonstrating methodologies/tools to increase the control and observability by the relevant system operators of MV and LV networks integrating smart technologies in a large scale. Technical challenges regarding reverse power flows, network congestion and losses, power quality, etc. must be addressed through modelling and demonstration in real conditions to propose innovative solutions based on technologies (storage, EVs, power electronics with new</p>



	<p>functionalities, etc.) and/or new operational modes (control and scheduling algorithms and new topologies, increased network automation and observability, accurate forecasting, etc.). The demonstration cases must be real cases where grid quality of service needs improvement and historical data should be utilized to measure the improvement obtained by the developed functionalities.</p> <p>Special attention should be paid to the functionalities and capabilities brought by storage to cope with those technical challenges, such as frequency response, voltage stabilization, real-time intermittency smoothing, islanding, back up, etc. ICT infrastructures for information exchange between all the actors involved (DSOs, TSOs, aggregators or ESCOs, etc.) and the increase of observability and decision-making almost in real time must be included as part of the solutions and/or new operation strategies must also be proposed. A challenge would be to define the level of aggregation and periodicity needed.</p> <p>New roles for DSOs and the rest of relevant players of the system must be identified; the interaction between the actors will need to be defined; improvement obtained for the final users, for the grid control (quality of service) and the economic impact of the solutions demonstrated must be measured; and recommendations for new regulatory and market frameworks must be proposed to quantify the added value of the systems through appropriate economic evaluation.</p>
Target TRL	4-8
Funding Scheme	RIA and IA
Expected outcomes	<ul style="list-style-type: none"> • Methodologies/tools to increase the control and observability • Modelling and demonstration of new operational strategies in presence of intermittent sources • Identification of new roles for DSOs and the rest of relevant market actors
Expected Impact	<ul style="list-style-type: none"> • Projects in this topic will contribute to integrate more renewables at the distribution level for security of supply in a regulatory framework with well-defined roles for DSOs and new and existing (i.e. TSOs) stakeholders. The increased control and observability of the MV and LV networks will result in higher network efficiency and lower costs, while maintaining the security of the system. • The main expected outcomes are methodologies/tools to control and operate MV and LV networks and associated market structures including new stakeholders. The development effort should pay special attention on optimal utilization of storage in network management but should take also other controllable resources into account. New developments regarding hardware and software (protection systems, power electronics, etc.) are also envisaged. • Demonstrate economic feasibility of the solution.
Possible partners	DSOs, TSOs, utilities and other energy sector stakeholders (ESCOs, aggregators, etc.), technology developers and system providers (storage, power electronics, ICTs, etc.) as well as academia (technological centres & universities).



Proposal Duration	3-5 years depending on the scope
Estimated Budget	40 M€ Up to 20 M€ (IA projects) and 6 M€ (RIA projects)

Topic 17	Integrated management of MV and LV networks based on DER
Main FOs	D8 – Monitoring and control of LV network D9 – Automation and control of MV network D3 – DSO integration of small DER D4 – System integration of medium DER D5 – Integration of storage in network management
Supported FOs	D7 – Integration with other energy networks T13 – Flexible grid use
Specific Challenge	<p>The massive and ever increasing penetration of intermittent and distributed generation will impact the operations of both MV and LV networks, mainly by causing voltage profile problems and other issues associated with reverse power flows and local congestions.</p> <p>Since the MV and LV networks are coupled, control decisions should therefore be made taking the needs of both MV and LV networks into account. Network management methods that are able to increase the hosting capacity for DER with reduced total costs should be developed. The methods should be scalable to enable, on the one hand, the utilization of the increasing amount of measurement data and controllable resources and, on the other hand, be easily pluggable as a part of the current DSO systems to facilitate real network deployment. The developed network management methods should utilize all available controllable resources (distributed generation, controllable loads, energy storage) in an optimal way taking into account their different characteristics.</p> <p>In addition to developing novel methods for network management, new methods for network planning need to be developed in order to: 1) facilitate network operation; 2) evaluate the long term economic implications compared to alternative network management methods; 3) enable the potential benefits of increased flexibility to be realised (for example, deferring or avoiding network reinforcements). New roles of different actors (DSOs, TSOs etc.) also need to be studied.</p>
Content/Scope	<p>Innovative planning and operations including but not limited to the SCADA and DMS functionalities involving both the MV and LV grid will help DSOs improve the network capacity to integrate DER in an optimized way. The developed methods should aim beyond the integration of mature DER technologies and solutions should target the integration of next generation of DER currently under development, the integration of prosumers equipped with small DER, as well as analysing (simulations and/or demos) storage as an integrated asset in micro-grids and virtual power plants (VPPs) to provide services at the MV/LV network level. All types of active resources should be taken into account, including e.g. distributed generation, controllable loads, electric vehicles and storage systems (including also hybrid storage systems).</p> <p>Management tools and/or methodologies and schemes to control and</p>



	operate micro-grids and virtual power plants (VPPs) in the MV/LV networks must be developed with DSOs integrating new business cases and new stakeholders' participation (prosumers, aggregators, ESCOs, TSOs, etc.) in energy and flexibility markets. New roles for DSOs should be analysed in a single market framework.
Target TRL	4-8
Funding Scheme	Mainly IA but depending on the scope, RIA could also fit.
Expected outcomes	Main features expected are: management and monitoring tools for LV and MV networks taking into account also emerging micro-grids and VPPs, CBA tools for determining the benefit of utilizing active network management methods and recommendations and/or guidelines for regulatory framework and market design.
Expected Impact	<ul style="list-style-type: none"> • MV/LV network operation will be improved and the hosting capacity for distributed generation will increase. • Resilience: the integrated MV-LV management and the contribution of DER to system services will improve the resilience of the electricity networks by offering more degrees of freedom to DSOs when operating the distribution grid close to its physical limits. • Market: Recommendations on market rules and mechanisms for provision of ancillary services provided through the MV and LV networks. • Expected outcomes are the management (control) tools for distribution network operation by the DSOs, CBA tools for quantifying the added value of the new management tools and recommendations for new market schemes including new stakeholders.
Possible partners	DSOs, TSOs, utilities and other energy sector stakeholders (ESCOs, aggregators, etc.), technologies developers and systems providers (storage, power electronics, ICTs, etc.) as well as academia (technological centres & universities).
Proposal Duration	3-5 years
Additional information	The Smart Grid Architecture Model (SGAM) should be used in the R&I activities to be carried out.
Estimated Budget	40 M€ Up to 20 M€ per project (IA), up to 6 M€ per project (RIA). Several projects of different technologies complementing each other are envisaged.

3.3.5 COUPLING BETWEEN FLEXIBLE GENERATION AND STORAGE

Topic 18	Integration of storage in thermal generation for increased flexibility
Main FOs	T22 - Flexible thermal power generation D14 - Integration of flexible decentralised thermal power generation
Supported FOs	T10 - Storage integration, use of storage services D1 - Active demand response D5 - Integration of storage in network management



<p>Specific Challenge</p>	<p>With a growing share of renewable power, especially when having priority access to the grid, thermal power plants must increasingly shift their role from providing base-load power to providing fluctuating back-up power to meet unpredictable and short-notice demand peaks. The most efficient generation using CHP is also challenged when the need of electricity and heat do not match, therefore reducing CHP application. Using excess renewable energy at times of low demand through the integration of storage – be it electrical, thermal, mechanical or chemical – into thermal power plants can help optimise their operations. Decoupling heat and electricity generation will allow for a more efficient energy use via flexibilisation of demand response to the different consumers. The search of energy symbiosis with intensive industries will be complementary to storage. Thermal power plants, as part of the solution, must operate more flexibly than originally designed to satisfy the grid stability and flexibility requirements.</p>
<p>Content/Scope</p>	<p>Activities need to focus on the design and demonstration of the integration of energy storage systems within thermal power plants to increase flexibility and efficiency and/or absorption of over-production from renewable sources, progressing solutions that already have reached at least TRL 3 to demonstration levels of both technology and prototypes. Solutions should be applicable to both existing and new plants. Examples of how to address this challenge may be:</p> <ul style="list-style-type: none"> • Realisation of integrated thermal energy storage prototype version for operational investigations and implementation in overall plant design/configuration. • Cycle CO₂ for synthetic fuel generation. • Integration of power-to-fuel technologies into power plants, e.g. generation and storage of renewable fuels (e.g. hydrogen, methane and other chemicals) and adaptation of power plant design. • Identification and development of chemical generation and storage concepts which can be integrated into power plant environment (e.g. safety aspects). • Development of prototypes for complete process chain using compressed air, batteries, or other kinds of mechanical or electrical energy storage to increase the flexibility of thermal power plants. • Interlink fuel generation to other sectors by exploiting symbiosis between transport and power sector
<p>Target TRL</p>	<p>4-7</p>
<p>Funding Scheme</p>	<p>RIA and IA</p>
<p>Expected Outcomes</p>	<p>Pilot demonstration of highly responsive and cost-effective energy storage integrated with thermal power plants to show the potential for increased grid stability and flexibility. The projects could also provide recommendations for improving the regulatory framework to ensure the efficient exploitation of integrated storage possibilities.</p>
<p>Expected Impact</p>	<p>Innovative integrated energy storage has a game changing role to play in transforming network management and flexibility to meet the new demands. Optimisation of operation of thermal power generation through storage, for instance by bridging between stop and restart of a generator</p>



