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RTD - Energy
ENER - Renewables, R&I, Energy Efficiency
JRC – Institute for Energy and Transport
SET Plan Secretariat



Issues Paper No.4 - DRAFT
(version 17/12/2015)

Energy Systems

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

Purpose of this document

This document¹ is intended to progress the implementation of the actions contained in the SET-Plan Communication², 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/>.

¹ 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.

² "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%³ 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 2020⁴ 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 characterised by assets with life times of 30-40 years and more. Therefore, all developments should also be in line with a 2050 perspective.

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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, digitalisation 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 digitalisation also introduces new risks and requirements for (cyber) security.

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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' Communication⁵. Collaboration between Member States and between regions has obvious benefits for the pooling 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.

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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,

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

⁴ Renewable energy progress report, COM(2015) 293 final

⁵ 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

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

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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;
- Cross-technology options;

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Targets

As an overarching target, 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 competitive, 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.

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Comment [A2]: This "variable" renewables target may not be realistic in the 2030 timeframe, even with the public policy target of 27% share of renewables.

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 minimise 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.

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- **Storage:** an ensemble of cost-competitive storage solutions must be developed to service the power system 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 situations⁶, and other applications (for instance power to gas/fuel).

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⁶ Baumgartner (2015)

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- **Demand-response:** an ensemble of services and associated technological solutions (hardware, software, data exchange and market mechanisms) and societal solutions must be developed to increase efficiency and safety of the power systems. It will enable customers and prosumers to play a role in the energy system by providing energy and services to the energy system (including, distribution grid, transmission grid, retailers, generators, etc.). This may result in the emergence of new actors, such as energy service providers, cooperatives, and aggregators, 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 third party access to anonymised or aggregated 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 provide efficiently and effectively the services required for balance and stability of the power system and exploit the potential capabilities of both thermal and renewable generation.

- Cross-technology options: xx

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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.

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In any case, the actual costs will depend on the way the network operators and other market players will deploy these technologies (pace, scale, asset loading profile, consumer acceptance, etc.), and the pace and scale of deployment for regulated entities will be dependent on the cost recovery regime in place. In the R&I phase, these costs can only be roughly estimated.

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 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 prioritised perspective needs to be adopted.

Comments on the proposed actions:

The Grid+Storage proposal has already mapped the actions of the EEGI roadmap and the actions of the EC roadmap (see section 2.3 of the technical annex of the contract):

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Comment [A5]: How will the R&I roadmap be delivered by the Grid+Storage project be taken into account? And Grid+Storage effort be continued by call LCE3 2016. Are there redundant exercises? [see below]

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All consortium members have contributed directly or indirectly via the associations to the construction of the draft Integrated Roadmap of the SET-Plan from September 2013 to June 2014. With reference to the format of this Integrated Roadmap as of June 2014, the following table illustrates how the EEGI team RTD&D clusters match with the activities of the SET-Plan integrated roadmap. For the advanced research programme, the listed actions are:

- **Action 1:** New methodologies to design grid architectures and plan transmission and distribution networks
- **Action 2:** Research for energy system compatible renewables and new user integration
- **Action 3:** Research and tools development for grid asset management to increase network flexibility and continuity of supply
- **Action 4:** Development of innovative tools for grid operation
- **Action 5:** R&D of tools to support new market designs at Pan-European and regional levels
- **Action 6:** tools for scaling up innovative demonstrations

These actions match the functional projects of the existing EEGI roadmap (D_j, T_j, TD_k) as follows:

