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**SET Plan Secretariat**



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### Energy Systems

(Increase the resilience, security, smartness of the energy system)

#### **Purpose of this document**

This document<sup>1</sup> is intended to progress the implementation of the actions contained in the SET-Plan Communication<sup>2</sup>, and specifically the actions concerned with the priority related to "Energy systems". It is part of a series of Issues Papers jointly prepared by the European Commission and discussed with the representatives of the EU Member States and countries part of the SET-Plan, working together in the SET-Plan Steering Group.

The Issues Papers are sent to stakeholders for comments/feed-back. They are meant to propose to stakeholders strategic targets/priorities in different areas of the energy sector. They will frame the discussions of the SET Plan Steering Group with the stakeholders within the action area "Energy Systems" and will be used to come to an agreement on targets/priorities.

Stakeholders are invited to take position on the proposed targets in accordance with the guidelines set out in the paper The SET Plan actions: implementation process and expected outcomes and submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by 08/01/2016 at the latest. All relevant documents and material are available on the SETIS website <https://setis.ec.europa.eu/>.

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<sup>1</sup> This document is a working document of the European Commission services for consultation and does not prejudice the final form of any future decisions by the Commission.

<sup>2</sup> "Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation" (C(2015)6317)

## Introduction

In the 2020 and 2030 climate-energy packages, the EU committed itself to lower greenhouse gas emissions by 20% by 2020 and 40% by 2030, with respect to 1990, and to reach a share of renewables of 20% by 2020 and at least 27% by 2030. Renewable shares may further increase to 40-60% by 2050.

In this framework, the electricity network has a central role to play. In 2013, 22%<sup>3</sup> of our final energy consumption is satisfied using electricity as energy carrier, 26% of the EU's electricity was generated from renewables and 10% from variable sources such as wind and solar. The share of renewables in electricity would increase from 26% in 2013 to 34% in 2020<sup>4</sup> and could exceed 50% by 2030 with an increasing contribution coming from variable sources considering that the contribution of hydropower stays stable at around 11%. The energy system is characterized by assets with life times of 30-40 years and more. Therefore all developments should also be in line with a 2050 perspective.

Owing to the increasing number of appliances and to the expected penetration of heat pumps and electric vehicles, the share of electricity in the overall energy consumption is expected to rise.

In parallel, consumers - including individual energy users, user groups, and small and medium industrial and commercial actors - will further increase their expectations and will take an increasingly active role in the energy system.

Finally, digitalization of the energy system is also progressing: systems and devices become more and more (inter)connected. Proprietary and open systems are under development opening the way towards new services, new market and business models with new players, more integration, increased energy efficiency, better forecast modelling and asset management. This increased digitalization also introduces new risks and requirements for (cyber) security.

Today, our EU energy system is still strongly determined by borders between Member States. Interconnections between the national electricity, networks are still limited; coordination among electricity, gas and heat networks is still in its infancy. Creating links between these networks would provide more flexibility, more resilience and allow a larger penetration of variable renewables by balancing over larger areas. This approach is underpinned by the recent 'Energy Union' Communication<sup>5</sup>. Collaboration between Member States and between regions has obvious benefits for the mutualisation of assets bringing security of supply and the resilience of the system in case of crisis. This is also needed to achieve a fully integrated energy market and will allow us to make faster progress in the decarbonisation of our economy. Finally, the above-mentioned Communication highlights the importance of a well-coordinated research and innovation as a key element for our competitiveness.

All this will require many changes not only in terms of new technologies (e.g. smart energy management systems, energy storage, conversion and delivery) but also in terms of planning and operation of infrastructures, interconnections inside and between Members States, regulatory environment,

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<sup>3</sup> Mapping and analyses of the current and future (2020-2030), deliverable N°1, Nov 2015.

<sup>4</sup> Renewable energy progress report, COM(2015) 293 final

<sup>5</sup> A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy (Com(2015) 80 final

[https://setis.ec.europa.eu/system/files/Communication\\_Energy\\_Union\\_en.pdf](https://setis.ec.europa.eu/system/files/Communication_Energy_Union_en.pdf)

harmonization of standards, and new business models from end to end (energy production to final consumption).