	or by providing the needed time to achieve optimal ramp-up/-down, will allow fast load changes to be met. This option can also contribute to increasing efficiency of thermal power plants – including fuel efficiency, which will be translated into a reduction of CO ₂ emissions of the overall energy system. Integration of storage will enable the de-coupling of generation of power and heat in CHP plants.
Possible partners	The projects should be performed in a relevant environment and connected to the electric grid. So thermal power plant operators and technology suppliers should naturally work together in pilot application. For cross-sector energy storage (Power to Fuel or Power to Chemical) additional partners from chemical, petrochemical industry can be beneficial. For Power to X to Power application (Battery, LAES, CAES, re-combustion of synthetic fuels, etc.) cooperation with grid operators and storage operators can be supportive for the project implementation.
Proposal Duration	3 - 5 years
Estimated Budget	EUR 40 - 60 million for one big demo project or multiple pilot projects

Topic 19	Towards fully dispatchable RES: variable RES with storage
Main FOs	T10 - Storage integration D5 - Integration of storage in network management
Supported FOs	D3 - System integration of small DER D4 - System integration of medium DER T9 – Enhanced ancillary services for network operation T12 – Improved RES forecasting and optimal capacity operation T13 - Flexible grid use T15 - Market grid integration
Specific Challenge	In a future scenario with large penetration of variable renewables, like solar and wind generation, electric grid stability becomes an issue. A wide range of projects have proposed solutions for frequency issues and in some cases these solutions are already in operation. These projects often rely on storage to respond to grid frequency deviations, and in some European countries frequency response market exists. Hybrid systems, where storage units are localized at the generation plant, would make the fluctuating renewable resources a dispatchable, predictable, flexible generation asset, able to provide any generation and network system requirements. A mixed solution based on the use of high efficiency conversion systems, will also contribute in parallel to design a full green solution, minimising the losses in the use of the renewable energy sources for supplying the power system. The major challenge here is to combine storage with a fluctuating renewable asset (e.g. wind, solar, marine) with a positive business case, having more responsibility in dispatching energy and participating in ancillary services markets. This type of solutions is technically feasible, but markets need to be found or developed, regulatory issues need to be solved and control of the storage systems needs to be worked out.



Content/Scope	<p>The associated R&I activities are:</p> <ul style="list-style-type: none">• Evaluation of hybrid solutions for an optimal combination of RES with energy storage to manage RES uncertainty, from both the technical and economic perspective.• Demonstration on different scales, for example with a single wind turbine and with large wind parks, for short-term (some seconds) and for long-term (days /weeks/months) storage. Small domestic solar generation is out of the scope of this topic because the influence on the grid is limited and research has already been performed.• Finding and developing markets, business models and profit solutions for the combination of renewables and storage. Optimizing self-consumption, peak-load reduction resource aggregation, curtailment management, grid-code compliance, real-time intermittency smoothing and load shifting capabilities are available opportunities.• Algorithm development for defined sizes and applications of storage with renewables. The algorithm must be able to decide when to store or discharge energy depending on electrical grid status, resource forecast, and market conditions.
Target TRL	4-7
Funding Scheme	RIA and IA.
Expected outcomes	<p>The outcome of the project is the demonstration of the local coupling of storage with solar and/or wind energy assets with the broader energy system, enabling renewable energy to be fully flexible and ensuring the sustainability of the future energy system. DSOs and TSOs could use the results to promote storage, so that the investments in the electricity grid can be reduced.</p>
Expected impact	<ul style="list-style-type: none">• Maximize profits for the owners of assets (wind power and PV plants) and decrease the frequency deviations in the grid because of overproduction of electricity at certain moments of the day.• By stabilizing the electricity production from solar and wind assets the amount of backup power provided by fossil sources can be reduced; this will lead to a decrease of CO₂ emissions.• The R&I activities to be carried out should help lower the cost of storage integration through the promotion of standards and the economies of scale.
Additional Information	<p>Demonstration project(s), which show the business cases, the delivered power to the grid (including the efficiency of the algorithms).</p>
Possible partners	<p>Network operators, retailers and aggregators, generators, BRPs, storage equipment manufacturers, ICT solution providers, regulatory bodies, R&D institutes, end-users, organizations promoting standards, technical consultancy and operation algorithm developer.</p>
Proposal Duration	3-5 years
Estimated budget	30 M€



Topic 20	Managing system flexibility with a smart balance between intermittent and dispatchable solar generation
Main FOs	D4 - System integration of medium DER T22 - Flexible thermal power generation
Supported FOs	T12 – Improved RES forecasting and optimal capacity operation T10 - Storage integration, use of storage services D14 - Integration of flexible decentralised thermal power generation
Specific Challenge	<p>Concentrating Solar Power with Thermal Storage (CSP/STE) plants have proven their capability to generate dispatchable electricity in a very predictable schedule but their LCOE is still higher than other non-dispatchable renewables, such as PV and wind. In the case of PV plants, their availability is restricted to the sunshine hours, which makes it difficult for the grid operators to currently handle shares higher than 30% of generation of non dispatchable sources (on average). One way to both increase the share of renewables contribution and, additionally, reduce the LCOE of CSP/STE plants, is by means of hybrid (PV-STE + Thermal Storage) plants, which are deemed to be a feasible solution to increase dispatchability and the number of yearly operation hours thanks to thermal storage solutions. Projects should also demonstrate the intrinsic value of STE (Solar Thermal Electricity) plants in a specific regional system and show that non-intermittent, though less deployed renewable energy sources can deliver flexible energy thus preventing both, restrictions in the operation of other renewable power plants and additional costs for balancing. To this end, a higher flexibility of the CSP/STE power block would be needed as well as the development of a suitable PV/CSP interface and smarter electronic and control devices.</p>
Content/Scope	<p>The project will develop and validate design tools and operation strategies for a hybrid solar power plant (PV/STE + Storage) for a specific location (commercially existing STE plant) to achieve the functionalities of a non-intermittent power generator. In addition, it shall demonstrate the performance and benefits of STE within a given regional market and based on a specific generation mix by estimating the specific threshold of RES penetration in the system and their relative performance.</p> <p>The proposed tasks are:</p> <ul style="list-style-type: none"> - To develop methods to optimize the costs through dimensioning and operation strategy of the different plant blocks for a specific location. - To enhance the existing solar resource forecasting techniques, decreasing the forecast time window to effectively manage the energy extraction from the storage tanks to achieve the production schedule. - To study the operation data from at least one real-life hybrid plant to validate the proposed strategies. - To set up two case studies (adjacent countries /non-adjacent countries) to assess the penetration level of intermittent renewables based on the criteria “energy market value” and “typical solar plant production profiles”. - To assess the value of storage from STE plants per energy value (contribute to day-ahead energy equilibrium), ancillary services (contribute to intra-day power equilibrium) and dynamic frequency response (contribute to system inertia), providing dispatchability to



	<p>currently non-dispatchable renewable sources, like PV.</p> <ul style="list-style-type: none"> - To assess the complementarity of flexible and non-flexible generation technologies. - To demonstrate the validity of existing cooperation mechanism (listed in the New Clean Energy Package 2017 proposals).
Target TRL	5-7
Funding Scheme	RIA
Expected outcomes	Driving the energy transition to achieve a more balanced ratio between dispatchable and non-dispatchable renewable technologies to reach the penetration objectives
Expected Impact	The delivery of design criteria and operation strategies to optimize the dispatchability of hybrid solar power plants (STE/PV) with thermal storage so they can be considered as baseload generators in the grid.
Possible partners	Network operators, CSP and PV generators, CSP, PV and storage equipment manufacturers, ICT solution providers, Research centres, etc.
Proposal Duration	4 years
Estimated Budget	18 - 25 M€

3.4 IMPROVED COMPONENTS OF THE ENERGY SYSTEM

3.4.1 ELECTRICITY NETWORKS

3.4.1.1 JOINT TRANSMISSION AND DISTRIBUTION ISSUES

Topic 21	Smart asset management using innovative hardware and software technologies
Main FOs	<p>T2 - Smart asset management T18 - Big data management D13 - Asset management</p>
Supported FOs	T10 - New technologies, Internet of things
Specific Challenge	<p>Assets are aging, are operated to the limit of the capabilities, and are exposed to new operating conditions and patterns than what they were originally designed for. Under these circumstances, maintenance becomes relevant to ensure the proper performance of the existing assets. The challenge is to improve each link (4) in the value chain: 1) Beginning to review the lifetime prediction modelling based on extended parameters, 2) going throughout the definition of new and reliable monitoring systems, 3) specifying and developing new and, relevant heuristics and approximations for integrated, realistic and workable frameworks. And finally 4) demonstrating how these approaches can be implemented, scaled up and replicated at effective cost so that the expected benefits are realised.</p>
Content/Scope	<ul style="list-style-type: none"> • To integrate new sensors and new equipment condition monitoring approaches based on distributed technologies and through ICT technologies.



