Annex to EPPSA, EUTurbines and EUGINE Joint input paper to Issues Paper No.4

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RTD - Energy
ENER - Renewables, R&I, Energy Efficiency
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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[1] is intended to progress the implementation of the actions contained in the SET-Plan Communication[2], 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 prejudge 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 2020[4] 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 [5]. 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,

[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

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 and reduce the environmental impact, **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, which may be different per geographical area:

- 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, service s 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: Energy storage, related to the electricity system, is the act of deferring an amount of the final energy that was generated to the moment of use, either as final energy or converted into another energy carrier[6], for which a wide range of options are available. 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 to seasonal balancing). As these technologies shall be applied at generation, transmission, distribution or consumption level, R&I activities should be closely connected to

[6] Following the definition supported by the energy storage sector.

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Deleted: variations on daily and longer time frames these different levels, in order to ensure an efficient integration. Storage solutions shall include not only the storage technology itself, but should look at the entire process, from transformation to re-transformation and use.

Deleted: 'Storage' encompasses re-electrificati (including the potential offered by electric vehicl and production of storage and non-storable ener particularly for power to heat which is already co competitive in several situations[7], and other applications (for instance power to gas/fuel).

- 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: To achieve the overarching target, thermal power plants in the future will need to be optimised for maximum flexibility to ensure the smooth functioning of the system. These flexibility improvements have to incorporate the overarching target of maximise efficiency as well. In the context of the SET-plan, integration of flexible backup and generation solutions will be privileged that can at the same time provide a maximum of flexibility 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 power generation. In addition, the further development of hybrid plants combining variable power generation from renewables with the reliability of dispatchable energy sources should be further supported for power generation, as well as solutions for an efficient conversion of existing power plants, to contribute to a cost-effective and low-emission backup.

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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.

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.

For the abovementioned potential indicators, identifying gaps/barriers to meet the target in terms of data availability, quality and comparability will be necessary to ensure a reliable and fair measurement of progresses as well as to assess the level of ambition of the proposed target. The development of such indicators would also need to be developed in consultation with all relevant stakeholders.

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 asses 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.

For monitoring R&I options and progress in technologies, services, systems, specific performance targets relative to today's state of the art shall be defined for the different identified flexibility options (e.g. based on the deliverables mentioned in the INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME). These will ensure that R&I efforts stay focused and would contribute to the progress assessment. In this sense, information available in the currently existing Integrated Roadmap and other similar or related documents could be used as basis, which would, in turn, guarantee continuity of the work done in the past. Time to develop and agree on such performance targets will be needed and this would require the involvement of all relevant stakeholders.

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Implementation

Given the different nature of the four identified flexibility options, and in order to guarantee a technology-neutral approach, implementation plans for each of these options need to be developed in a coherent and coordinated way while keeping in mind the specificities and the stage of technology development of each option.

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.

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

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

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

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 electrolysers 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

Annex 2: R&I priorities for Flexible back-up and generation

Efficient and Flexible Thermal Power Generation – Operational flexibility: Improvements in the following areas will contribute to increasing the flexibility, efficiency and response capability of thermal power plants – **these areas built on the existing Horizon2020 LCE17-2014 and LCE28-2017 calls** (Highly flexible and efficient fossil fuel power plants):

- **Start-up/shut-down ability:** further improving the ability of the thermal power generating facility to move within a specified time from a defined idle state to synchronous operation with a defined power output. The same applies to the ability of a facility to return to a defined idle state within a given timeframe.
- **Load following capability:** further increasing the rate at which a power generating facility can increase or decrease its output. This flexibility increase must apply to existing and new power plants' components.
- **Minimum load:** further reducing the minimum load at which a power generating facility can reliably operate. It needs to be kept in mind that running a thermal power plant in partial load decreases its efficiency.
- **Efficiency:** further improving the conversion rate of energy from different forms into electricity, which defines the efficiency of a thermal power plant. Aspects in the operational flexibility of the thermal power plant will also have an impact on its overall efficiency, hence the need to increase part load efficiency.

Fuel flexibility: Thermal power plants of the future need to increasingly be able to flexibly use different fuel sources and be capable of switching among them – including biofuels, biomass, etc.

Energy storage at thermal power plants: Thermal power plants can improve their efficiency and flexibility by storing excess energy on site in case of demand variations and using this at times of peak demand. Similarly also excess energy from variable renewables could be stored at thermal power plants or transformed into a syngas, chemical products etc., as support and/or possible alternative to fossil fuels.

Hybrid plants: Better integration of RES will be achieved via hybrid plants, for example to enable rapid switches between RES and thermal power generation, such as thermal solar plants, or to allow the use of CO_2 neutral biomass or hydrogen to increase electricity supply stability while reducing plants' carbon emissions.

Decentralised power generation: optimising the connection, control and management of decentralised power generation units, including those coordinated as "virtual power plants", and providing flexibility to the power system, which will help address and minimise the challenges in transport between the points of energy generation and consumption.

Combined heat and power generation (CHP): Increase of efficiency in CHP units, optimisation of decoupled use of heat and power (by buffers, by storage of heat, power-to-heat or power-to-gas) and better integration of existing industrial CHP plants into the grid.

Improvement of robustness: Improved robustness of thermal power plants, allowing even with increased cycling, to minimise wear & tear effects. The number of starts through the lifetime of the power plant will, thus, also have an impact – the goal is to be able to increase those as well.

Optimisation of costs: Investments costs should be optimised to be in a position to recover costs with a reduced number of operating hours per year.

Emission reduction: The increased cycling of flexible thermal power plants creates challenges regarding the emissions performance of these power plants. The optimisation of the emissions performance under these conditions is a new technical challenge that needs to be addressed.