To achieve this, a system approach is needed aiming at a greater flexibility and effective capacity of the electricity system to allow an ever-increasing share of variable renewables and to cope with new variable consumption profiles owing to, for example, electric vehicles. To provide this flexibility to the system, a range of solutions must be developed not only across the entire chain (generation, transmission, distribution and customers) but also to reinforce / create new links with other networks, namely power to heat, power to gas / fuel, connection with the electrical component of the transport network. Technologies, systems and services for more flexibility should therefore be developed in the following areas:

- Energy grids and systems and integration,
- Storage, connection with other networks,
- Demand response,
- Flexible backup and generation.,

### **Targets**

**As an overarching target, the SET-Plan R&I will aim at developing, maturing and demonstrating (up to TRL7 to 9) technologies, systems and services which have the potential of being cost effective so that the EU electricity system is capable of hosting 45% of variable renewables by 2030 and operate in a safe, stable and secure way.**

To achieve this target, all flexibility options should be combined in an optimum way:

- **Energy grids, systems and integration:** technologies, systems and services are developed allowing real time monitoring and fast reaction asset management in such a way that the power network operates in a safe, stable and secure way, at least with the same level of performance as today in terms on interruptions, speed of restoration of services, etc. or better. This would also entail a reduced curtailment of RES and DER. These technologies, services and systems will also tend to minimize losses in the system and enable increasing levels of transfer capacity and more cooperation, including at regional level. Systems of systems should be developed which are capable of integrating all actors (demand-response, storage, flexible backup and power generation); they will increasingly rely on ICT technologies for technical systems and for consumer interaction. These raise new challenges of data handling, privacy and security i.e. resistance to threats and resilience.
- **Storage:** an ensemble of cost-competitive storage solutions must be developed to service the grid at different levels (generation, transmission, distribution, consumers) and different timescales (from real-time balancing to variations on daily and longer time frames). 'Storage' encompasses re-electrification (including the potential offered by electric vehicles) and production of storage and non-storable energy particularly for power to heat which is already cost competitive in several situations<sup>6</sup>, and other applications (for instance power to gas/fuel).

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<sup>6</sup> Baumgartner (2015)

- **Demand-response:** an ensemble of services and associated technological solutions (hardware, software, data exchange and market mechanisms) and societal solutions must be developed that enable customers and prosumers to play a role in the energy system by trading energy and services to the energy system; this will require the emergence of new actors such as energy service providers, cooperatives, aggregators etc. for residential, commercial and industrial consumers. These solutions should allow customer to activate their 'assets' via automated home energy consumption, variable energy production, electric cars, , building energy management systems, industrial systems, etc. This will strongly rely on automation and secured data handling with nondiscriminatory access to data.
- **Flexible backup and generation:** in the context of the SET-plan, integration of flexible backup and generation solutions will be privileged that can at the same time create services and significantly decrease GHG emissions. Solutions should aim to economically provide the services required for balance and stability of the power system and exploit the potential capabilities of both thermal and renewable generation.

### **Monitoring of the target:**

#### **The EU electricity system is capable of hosting 45% of variable renewables by 2030 and with a perspective of up to xx% by 2050.**

While it is difficult to fix shares and targets for each of the flexibility and delivery capacity options, the contribution of the different options and the progress can be assessed based on EU energy system modelling and to a range of realistic scenarios which can verify that the system can handle daily and seasonal variations and will ultimately deliver the share of variable renewables enabled by these solutions. These 45% at EU28 level will of course represent an average across both regions and sources which means that locally systems with very high shares of renewables will be operating while in other regions, this share will be more modest. Modelling should provide a panorama of the expected requirements in terms of local hosting capacities, transfer capacities, storage and conversion capacities, demand-response and flexible backup and generation.

#### **The EU electricity system is capable of operating in a safe, stable and secure way.**

To measure the progress in this domain, it is proposed to define indicators for stability, safety and security with grid operators who bear the responsibility for these matters. Reference values should then be established based on historical data and the evolution of the situation predicted. These are clearly non-trivial issues, requiring work and most likely the use of electricity system models.

#### **Technologies, systems and services have the potential of being cost competitive**

Cost competitiveness can be assessed following two different approaches:

- regarding the cost of energy (production, distribution, transmission), the 'usual' indicators can be employed (CAPEX, OPEX, price per kWh) and the comparison made with technologies, systems and services in place; Particular approaches should be used to assess deferral of traditional grid reinforcements (copper and iron) against increased intelligence (sensors & ICT).
- regarding services to the grid, the assessment is less straight forward but one can assess the extra cost and spread it over the volume of energy serviced as an indicator.