	<ul style="list-style-type: none"> • To extract the maximum information out of the data using advanced analytics and Big Data technologies. • To implement robotics for automated condition monitoring or diagnostic systems for incipient problem detection, as well as to intervene in hostile environments and avoid the need for human maintenance. • Use of drones and best working practices for network monitoring, live line maintenance. • Inventory solutions based on digital approaches, tablets, wearables and other elements to support asset management and intelligent management. • Maintenance solutions based on wearables, robotics, drones and other elements that reduce the number and duration of the interruptions of the service, the risk of live-works on the electricity installations, and the time needed for repairs. • To develop a system approach to define maintenance and replacement budgets and to coordinate the resulting activities of replacement and repairing with System expansion and System operation, by using suitable probabilistic reliability management approaches. • To use Internet of Things (IoT) concepts • Explicit modelling of asset management to consider the impact of grid design on future reliability and socio-economic performances (including expected market surpluses and costs of service interruptions). A probabilistic approach coherent over all time frames needs to be deployed.
Target TRL	6-8
Funding Scheme	Preferably EC and national funding, if available
Expected outcomes	<ul style="list-style-type: none"> • New approaches for extending lifetime of existing power components based on improved monitoring, measurements and models to determine their health and remaining lifetime in the future • Novel approaches for managing critical assets based on probabilistic risk assessment and optimization of maintenance planning
Expected Impact	<ul style="list-style-type: none"> • Improvement of asset management and maintenance. • Safer grid operation and reduction of accidents in maintenance. • Better use of available data. • Optimized costs for asset maintenance activities while increasing the life time of existing assets.
Possible partners	TSOs, DSOs, Service and equipment providers, Safety organisations.
Reference projects	GARPUR
Proposal Duration	2019-2022
Estimated Budget	14 M€



3.4.1.2 TRANSMISSION NETWORKS

Topic 22	Smart and flexible grid design and planning with probabilistic reliability assessments in uncertain framework
Main FOs	T1 - Optimal grid planning and design
Supported FOs	T4 - Environmental challenges and stakeholders T10 - Storage integration T13 - Flexible grid use
Specific Challenge	<ul style="list-style-type: none"> To upgrade and smarten power system planning for flexible transmission systems in order to maintain the same quality of supply in a more uncertain and more interconnected system. The new planning methodologies, based on probabilistic approach for climate patterns, and RES generation, shall involve variable RES and DER, demand response, storage and the interface with other energy and transport/mobility networks; they will also duly consider new technologies in the transmission network, the evolution of European energy market and new business models. To upgrade methods for adequacy planning due to the increased variability.
Content/Scope	<ul style="list-style-type: none"> To develop grid planning tools and metrics within an uncertainty framework, i.e. using probabilistic approach, no regret options and risk analysis/risk management perspective. To develop power system planning methods and criteria that optimize transmission grid flexibility combining electricity market analysis, production capacities, demand response capacities and infrastructure, storage and environmental constraints, both at the transmission and distribution levels. To identify system-wide stress situations through multi-risk analysis; to include an adequacy assessment including the decommissioning of thermal plants, the coupling with other energy networks, specially gas and mobility but also heat and cold. To identify cost-effective solutions avoiding over-investments, over-reserve capacity and sub-optimal solutions.
Target TRL	4-8
Funding Scheme	RIA
Expected outcomes	<ul style="list-style-type: none"> Grid planning scenarios and methods within an uncertainty framework (i.e. using probabilistic approach) by anticipation of time and relevance of future power grid users Grid planning tools and metrics able to better exploit flexibility from power grid users Novel planning methodologies considering: <ul style="list-style-type: none"> Future decommissioning of conventional power plants Modelling of demand-side response Use of flow-based market methodology
Expected Impact	<ul style="list-style-type: none"> Increased system flexibility, stability and security achieved also through improved system design.



	<ul style="list-style-type: none"> • Stronger transmission backbone for enabling the electricity market and facilitate power transactions, develop business opportunities. • Smarter adequacy assessments including different energy system's components supportive interactions. • Send correct and sufficient investment signals to the stakeholders responsible of building the infrastructures, including political leaders.
Possible partners	TSOs, DSOs, universities and research centres, software developers, experts in the field of system operation, planning and markets.
Proposal Duration	2019– 2024
Estimated Budget	20 M€

Topic 23	Public acceptance and stakeholders participation
Main FOs	T4 - Environmental challenges and stakeholders
Supported FOs	T1 - Optimal grid planning T2 - Smart asset management T3 - New materials and technologies T14 - Interaction with non-electrical energy networks T20 - Internet of Things
Specific Challenge	The realisation of a secure, sustainable and competitive European System requires the development of an underlying electricity infrastructure. There is a need to improve public acceptance and stakeholder's participation when planning new infrastructure, while also reducing environmental impact.
Content/Scope	Increase communication campaigns, develop social impact studies and increase the involvement of local and territorial bodies in the early stage of planning of the infrastructure.
Target TRL	5-7
Funding Scheme	IA
Expected outcomes	<ul style="list-style-type: none"> • Guidelines on best practices to manage projects from the very beginning to minimise their negative effects and promote stakeholder engagement and acceptance (for each situation / kind of project or asset). • Guidelines for public debate • Guidelines for streamlined environmental authorisation process, harmonized at EU level • Harmonization of authorization procedures for cross-border projects
Expected Impact	<p>Minimize the number of projects/assets that could not be realised for public acceptance issues.</p> <p>Among those ones that can be realised:</p> <ul style="list-style-type: none"> • Adoption of technical solutions which bring higher return into socio-economical terms on a global scope (not linked to specific social groups); • Reduction of the realisation time of the selected technical solutions.



Possible partners	NGOs, citizens associations, local communities; communication companies, TSOs and DSOs
Reference projects	Best Grid, Inspire grid, Realised grid, Gridtech
Proposal Duration	2019-2026
Estimated Budget	5 M€

Topic 24	ICT systems and data handling for control chain
Main FOs	T18 - Big data management T19 - Standardization, protocols for communication, and data exchange T5 - Grid observability
Supported Functional Objectives	T6 - Grid controllability T21 - Cyber-security
Specific Challenge	<p>The future power system will become much more complex and unpredictable compared to the current situation. Generation facilities will be smaller and aggregated. Demand facilities will become more flexible and respond to price changes. The intensive application of converter based power electronics in production and demand facilities will continue, e.g. electrical vehicles and storage units will be widely spread. The power system will be facing a complex mix of AC and DC interconnectors in order to control the flow direction of active power. The active power flows will no longer only be from high voltage level to low voltage level, as production facilities will be connected at the lower voltage levels. The stability predictability and stability margins will be challenged so that more advanced control strategies are requested. The information exchange needs will increase and the needs for IT applications to transmit, secure and process huge amount of information will be a major driver.</p> <p>Currently there is a critical need for cost efficient ICT infrastructure for data monitoring, control and storage of real-time information, such as efficient data warehouse solutions, data mining tools to analyse huge amount of real time and processed data, advanced application to determine preventive control actions for further automation of the system controls in order to keep the stability of the grid.</p> <p>Cyber-security is a major issue and hence it needs to be dealt with on a strategic level to ensure reliable and secure operation of the power system.</p>
Content/Scope	<ul style="list-style-type: none"> • Development of requirements and specifications for the future reliable and secure supportive ICT infrastructure; • Data monitoring and analysis for the control chain actions and automation of basic as well as higher level control strategies needed by the TSOs; • Definition and analysis of use cases implementing upcoming technologies; • Assessment of new business opportunities for different stakeholders; • Assess cyber-security requirements and specification to feed in future



	standards.
Target TRL	6-8
Funding Scheme	RIA
Expected Outcomes	<ul style="list-style-type: none"> • Cost effective solutions for a modern ICT infrastructure. • Advanced algorithms for implementing decision support applications to grid control centres. • Solutions of implementing automatic control and balancing of the grid system.
Expected Impact	<ul style="list-style-type: none"> • Improved system performance by increasing stability, predictability and controllability based on improvements in observability, service ability and user interfaces. • Preservation and improvement of present high level of security of supply. • Pushing for a higher level of operator training and initial skills. • Requesting more simulation tools to support a higher level of automation in grid management.
Possible Partners	TSOs, DSOs, IT providers, Data management companies
Additional Information	A huge amount of conference articles illustrates the needs for improvements and the trends in tools and infrastructure solutions. This topic is in line with the R&I activities addressed in topic 9.
Proposal Duration	2018-2022
Estimated budget	10 M€

Topic 25	Enhanced grid observability and assessment of pan European system stability
Main FOs	T5 - Grid observability T6 - Grid controllability
Supported FOs	T7- Expert systems and tools T13 - Flexible grid use
Specific Challenge	Increasing renewable generation and cross-border interconnection significantly influences the dynamics of the grid and poses serious challenges to the stability of power transmission networks (ride-through capability, resilience); risks of cascading events, network separation, voltage and/or frequency collapse require new containment measures and protection criteria. Moreover, these risks are no longer local phenomena, rather they must be handled across countries and jurisdictions.
Content/Scope	<ul style="list-style-type: none"> • To assess with a new uniform methodology the operational limits of the integrated power system. • To develop a methodology that exploits the real-time grid monitoring information for system planning, operation and decision support.