	Actions					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Advanced Research Programme	-	-	-	<u>D7</u>	-	-
	-	<u>D1</u>	-	<u>D8</u>	-	-
	<u>D11</u>	<u>D2</u>	<u>D12</u>	<u>D9</u>	-	-
	<u>T1</u>	<u>D3</u>	<u>T15</u>	<u>D10</u>	<u>T10</u>	-
	<u>T2</u>	<u>D4</u>	<u>T16</u>	<u>T6</u>	<u>T11</u>	<u>TD5</u>
	<u>T14</u>	<u>D5</u>	<u>T17</u>	<u>T7</u>	<u>T12</u>	-
	-	<u>D6</u>	-	<u>T8</u>	<u>TD3</u>	-
	-	<u>T3</u>	-	<u>T9</u>	-	-
	-	<u>T4</u>	-	<u>TD1</u>	-	-
	-	<u>T5</u>	-	<u>TD3</u>	-	-
	-	<u>TD2</u>	-	<u>TD4</u>	-	-

For the Industrial research and demonstration programme, the listed actions are:

- **Action 1:** Demonstration of novel interoperable technologies integrated into energy grids
- **Action 2:** Demonstration of grid integration of RES, storage and new users
- **Action 3:** Demonstration of novel grid assets management techniques
- **Action 4:** Demonstration of tools for improved grid operation
- **Action 5:** Demonstration of tools validation to prepare recommendations for novel market design

These actions match the functional projects of the existing EEGI roadmap (D_j, T_j, TD_k) as follows:

	Actions				
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Industrial research and demonstration programme	<u>T3</u>	<u>D1</u>	<u>D12</u>	<u>D7</u>	<u>D13</u>
	<u>T4</u>	<u>D2</u>	<u>T15</u>	<u>D8</u>	<u>T10</u>
	<u>T5</u>	<u>D3</u>	<u>T16</u>	<u>D9</u>	<u>T11</u>
	-	<u>D4</u>	<u>T17</u>	<u>D10</u>	<u>T12</u>
	-	-	-	-	-

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		D5		T6	
				T7	
				T8	
				T9	
				TD1	
				TD3	
				TD4	

For the Market take-up programme, the listed actions are:

- **Action 1:** Modular development plans of the pan European transmission system based on new planning and grid architectures
- **Action 2:** Scaling up and replication
- **Action 3:** Interoperability of standards for data and knowledge exchange
- **Action 4:** Improved awareness and acceptance by the public of new grid infrastructures and energy metering and use
- **Action 5:** Increasing stakeholders acceptance of novel energy market design and products
- **Action 6:** Training tools and EU level

These actions match the functional projects of the existing EEGI roadmap (D_j, T_j, TD_k) as follows:

Market take-up	Actions					
	1	2	3	4	5	6
	T2				D1	
	T14	TD5	TD5	T14	D2	T8
					T14	

The on-going work of Grid+Storage project will provide an upgrade of the EEGI roadmap for public consultation by the Members States (end-March 2016) and the larger set of stakeholders (end-April 2016). The final documents is scheduled for the SET approval by end-June 2016).

The implementation plan setting the new priorities will be delivered by October 2016 for a public consultation and approval by December 2016.

For more details, see: <http://www.gridplusstorage.eu/deliverables>

Should one not use this service contract to implement the above proposed actions?

[Annex: 1 Relevant actions of the 'Towards and Integrated Roadmap document' needed to achieve the targets](#)

HEADING 2: Ensuring Energy System Integration

Challenge 1: Energy Grids

ADVANCED RESEARCH PROGRAMME

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

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

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

INNOVATION AND MARKET-UPTAKE PROGRAMME

Comment [A6]: Selected industry stakeholders were requested to provide a ranking of these actions in Nov. 2015 (again under a very short deadline). At the time, ED coordinated its input via the ETP SG.

It would be advisable for the SET-Plan Secretariat and DG ENER to revisit the ranking received.

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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)

ADVANCED RESEARCH PROGRAMME

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

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

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

INNOVATION AND MARKET-UPTAKE PROGRAMME

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

ADVANCED RESEARCH PROGRAMME

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

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

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

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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

INNOVATION AND MARKET-UPTAKE PROGRAMME

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

ADVANCED RESEARCH PROGRAMME

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

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INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

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

ADVANCED RESEARCH PROGRAMME

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

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

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))

INNOVATION AND MARKET-UPTAKE PROGRAMME

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