In any case, the actual cost will depend on the way the market will adopt these technologies (speed, scale, consumer acceptance, etc.) and in the R&I phase, these costs can only be extrapolated. It will also depend

on the eventual system usage and asset loading profiles resulting from the collective behavior of market actors.

### **Monitoring R&I progress in technologies, services, systems**

In addition, it is proposed to monitor the progress in the development of technologies, services and systems in terms of TRL over the year. This 'board' should assess at what pace R&I progress is achieved (the pace can vary depending on the technologies) and when these elements will be available / ready for deployment, and should determine the condition under which a technology, service, system is introduced in the energy system modelling.

### **Other important elements:**

Continuity should be ensured in the maturation of solutions ranging from advanced research programmes, industrial research and demonstration programmes, innovation and market uptake programmes as well as the socio-economic sciences relevant in this context. Also, in particular for the higher TRLs and the most integrated projects, these developments should be accompanied by analysis of the regulatory environment and the business models.

Also, sharing experiences in the scaling-up and system integration of new technologies across actors in Europe is crucial to ensure a swift and efficient deployment of technologies, especially among non-competing regulated actors.

### **Proposed actions**

While Horizon 2020 will continue to support this action via Calls for Proposals, the goal of this round of consultation is to consult stakeholders and Member States to identify a limited number of priority actions which:

- have a strong added value to be carried out at EU level and or through collaboration between Member States,
- have a strong leverage i.e. will need a limited or no support from Horizon 2020 but will pool together a number of resources,
- for which the progress and achievements can be monitored with indicators.

We are therefore looking for your views / proposals. The annex below reproduces the titles of actions which were identified in the annex of the document 'Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU Energy System' and can be used as a basis but proposals for priority actions do not necessarily need to be based on this list. With more than 70 actions listed, it is clear that a more integrated and prioritized perspective needs to be adopted.

## **HEADING 2: Ensuring Energy System Integration**

### **Challenge 1: Energy Grids**

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#### **ADVANCED RESEARCH PROGRAMME**

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*Action 1: New methodologies to design grid architectures and plan transmission and distribution networks*

*Action 2: Research for electric grid compatible renewable and new user integration*

*Action 3: Research and development of novel tools for grid asset management in order to increase network flexibility and continuity of power supply*

*Action 4: Development of innovative tools for grid operations*

*Action 5: Research and development of tools development to support new market designs at Pan-European and regional levels*

*Action 6: Research for methodologies and development of tools which enable scaling up and replicating the results of innovative demonstrations*

*Action 7: Research and development of new materials for grid applications*

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#### **INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME**

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*Action 1: Demonstration of novel interoperable power technologies integrated into Electricity Grids*

*Action 2: Demonstration of the grid integration of renewable generation, electricity storage and new users*

*Action 3: Demonstration of novel grid asset management techniques*

*Action 4: Demonstration of tools for improved Grid operations*

*Action 5: Demonstration of novel tools to prepare recommendations for novel market designs*

*Action 6: Demonstration of small generators upgraded for Network Code compliance*

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#### **INNOVATION AND MARKET-UPTAKE PROGRAMME**

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**Action 1: Modular development plans of the pan European transmission system based on new planning and grid architectures**

**Action 2: Scaling up and replication platform to support the market uptake on innovative grid operation and electricity market solutions**

**Action 3: Interoperability of standards for data and knowledge exchange**

**Action 4: Improved awareness and acceptance by the public of new grid infrastructures and electricity metering use**

**Action 5: Increasing stakeholder acceptance of novel energy market designs and products.**

**Action 6: Training tools and workforce certification at EU level**

## **Challenge 2: Storage (Heat and Cold, Electricity, Power to Gas or other energy Vectors)**

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### **ADVANCED RESEARCH PROGRAMME**

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**Action 1: Enhanced Storage materials**

**Action 2: New Technologies for Next Generation Central and De-central Storage Technologies of any scale**

**Action 3: Improved second generation technologies for Next Generation Central and De-central Storage Technologies of any scale**