	<ul style="list-style-type: none"> Assess at demo level the capacity of devices and technologies like DLR, FACTS, WAMS, and PMU to enable operate the transmission system closer to its physical limits with high reliability and defer new infrastructure while absorbing more RES power. To explore the role and impact of existing and emerging ICT for grid observability and controllability. In this matter, the use of co-simulation techniques able to simulate ICT impact in power systems is key to ensure a reliable digitalisation of pan European system. To realise and demonstrate improved real-time grid monitoring based on smart control logics, also making optimal use of smart asset management technologies. To involve other grid operators, and particularly DSOs, in the above scope.
Target TRL	3-7
Funding Scheme	RIA
Expected outcomes	<ul style="list-style-type: none"> Upgraded methodology and use cases for setting up and exploiting real-time monitoring schemes. Specification and deployment of real-time monitoring devices and improvement of grid performance, DSO information exchange and interconnector optimization. Novel advanced tools and means, including market-based instruments, for secure operation of the future power system with close to 100 % inverter-based RES: <ul style="list-style-type: none"> For optimal system planning and asset utilisation closer to stability limits For fast real-time and continuous prediction of dynamic stability margins For fast real-time determination of preventive mechanisms for continuous dynamic stability For optimal and market-based activation of cross-border dynamic stability services Recommendations and roadmap for utilisation of real-time dynamic stability monitoring and control mechanisms.
Expected Impact	<ul style="list-style-type: none"> To develop replicable methodologies and use-cases for setting up and exploiting real-time monitoring schemes. Promote the observability of the network in an ever increasing uncertain boundary. Maintain European leadership in state-of-the-art technology like WAMS, PMU. Reduce the costs of new infrastructures and boost coordination with the DSOs and cross border actors.
Possible partners	TSOs, DSOs, Technology providers, Universities & Research centres and a demo site.
Reference projects	PEGASE, MIGRATE, TransFlex
Proposal Duration	2017-2021



Estimated Budget	30 M€
Topic 26	Cross-border use of ancillary and flexibility services
Main FOs	T9 - Enhanced ancillary services
Supported FOs	T1- Optimal grid design T13 - Flexible grid use
Specific Challenge	TSOs are responsible for the secure and reliable operation of their systems, as well as for the interconnections with other transmission systems. Moreover, energy storage technologies as well as different types of flexibility products can deal with the intermittency of the increasing share of RES but also could lead to new market services, even to new business models. The target for a single European wholesale electricity market requires the integration of new technologies in the power system but also requires the best exploitation of all available resources: in this sense the cross-border use of ancillary and flexibility services plays a key role in the most cost effective way since they increase system's stability ensuring at the same time a smoother transition to the large penetration of RES. The coordination at cross-border level is of crucial importance towards this target.
Content/Scope	Exchange of flexibility resources/ancillary services with the focus on specific service elements and the respective business models, control mechanisms, responsibilities and cross-border capacity treatment procedures.
Target TRL	5-8
Funding Scheme	RIA
Expected outcomes	<ul style="list-style-type: none"> • New market-design proposal, prototypes, and simulation tools. • Demonstration of effective solutions for cross-border exchange of ancillary services
Expected Impact	<ul style="list-style-type: none"> • Increasing amount of ancillary services and flexibility resources made available across the interconnected borders and market zones. • Improved control of renewable energy sources in the conditions of reduced control reserves from coal-fired and gas-fired production units. • Improved security of operation derived from energy efficient solutions. • Improved stability and increase of the reliability of the system. • Better exploitation of resources between countries with different types of energy mix. • Avoided or deferred investments into new assets providing flexible services (e.g. storage).
Possible partners	Research institutions, solution and IT providers, retailers and TSOs.
Proposal Duration	2017-2020
Estimated Budget	10 M€



Topic 27		Demand response engineering
Main Objectives	Functional Objectives	T11 - Demand response T19 - Standardisation and data exchange
Supported Functional Objectives		T5 - Grid observability T6 - Grid Controllability T9 - Enhanced ancillary services for network operation T13 - Flexible grid use
Specific Challenge		<ul style="list-style-type: none"> Services provided by large size prosumers and by medium-small prosumers connected to the HV, MV and LV grid; advanced management of selected industrial clients based on system benefits analysis. Adequacy assessment and expansion planning considering demand-side resources.
Content/Scope		To demonstrate the feasibility of Demand Side Response (DSR) to provide innovative ancillary services to power systems. The topic aims at analysing different operation schemes, providing scenario analysis on the feasibility and penetration of DSR techniques and defining case studies for real-environment implementation. Demonstration of concepts is key to extend the state of art on this subject.
Target TRL		5-7
Funding Scheme		RIA
Expected outcomes		<ul style="list-style-type: none"> An exhaustive identification of the novel services that can be provided with DSR, like FCR, FRR, and congestion management; for each specific function, a comparison with traditional resources should be evaluated. Model for customer behaviours and baseline forecasting. Analysis of key-factors and guidelines for DSR implementation: consumer and producer aggregators, advanced dispatching tools, imbalance regulation, and new market schemes. Definition of communication tools, platforms, and devices for increased observability and controllability of resources and measurement acquisitions.
Expected Impact		<ul style="list-style-type: none"> An increase of the available resources for ancillary services provision, an improvement of the system flexibility and a higher security. The possibility for electrical consumers to exploit economic advantages associated to the service provision. A higher interaction between TSOs and DSOs, optimizing the available flexibility resources in the system.
Possible partners		Research centres or academic institutions may be involved in scenario identification; big industrial consumer may contribute to demonstrators' implementation. Process integrators, electrical distributors and external suppliers may also be considered.
Proposal Duration		2017-2022
Estimated budget		4 M€



Topic 28	Coordination and Measurement of System's flexibility mechanisms
Main FOs	T13 - Flexible grid use T16 - Business models C4 - Economic (T15, T16, T17) D12 - Planning and asset management
Supported FOs	T1 - Optimal grid design T4 - Environmental challenges & Stakeholders C2 – Power system flexibility (T6, T7, T8) C1 – Modernisation of the network (T3, T4) C4 – Flexible grid design (T17) D5 – Integration of storage in network management
Specific Challenge	<p>To achieve the ambitious energy and climate targets of the EU for the energy sector by 2030, high levels of intermittent renewable generation will be integrated in the network which will introduce challenges on different time scales in balancing generation and supply in the near and coming future. Energy storage technologies and other forms of flexibility products, such as cross-border interconnectors, electric vehicles, DR, interfaces between energy networks, can deal with the intermittency that renewable integration brings. The role, cost, potential and value of these flexibility products that can be offered in multiple markets is, however, still uncertain. So far, existing models that value flexibility either focus on comparing different solutions on a short term, focus on a single (mostly batteries) type of technology or look at revenue streams based on electricity tariffs. The main challenge remaining is how to value flexibility products:</p> <ul style="list-style-type: none"> • across different markets (day ahead, intra-day and balancing) and through participation on different time-scales (seconds, minutes, day/night, weeks, seasonal), • under uncertainty (i) of intermittent resources, (ii) of the need for (location and time specific) balancing services and (iii) of present-day as well as future system development and climate scenario's (iv) of demand-side response. <p>Modelling and forecasting the total value of flexibility products under uncertainty under future scenario's is important for both utilities, network operators and storage owners. Adequate valuation of flexibility under uncertainty, namely, ensures the development of flexibility products and assesses the contribution, potential, type and size of flexibility products to help relieve network congestions and provide necessary short, medium and long-term balancing products for expected high levels of renewable generation within the EU-wide network. Furthermore, appropriate bidding strategies are required to realise this value across these multiple timescales and markets.</p>
Content/Scope	<p>This topic focusses on assessing the need, market size and requirements of different kinds of flexibility products and their valuation in the energy market under uncertainty.</p> <ul style="list-style-type: none"> • Developing (forecasting) models to determine overall market value of flexibility products, considering uncertainty and risks related to



	<p>resources, future scenarios and technical limitations. The models should include co-optimisation between different markets under different present-day and future scenario's, and consider various revenue streams for spot, intra-day and balancing markets. Models should also have an energy system perspective (i.e. include all sectors); have small resolution (i.e. hourly, so it can account for the variability of renewables); and be able to consider the different technologies that can provide flexibility (including a real time monitoring methodology that exploits dynamic line rating (DLR) and sensors, etc.).</p> <ul style="list-style-type: none"> • The tools can be used for scenario analysis and forecasting under uncertainty over different time scales to advice decision-making (including bidding strategies) in the role, operational behaviour, congestion and balancing potential. • Moreover develop market mechanisms that integrate new storage technologies and DLR to boost the capacity of the network and incentivize for new flexibility services by stakeholders, prosumers, TSO/DSO coordination and cross-border trading.
Target TRL	3-8
Funding Scheme	RIA
Expected outcomes	<ul style="list-style-type: none"> • Expected project outputs are models that can value (need, market size and requirements) flexibility products and their added values and competitiveness. • Promoting real-time monitoring and DLR improves the utilization of existing grid infrastructure and defers conventional investment in new OHLs.
Expected Impact	<ul style="list-style-type: none"> • The integration of large-scale flexibility components in the market will enable cost-effective balancing of renewable energy generation and supports the path towards "100%" renewable-based energy systems. • Improve location-specific congestion management and network balancing. • Reduce uncertainty and enable investment in and increase the uptake and participation of flexibility products in the electricity market adding important balancing products at EU level. • Methodology and use cases for setting up and exploiting real-time monitoring schemes for increased flexibility; respective pilot project to implement the method. • Methodology for market based mechanisms to remunerate flexibility services and promote new business opportunities for storage integration and optimal investments in the network; simulation tools and use-cases, lab demo.
Possible partners	Network operators, retailers and aggregators, generators, BRPs, equipment manufacturers, ICT solution providers, regulatory bodies, R&D institutes, end-user associations, organizations promoting standards.
Reference projects	evolvDSO, Optimate, SEETSOC
Proposal Duration	2017-2022



Estimated Budget 10 M€

3.4.1.3 DISTRIBUTION NETWORKS

Topic 29	Innovative approach for grid operation
Main FOs	D10 - Smart metering data processing and other big data applications
Supported FOs	-
Specific Challenge	Smart meter roll-out is ongoing in many European countries. It will result in the collection of large amounts of data that can enhance grid operation on one side and will necessitate large adaptation of information systems on the other side. In addition to this, electronics industry offers innovative solutions that can improve grid operation optimising network flexibility and facilitating the integration of renewable generation on distribution networks.
Content/Scope	R&I activities to be developed and demonstrated are: <ul style="list-style-type: none"> • Development and demonstration of new algorithms integrated into the operation systems to improve the quality of service. • ICT architectures and processes in order to cope with increasing amounts of data. • Electronic solutions to support smart grid operation. • To develop grid planning tools and metrics within an uncertainty framework, i.e. using probabilistic approach, no regret options and risk analysis/risk management perspective.
Target TRL	5-8
Funding Scheme	RIA and IA
Expected outcomes	<ul style="list-style-type: none"> • Demonstration of benefits (operational, planning) thanks to improved data analytics (AI, machine learning...) and data collection and processing • Tools to adequately process big data and related architecture • Execution of pilot projects with field test environments including the implementation of platforms in real life trials • Increased distribution system flexibility, stability and security achieved also through improved system design.
Expected Impact	<ul style="list-style-type: none"> • Smarter and safer grid operation. • Better use of available data. • Enabling the digitalisation of the networks.
Possible partners	DSOs, ICT providers
Proposal Duration	3 years
Estimated Budget	40 M€

Topic 30	EV/PHEV charging infrastructure and integration in smart energy systems
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Main FOs	D6 - Infrastructure to host EV/PHEV – Electrification of transport D5 - Integration of storage in network management
Supported FOs	D3 - System integration of small DER D8 - Monitoring and control of LV network D9 - Automation and control of MV network
Specific Challenge	Charging infrastructures are not deployed at the pace required by the EV/PHEV market evolution and mobility needs (e.g. within cities, long distance travels...). The lack of appropriate infrastructures are probably slowing down the electrification of transport other reasons being e.g. inappropriate business models. Solutions to foster the roll out of EVs are needed. First, it is necessary to have a number of real fast-charging solutions (less than 10 minutes) spread appropriately in the routes and cities to allow the user to be less dependent of the battery capacities. The impact of the charging systems on the grid operation and development needs to be minimised through intelligent solutions. Alternative and innovative proposals should be established to make the charging infrastructures develop and appropriated business models as well as regulatory changes should be proposed to make this infrastructure deployment possible.
Content/Scope	Several aspects should be studied: <ul style="list-style-type: none"> • Development and demonstration of very-fast charging solutions (< 10 min) integrated in smart management systems to minimize the impact on the grid operation. • Development of systems to plan and simulate the cities and routes for optimized deployment of infrastructures. • Innovative uses of reduced and economic storage solutions integrated in the critical points to make possible a faster charging with reduced impact on the grids.
Target TRL	5-8
Funding Scheme	RIA and IA; Funding schemes could also be articulated around the European Green Vehicle Initiative.
Expected outcomes	<ul style="list-style-type: none"> • Demonstration of a real-life trial proving the performance of the developed smart management systems into the grid. • Optimized planning by taking into account constraints and needs from users, grid operators and charging point operators. • New business models, regulatory recommendations and proposals of incentives to accelerate the deployment of infrastructures • Harmonized tools to manage the interactions between different stakeholders involved in the EV chain (users, grid operators, charging point operators, energy vendors)
Expected Impact	<ul style="list-style-type: none"> • Faster deployment of zero-emission transports. • Cleaner air in the cities and a healthy place to live in for citizens. • A new business model that allows accelerating the implementation of EVs in the cities and routes.
Possible partners	<ul style="list-style-type: none"> • Main stakeholders: DSOs, charging point operators, energy vendors, technology providers (storage, RES interfaces, EV manufacturers...), storage operators. • Other stakeholders: road/city utilities, large users (e.g. public or private



	companies with corporate EV fleets), owners of commercial / logistic chains (gasoline stations, supermarkets, fleet managers).
Proposal Duration	3 years
Estimated Budget	30 M€

3.4.2 STORAGE UNITS

Topic 31	Advanced energy storage technologies for energy and power applications
Main FOs	D5 - Integration of storage in network management T10 - Storage integration
Supported FOs	T17 - Flexible market design D3 - System integration of small DER D4 - System integration of medium DER
Specific Challenge	<p>The energy transition will have a tremendous impact on balancing electricity supply and demand in the future, rising also concerns on the stability and reliability of the system. The increase on the supply side of intermittent renewable energy sources, like wind and solar, will result in larger fluctuations in demand and supply. This will result in an increased need of intraday, intraweek and seasonal modulation. Network operators will need different grid balancing services to guarantee real-time balancing of generation and demand and different technologies of storage will be crucial to support system stability.</p> <p>Energy storage technologies for energy and power applications, such as balancing, seem to be still far to meet technical and economic targets. For example, while current available storage technologies are proving their effectiveness in fast balancing services, there is still a strong need to optimise and demonstrate storage technologies able to cover the intraweek and seasonal modulation needs. Moreover the total cost of storage systems, including all the subsystem components, installation, and integration costs need to be cost competitive with other non-storage options available to electric utilities.</p> <p>The principal challenges to focus on are:</p> <ul style="list-style-type: none"> • Identify use cases of storage in the various services it may provide to the grid, individually and in multiple or “stacked” services, where a single storage system has the potential to capture several revenue streams to achieve economic viability. • Cost competitive energy storage technology - Achievement of this goal requires attention to factors such as life-cycle cost and performance (round-trip efficiency, energy density, cycle life, degradation, etc.) for energy storage technology as deployed. Long-term success requires both cost reduction and the capacity to realize revenue for all grid services storage provides. • Validated reliability and safety - Validation of the safety, reliability, and performance of energy storage is essential for user confidence. • Equitable regulatory environment - Value propositions for long-term grid



	storage depend on reducing institutional and regulatory hurdles to levels comparable with those of other grid resources.
Content/Scope	<p>The following R&I activities should be addressed:</p> <ul style="list-style-type: none"> • Materials and systems engineering research to resolve key technology cost and performance challenges of known and emerging storage technologies (including manufacturing). In particular, proposals should aim at new storage technologies with a significant improvement on the reduction of capital cost, increasing system efficiency and extension of cycle life over the state of art performance. • Validation of the safety, reliability, and performance through programs focused on degradation and failure mechanisms and their mitigation, and accelerated life testing • Collaborative field trials and demonstrations enabling accumulation of experience and evaluation of performance – especially for enhanced grid resilience. <p>Proposers could address this topic following a 3-step approach⁴: grid operators propose a real-life scenario for an energy storage solution ii) R&D institutes and industry develop the energy storage solution iii) The whole consortium test and evaluate the technological viability and reliability from a technical and economical point of view.</p>
Target TRL	4-8
Funding Scheme	RIA or IA.
Expected outcomes	<ul style="list-style-type: none"> • New and advanced energy storage systems (including storage technology, power electronics, etc.) able to provide multiple services to the power grid at competitive cost tested in relevant environment • Recommendations to remove regulatory and market design hurdles to ensure a level playing field for energy storage solutions in the power sector
Expected Impact	<ul style="list-style-type: none"> • Energy storage should be a broadly deployable asset for decarbonising the European economy and the energy transition. • Long-term energy storage should be available to industry and regulators as an effective option to resolve issues of grid resiliency and reliability. • Demonstrations in an operational environment.
Possible partners	R&D institutes, equipment manufacturers, utilities, network operators, generators, regulatory bodies.
Proposal Duration	4 years
Estimated Budget	30 M€