**Action 4: Storage System interfaces**

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### **INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME**

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**Action 1: Storage System Integration and Benefit Assessment via Simulation of System Embedding**

**Action 2: Central and De-central Storage Technology Demonstration of any scale**

**Action 3: Storage System integration Demonstration**

**Action 4: Storage Manufacturing Processes**

**Action 5: Storage Recycling**

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### **INNOVATION AND MARKET-UPTAKE PROGRAMME**

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**Action 1: Storage Standardisation**

**Action 2: Storage Business Case Evaluation in global market environment/systems**

**Action 3: Storage Business Cases in local market environment/systems**

**Action 4: Soft Aspects and Society Acceptance**

**Action 5: Closed storage material loop**

### **Challenge 3: Demand Response**

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#### **ADVANCED RESEARCH PROGRAMME**

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**Action 1: Tool development to support new electricity energy market designs that support Demand Response**

**Action 2: Develop mechanisms to enable the participation to the electricity market of all relevant actors and to ensure the full exploitation of Demand Response**

**Action 3: Develop integrated solutions to maximise value chain performance and cost competitiveness of Demand Response**

**Action 4: Develop holistic communication systems to provide security, oversight and participation opportunities between DSO, TSO, Aggregators**

**Action 5: Develop load forecast tool with full integration of Demand Response**

**Action 6: Functional and Virtual Power Storage**

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#### **INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME**

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**Action 1: Demonstration of the integration of Demand Response in electricity energy grids**

**Action 2: Demonstrate the full value chain performance, the cost competitiveness and the system integration capability of Demand Response**

**Action 3: Demonstrate system services from Demand Response**



**Action 4: Demonstrate the capability of smart interfaces, management modes and new services to increase the integration of Demand Response in the energy system**

**Action 5: Control of distributed energy resources for demand response**

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#### **INNOVATION AND MARKET-UPTAKE PROGRAMME**

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**Action 1: Demand Response and new users integration: scaling up and replication**

**Action 2: Standardisation needs.**

**Action 3: Market framework and business models for demand response**

**Action 4: Regulatory aspects to enable Demand Response**

**Action 5: Demonstration of and regulatory development support for demand response aggregation**

**Action 6: Demonstration of and regulatory development support for further visibility and manageability of demand**

#### **Challenge 4: Flexible /Back-up Energy Generation**

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#### **ADVANCED RESEARCH PROGRAMME**

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**Action 1: Innovative Tools to support new grid market designs and mechanisms at EU level**

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#### **INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME**

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**Action 1: Improve flexibility of the production from RES flexible technologies**

**Action 2: Programme in design and demonstration of new generation of turbine and generator: Hydro plant upgraded for better grid-balancing**

**Action 3: Efficient and Responsive Thermal Power Plants**

**Action 4: Flexible and Efficient Gas and Steam Turbines**

**Action 5: Programme in design and demonstration of new generation of turbine and generator: New generation of hydropower turbine and generator design**

**Action 6: Programme in improving power converters to permit variable-speed operation: Power electronics and converter technology for hydro projects**

## **Challenge 5: Cross-technology Options**

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### **ADVANCED RESEARCH PROGRAMME**

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***Action 1: Cross Sector Chemical Storage Technologies***

***Action 2: Small hydro power plant as active component in a VPP***

***Action 3: Research for high cyber security***

***Action 4: Research for “big data” in the cloud, in real-time***

***Action 5: Enhancing Network Interaction and synergies – Gas and Electric networks***

***Action 6: Energy Systems Integration – Testing and Evaluation of Integrated Energy Systems***

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### **INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME**

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***Action 1: Demonstration of high cyber security***

***Action 2: Demonstration of “big data” in the cloud, in real-time***

***Action 3: Demonstrate the flexibility of PEM electrolyzers at large scale***

***Action 4: Optimised integration of renewable energy sources and surplus heat in DHC and enhancement of thermal energy storage at system level***

***Action 5: Demonstration of large Smart Thermal Grids***

***Action 6: Take into account the electrical network needs to Optimize centralized Hydrogen production (spot price, load curtailments (on peak), over consumption (off peak))***

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### **INNOVATION AND MARKET-UPTAKE PROGRAMME**

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***Action 1: Improved, highly efficient substations for both present and future lower temperature networks***