Topic 32⁵	Coupling of electricity and transport networks
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⁴ Although all items need to be addressed, the first item (new materials and components) are out of the scope of the ETIP SNET and should be funded through a different programme.

⁵ This topic is also related to the coupling between the electricity network and the transport sector, which is not a network as of today. It is therefore classified as a storage topic since V2G applications could be one of the major source of coupling.



Main FOs	D6 - Infrastructure to host EV/PHEV – Electrification of transport
Supported FOs	D2 - Energy Efficiency from integration with smart homes and buildings D5 - Integration of storage in network management
Specific Challenge	<p>The energy transition will have a tremendous impact on balancing supply and demand in the future. The increase on the supply side of intermittent renewable energy sources like wind and solar, the rapidly growing electric vehicle (EV) market, the use of electricity for clean fuel production (i.e. hydrogen electrolyzers) and the electrification of houses on the demand side will result in larger fluctuations in demand and supply. This will put pressure on the reliability of the grid. At the same time, it can be the solution to the balancing problem if managed intelligently. Grid operators will need different grid balancing services to compensate for the loss of conventional power plants and inertia.</p> <p>Energy storage can be used to provide grid services. Integration of the grid with EVs and clean fuel production at consumer or at distribution level seems to be needed to unlock this potential for grid operators.</p> <p>Hydrogen refuelling stations are part of the scope, as fuel cell electric vehicles (FCEV) are electric vehicles participating to the electrification of transport. Their dynamic behaviour is however quite different from battery electric vehicles and can provide other benefits to integrated energy systems.</p> <p>It is expected that after 2025 a major part of new vehicles will be electric, some countries like Norway even think about a complete ban of petrol powered cars after 2025. To unlock the EV potential for grid operators (V2G applications), new market and business models, regulations and product specifications need to be developed and tested in pilots.</p>
Content/Scope	<p>This topic focusses on assessing the need for integrating the electricity sector with the mobility sector.</p> <ul style="list-style-type: none"> • Cross-sectoral integration. • Developing of fast-grid operating services for aggregated units. • Developing new market and business models. • Demonstrations for e-mobility and vehicle-to-grid to test market and business models.
Target TRL	TRL 4-6
Funding Scheme	RIA or IA.
Expected outcomes	<ul style="list-style-type: none"> • EV services to the power grid are identified and characterised (including feasibility analysis, potential benefits, business models, potential market size, etc.) • V2G technologies (including bi-directional chargers) are developed and tested at relevant environment • Solutions enabling integrated management of a fleet of EVs – Virtual (dynamic) Storage Power Plant (VSPP) – providing services of the power grid are developed
Expected Impact	<ul style="list-style-type: none"> • Improve market conditions for aggregated balancing products across the EU. • New market and business models that are beneficial for multiple sectors.



	<ul style="list-style-type: none"> • Demonstrations in an operational environment.
Possible partners	Network operators, automotive companies, consumer organizations, housing stakeholders, retailers, aggregators, generators, BRPs, equipment manufacturers, ICT solution providers, regulatory bodies, R&D institutes, end-user associations, organizations promoting standards, consulting firms.
Proposal Duration	3-4 years
Estimated Budget	20 M€ including demonstration projects

3.4.3 GENERATION UNITS

3.4.3.1 THERMAL GENERATION

Topic 33	Developing the next generation of flexible thermal power generation
Main FOs	T22 - Flexible thermal power generation D14 - Integration of flexible decentralised thermal power generation
Supported FOs	-
Specific Challenge	<p>The increase of variable renewable sources has a direct impact on thermal power generation units at both transmission and distribution levels, which need to become more flexible to adapt their operation to a system with a rapidly changing demand for flexibility, while maintaining highest efficiency and lowest emission levels.</p> <p>Flexibility, is understood as the ability to complement the variable renewable generation quickly and at lowest emission level, ensuring the necessary reliable electricity and heat/cold supply (start-up/shut down rate, ramp-rate and reduced minimum load). This also includes fuel flexibility (capacity to switch between renewable-based fuel as well as conventional, including different rates of mixtures, reacting to availabilities of carbon-neutral synthetic fuels like synthetic methanol or methane, hydrogen, ammonia, biomass derived from waste, etc.).</p> <p>Addressing efficiency at the same time as flexibility, is a no-regret option, also resulting in a reduced fuel consumption.</p> <p>Maintenance and repair costs reduction with an increased cyclic operation and cost-effective solutions for existing and new capacities needs to be developed.</p>
Content/Scope	<p>Focus is on progressing solutions that already reached at least TRL 3 in order to offer the highest potential. Activities should concentrate on increasing the operational flexibility of thermal power generation units installed both at transmission and distribution levels – including fuel flexibility – together with measures increasing efficiency at full and part-load, at lowest greenhouse gas emissions.</p> <p>Solutions shall either contribute to new concepts for thermal power plants or enable existing capacities to improve their performance.</p> <p>Examples of how to address this challenge may be:</p>



	<ul style="list-style-type: none"> • Component improvements both at centralised and distributed level, which contribute to the optimisation and flexibilisation of the power generation units, including flexible operation of CHP and CCHP; • Improvements in operational flexibility (start-up/shut down rate, ramp-rate and reduced minimum load); • Improvement of overall performance (efficiency and emissions) at partial loads; • Robustness of thermal power generation units for increased cycling (materials, lifetime estimation maintenance and repair costs reduction); • Modifications to allow multi-fuel operation (e.g. fuel handling, feeding, combustion and environmental controls); • Novel monitoring and control tools and advanced modelling tools for better operation management and decisional support; • Connecting components together for improved and different applications as well as better system integration between energy carriers, networks and sectors at the generation unit level. • Optimisation of the integration of distributed power generation technologies in the smart grids (e.g. power electronics).
Target TRL	3-7
Funding Scheme	RIA and IA
Expected outcomes	Technology developments and/or pilot or plant demonstration of thermal power plant flexibility improvement achieved by candidate hardware adaptations and DCS system up-grades. Projects could also provide recommendations on best practices for new plans in the future.
Expected Impact	Achieving a robust, sustainable, flexible, integrated and efficient thermal power generation fleet, able to cope with the systems challenges due an increasing share of variable renewable energy sources and deliver better system-wide flexibility in a cost-effective way.
Possible partners	Component/technology providers, utilities, research centres and universities, etc.
Additional Information	Technology developments ensuring that thermal power generation – including existing capacities – is ready to optimally use the gases generated under novel Power-to-Gas concepts, where alternative “green” fuels are provided. In the case of rehabilitation projects, funding is limited to the “innovative”, “first-of its kind” part.
Proposal Duration	3 years
Estimated Budget	65 M€

Topic 34	Adaptation and improvement of technologies to novel Power-to-Gas and Power-to-Liquid concepts
Main FOs	T22 - Flexible thermal power generation D14 - Integration of flexible decentralised thermal power generation
Supported FOs	-



<p>Specific challenge</p>	<p>Power-to-Gas and Power-to-Liquid are promising solutions for the future using excess energy at the times of low demand and providing a “green” fuel that can be used in flexible thermal power plant systems. More broadly, synthetic liquid or gaseous fuels can be used in this way to support the synergies between transport and power sector by cycling the CO₂ and therefore making CO₂ neutral fuels available. Power-to-Gas offers the best available seasonal storage option in the future energy system via the existing gas grid.</p> <p>Furthermore, hydrogen can be used as feedstock to produce methane combined to CO₂, increasing the direct impact in the current natural gas system.</p> <p>The main challenges are the adaptation of the combustion to the new gases as well as the cost-efficiency of the full process chain.</p> <p>Hydrogen leads to increased reactivity, which is manifested as increased flame speed and reduced ignition delay time. Both mechanisms affect the combustion performance in generation, which results in an increased risk of flashback in lean premixed combustion systems, leading to damaged hardware and elevated NOx emissions.</p> <p>Synthetic “low carbon fuels” like methanol or ammonia have low heating values and different emission behaviours than standard fuels. Combustion systems must be adopted to these characteristics as well as the environmental system.</p>
<p>Content/Scope</p>	<p>The overall purpose is to combine the advantages of efficient and dispatchable thermal power plant technology and the availability of a large storage solution like the existing gas grid with the ability of generating carbon-neutral “green” gas based on hydrogen. Specific to hydrogen combustion, the main objective is to avoid flashback and auto-ignition while keeping emissions low at high share of hydrogen in fuel. This includes:</p> <ul style="list-style-type: none"> • Development of combustion systems for stable combustion of gas mixtures with hydrogen progressively adapting the technology to 100% hydrogen; • Extension of low emission load range, improving flexible load operation; • Improved design of combustor liners to reduce exposure of surfaces to high-temperature gas and radiation; • Development of a safe hydrogen fuel starting methodology.
<p>Target TRL</p>	<p>3-6</p>
<p>Funding Scheme</p>	<p>RIA</p>
<p>Expected outcomes</p>	<p>Improvement of combustion systems and development of a safe hydrogen fuel starting methodology.</p>
<p>Expected Impact</p>	<p>Technology developments ensuring that thermal power generation – including existing capacities – is ready to optimally use the gases generated under novel Power-to-Gas concepts, where alternative “green” fuels are provided.</p> <p>Demonstrate the cost-efficient use of “green” gases and fluids for power and heat generation based on known thermal power generation.</p>
<p>Possible partners</p>	<p>Component/technology providers, utilities, research centres and universities, etc.</p>



Additional Information	-
Proposal Duration	3 years
Estimated Budget	10 M€

3.4.3.2 VARIABLE RES

Topic 35	Improved flexibility and service capabilities of RES to provide the necessary ancillary services in scenarios with very large penetration of renewables
Main FOs	T6 - Grid controllability: frequency and voltage stability, power quality, synthetic inertia T13 - Flexible Grid use
Supported FOs	T9 - Enhanced ancillary services for network operation D3 - System Integration of small DER D4 - System Integration of medium DER
Specific Challenge	<p>The share of renewable energy sources (RES) in the European energy system is expected to grow considerably per the objectives set by the EU and the Energy Roadmap 2050 considers that RES share in electricity consumption could reach up to 97% by 2050. Despite its obvious benefits the increasing penetration of RES also brings a higher level of variability and uncertainty. To ensure system security in real time, system operators make use of ancillary services dealing with unforeseen events like generation outages, load forecast errors and demand fluctuations.</p> <p>This scenario of future networks with very large presence of renewable generators will be duly driven by Power Electronics converters (responsible to connect to the grid the elements of this future networks: RES, Storage, HVDC, etc.) instead of synchronous generation. It is crucial to define several issues, such as: how the control vectors will assure the full control of this future network, which support functions will be considered as ancillary service, how can they be provided and who will be responsible for them. These new services should be involved in a very broad spectrum of applications like switched-mode power supplies, active power filters, electrical-machine-motion-control, flexible transmission systems, etc., to ensure the flexibility, integrity, stability and power quality. Renewable generators must be confronted to this new control paradigm and must be designed in consequence to be able to offer all these new services and to be adapted to the new stability criteria and monitoring parameters to ensure a flexible and safe operation with near 100% of RES.</p>
Content/Scope	<ul style="list-style-type: none"> • The renewables generators must be improved and adapted for the provision of ancillary services, such as frequency and voltage support, black start, islanding operation capacity and reserve functions, etc. • These new design concepts and advance strategies to offer the necessary and requested new services to the grid must be identified and developed depending on the penetration level of RES. New control strategies and interaction with other support system like energy storage and manageable RES shall be developed to be able to provide



	<p>frequency support and reserves if needed.</p> <ul style="list-style-type: none"> • To ensure the adequate system flexibility and the provision of ancillary services as well as instability mitigation by RES, procedures and strategies should be defined and tested using a multi-agent framework. The proposed solution must include the identification of new indicators for defining the flexibility and stability criteria in those future scenarios with high RES penetration need to be defined to monitor the proposed solutions. • Identify and implement strategies for overcoming possible interactions between the different controls. • Investigate different energy mix configurations for ensuring the electrical system stability. • Develop grid protection functions in PEC, in order to provide additional information to protection relays, enhancing fault detection. • Implement communication protocols with storage systems in PEC support functions (measurements, protection, voltage and frequency) even if there is no renewable energy resource available.
Target TRL	3-6
Funding Scheme	RIA
Expected Outcomes	<ul style="list-style-type: none"> • New RES control strategies and interaction with other generation sources • Identification of RES ancillary services • New procedures ensuring the provision of ancillary services from RES as well as instability mitigation • New indicators with regards to flexibility and stability criteria within high RES penetration. • New communication protocols and support functions covering large RES generation scenario.
Expected Impact	Support the path towards a 100% RES electrical system with ancillary services provided by RES while ensuring the stability and reliability of the grid
Type of partners	RES operators, manufacturers, Innovation/R&D Technology centres and universities, TSOs and DSOs
Additional Information	3 to 5 projects to be financed.
Proposal Duration	3 years
Estimated Budget	25 -30 M€

Topic 36	Enhanced smart RES flexible solutions and control strategies for Power Electronic Converter (PEC) dominated grids
Main FOs	T6 - Grid controllability: frequency and voltage stability, power quality, synthetic inertia
Supported FOs	T1 - Optimal grid design T3 - New materials & technologies



	<p>T4 - Environmental challenges & Stakeholders T9 - Enhanced ancillary services for network operation T10 - Storage integration, use of storage services D3 - System Integration of Small DER D4 - System integration of medium DER D5 - Integration of storage in network management D8 - Monitoring and control of LV networks D9 - Automation and control of MV network</p>
Specific Challenge	<p>Nowadays, the grid control is mainly based on large-scale power plants with synchronous generators. However, the share of grid-connected Power Electronic Converters (PEC) generators is continuously increasing. In the future grid scenario of up to 100% shares of renewables, the active contribution of PEC based generation to the grid stability and to the security of power supply becomes necessary.</p> <p>Current strategies for the PEC generation are expected to be reconsidered for the future power supply scenarios to meet stable network operation conditions in case of fault scenarios, like for example system split or short circuits. Inverters behave currently in accordance with the connection requirements, but whether this contribution to the short-term stability is sufficient after the occurrence of a disturbance in the future power system, is uncertain.</p> <p>New RES generation must evolve to a novel concept of Renewable Flexible Modules (RFM) that integrates not only the PEC but also other elements such as the energy storage in single controllable units to become fully flexible structures. This evolution will become crucial to achieve a 100% RES share in the future system and their massive deployment in the next years.</p> <p>RFM is a new system approach constituted not only by new component design like last generation of converters but also by a novel architecture including additional elements that will improve the overall system performance and a full Generation Flexibility. The RFM development will benefit from the PEC controllability based on the novel communication capabilities and the new control functions to be included, which makes possible for the future RES systems to offer a very broad spectrum of applications and system services. The increasing penetration of RFM in the RES system Generation also poses a challenge to the grid operators, affecting issues such as power quality, dynamic behaviour of the system or the existing protection systems.</p> <p>To address this challenge, it is necessary to full develop the RFM concept that will incorporate also a new PEC architecture and performances, new control and management, protection and communication functions, which in addition will avoid extra equipment, thus reducing costs and increasing simplicity and reliability.</p> <p>Standards and grid codes lack details concerning testing procedures and quality assessment criteria for grid control/support functions from PEC based generators in the context of PEC dominated grids.</p>
Content/Scope	<ul style="list-style-type: none"> • Describe and address future system's needs in terms of control methods enabling the interconnected grid to be operated in a stable manner by inverter-based /RFM generation. • Identify the qualification and interaction criteria of smart inverters to



	<p>assure the compliance with the required network necessities.</p> <ul style="list-style-type: none"> • Identify and develop the concept of RFM, including their components, architecture, topology, and interoperability requirements. • Define the evolution and/or adaptation of the existing PEC (corresponding topologies and control systems) to contribute to the RFM expected behaviour assuring: power quality standards, efficiency criteria, power ratings and voltage levels allowable in transmission and/or distribution networks, with the final goal of contributing to increase the network capacity and flexibility. • Explore additional functions of the future RFMs should also be. The fact that PEC continuously receives information about voltages and frequency from the network could be better exploited (by embedding PMUs for example), resulting in an integration of the control and monitoring capabilities, avoiding extra costs of excessive equipment in the grid. • Integrate additional protection functions at RFM level: e.g. RFM to provide additional information to transmission and/or distribution networks protection relays so fault detection and management is enhanced. • Implement communication protocols and analyse the feasibility of including storage systems in the RFMs • Investigate the role of storage systems and different energy mix configurations concerning grid control and additional generation flexibility • Provide recommendations for the renewables grid integration roadmap. • Develop the appropriate testing environments and implement advanced testing procedures of PEC's and RFM's grid support/control functions • Describe service quality assessment criteria of aggregated units • Support the development of grid codes and standards
Target TRL	Up to 7
Funding Scheme	RIA and IA
Expected Outcomes	<ul style="list-style-type: none"> • Identification and definition of inverter-based / RFM generation control methods enabling the stable operation of the system • Definition and availability of a new generation of Renewable Flexible Modules (components, architecture, topology, and interoperability requirements), including potential storage functions. • Availability of the appropriate testing environments and procedures of PEC's and RFM's grid support/control functions. • Identification and definition of the service quality assessment criteria of aggregated units and codes and standards of these solutions.
Expected Impact	Ensuring that PEC generation and RFM contribute to the reliability, security and stability of power supply in the European interconnected system in times of increasing renewables.
Possible partners	RES operators, manufacturers, Innovation/R&D Technology Centres and Universities and TSO's/DSO's
Proposal Duration	4 years



Estimated Budget	EUR 40-45 M€; 4-6 projects
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3.4.3.3 HYDRO PLANTS

Topic 37	Refurbishment and upgrade of existing hydropower with the purpose of increased flexibility and expanded storage capacity
Main FOs	T9 - Enhanced ancillary services for network operation
Supported FOs	T6 - Grid controllability T10 - Storage integration T13 - Flexible grid use
Specific Challenge	Hydropower is a renewable and flexible generation source and storage option that is ready for use. However, most of today's European hydro system is not built for today's increasingly harsh operation conditions. Most of the European hydropower plants were built many years ago, and it will be necessary to upgrade these plants soon. This gives an additional incitement to start retrofitting current hydropower plants to meet flexibility requirements and/or provide large-scale storage services over sufficient time scales. Some of these reservoirs may contain the energy of 100 - 1 000 times the largest PHS reservoir. Retrofitting or reconstruction of such systems will raise other challenges than just improving current technology. Civil works, machinery, optimisation and adaption to markets and new operational regimes will raise a lot of new challenges for an existing system. But sometimes not only refurbishments of large schemes are facing hurdles due to complexity or size and shall be seen as "first-of its kind".
Content/Scope	<ul style="list-style-type: none"> • Medium and large-scale demonstration projects should focus on implementation of innovative methods and solutions needed to refurbish and upgrade hydropower plants to become more flexible and/or to handle large-scale storage for time scales from seconds to seasons. • Medium and large scale demonstration projects incorporating technical improvements as well as optimised planning tools and market models.
Target TRL	5-7
Funding Scheme	IA (Demo) projects)
Expected outcomes	<ul style="list-style-type: none"> • Tools and models to evaluate the benefits of rehabilitation and upgrade existing plants to future demands. • Proof of new generation and robust component designs for hydropower core components. • Proof of improved hydro ramp response, efficiency, operational and grid balancing capabilities to provide back-up power for renewable power generation.
Expected Impact	<ul style="list-style-type: none"> • Existing hydropower, developed further into more flexible power plants providing fast regulation, and to large-scale pumped storage plants with increased capacity. This will allow Europe to use existing hydro facilities to tackle the increased need for balancing power and flexibility. • Reduced demand for network reinforcement.



	<ul style="list-style-type: none"> • New opportunities for extended installation of RES on subordinate network levels.
Additional Information	Beside the improvement of hydro equipment, innovation in refurbishment of plants will also require technology like tunnel and shaft drilling, sea operation, dyke erection, powerhouse prefabrication, sealing technologies and bladder reservoirs. Consortia seeking to (re)construct such plants will therefore need to gather players able to tackle civil works, grid integration and public acceptance.
Possible partners	Component/technology providers, utilities, research centres and universities, etc.
Proposal Duration	3-4 years
Estimated budget	20-25 M€; 3-4 projects with different focus (only the “innovative”, “first-of its kind” part of the projects will be funded)

Topic 38	Environmental impact assessment of hydropower projects
Main FOs	T4 - Environmental challenges and stakeholders
Supported FOs	D12 - New planning approaches and tools T9 - Enhanced ancillary services for network operation T10 - Storage integration T6 - Grid controllability
Specific Challenge	New hydropower operations will lead to changes in the yearly, seasonal, and daily fluctuations in reservoir water levels, and may also affect downstream water bodies and fish population. But the extent to which they do affect the bodies, the habitats and fish populations is poorly understood; therefore the safe limits of impact may also be over-cautious or insufficiently cautious. The same applies to existing hydropower stations, when they shall change operation regimes with the aim of enhanced flexibility (e.g. hydro peaking): an enormous potential for flexibility could be utilized if “simple” environmental restrictions can be replaced by “smarter” ones.
Content/Scope	Tools (methods and models) for environmental impact assessments.
Target TRL	5-7
Funding Scheme	RIA / CSA
Expected outcomes	New guidance on the relevant quantities to measure and monitor when performing an EIA on hydropower projects and on safety limits.
Expected Impact	<ul style="list-style-type: none"> • Better utilization of hydro resources in sensitive areas by minimization of the number of projects/assets that could not be realized/installed as a consequence of for public acceptance issues. • Better utilization of flexibility options from existing plants by smarter compatibility with environmental restrictions.
Possible partners	Engineers, universities and research institutes (water ecology), operators, equipment manufacturers and NGOs
Proposal Duration	3-5 years



Estimated budget 2-3 M€

3.4.3.4 CROSS-CUTTING TOPIC

Topic 39	Digitalisation of flexible, dispatchable generation technologies
Main FOs	T7 - Expert systems and tools: expert systems, decision-making support tools and advanced automatic control
Supported FOs	D13 - Asset management T18 - Big data management T9 - Enhanced ancillary services for network operation
Specific Challenge	The availability, reliability and productivity of dispatchable renewable generation equipment shall be improved under increasingly harsh operating conditions by “digitalisation”. This comprises enhanced models and design methods, data management and data analytics from monitoring and diagnostic systems for predictive maintenance, and finally, feedback into design.
Content/Scope	The following four points are seen as the highest priorities in the field of digitalisation for research, innovation and application during the next 5 years, each of them requiring research on new analytics, methods and innovation of design methods as well as the operation and maintenance of hydro power plants. <ul style="list-style-type: none"> • Simulation and design systems for plant machine components (e.g. digital twin), including the electromechanical system during the development and design phase allow to achieve higher flexibility and to optimize operation. • Predictive maintenance making use of sensor signals, digital modelling and advanced analysis methods such as life time simulation and artificial intelligence. • Operation optimization based on data analytics, taking into account real-time signals as well as input data from various sources such as weather forecast, sediment flow and electricity market. • New operative process base on new algorithms and innovative methods (i.e. big data and artificial intelligence).
Target TRL	5-7
Funding Scheme	RIA / IA
Expected outcomes	<ul style="list-style-type: none"> • Simulation methods for all components (such as CFD, Finite Element Methods, etc.) should yield reliable lifetime predictions for any load. • Monitoring systems for optimised maintenance intervals shall reduce outage time by 10% (2020), (20% in 2025)
Expected Impact	<ul style="list-style-type: none"> • System integration of RES generation is supported by more flexible electromechanical and electronic equipment and intelligent operation and maintenance management. • Such improved equipment and intelligent operation and maintenance systems will support the system flexibility due to <ul style="list-style-type: none"> ◦ Better commercial performance and output of the power stations due to the joint optimization of multiple units considering



	<p>electricity market information;</p> <ul style="list-style-type: none">○ Higher efficiency and reliability of the equipment due to better modelling and due to feedback of operation experience into design;○ Higher reliability and lifetime of the equipment during operation due to early failure detection, monitoring of environmental conditions, reduced risk of unforeseen outages, and better design.
Additional Information	<p>Project shall involve many different actors from different parts of the value chain quite possibly from different countries. The optimisation of maintenance intervals is very complex and also requires the knowledge and experience of operators, combined with the core proprietary knowledge of equipment manufacturers. This shall be done for different types of generation technologies and power stations (e.g. storage, run-of-river, high/low heads in the case of hydropower). Four projects are necessary in the EU for hydro. The implementation of the development results in pilot applications is highly recommended and should be supported in order to ensure well targeted development with highest possible impact.</p>
Possible partners	<p>Component/technology providers, digital solutions providers, utilities, research centres and universities, etc.</p>
Proposal Duration	<p>5 years</p>
Estimated budget	<p>25 M€; 3-5 projects / 3-5 M€ each (does not include demonstrators)</p>



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