26 August 2016

EUA-EPUE Response to SET-Plan Consultation on the

'Draft SET-Plan Declaration on Strategic Targets in the Context of an Initiative on Energy Systems'

BACKGROUND

This "Input Paper" provides the perspective of the European Platform of Universities in Energy Research & Education (EUA-EPUE) to the consultative process on the European Strategic Energy Technology Plan (SET Plan) - Key Action No. 4 – Energy Systems.

EUA-EPUE responds to the consultation from the perspective of the universities' role in society. Universities constitute a significant part of the research capacity in Europe. At the same time, they educate the highly skilled work force of our societies. We consider therefore that setting up the SET Plan projects with ensured integration of innovative research with education, including industrial partners, will provide a high pay-off towards achieving the energy system transition that is the objective of the SET Plan.

GENERAL COMMENTS

Europe has a number of world-leading experts, research laboratories and facilities dedicated to researching a large spectrum of features associated with the energy transfer in future grids, including innovative markets. University laboratories are the only organisations that currently have the expertise to effectively tackle the major scientific and technical barriers that the next generation of grid components will need to overcome to be successful. If Europe is to achieve these ambitious targets, thought must be given to the role of European Universities in their function as educators of the next generation of professionals in the energy field, as well as their independent expertise in research to ensure the development of strong research collaborations to resolve the problems faced in an optimal matter for short as well as long term. This research should address more than the technical elements, but extend towards the, social, political and economic elements. This multi-disciplinary nature of energy systems gets more and more reflected already in the educational portfolio of universities, where it extends beyond the electrical (power) engineering subject. However, a more complete support of multi-disciplinary research and education through the whole society will be required to aid this expertise to bring its benefits to society.

Along the same lines, universities also play a key role in communicating with the public and ensuring that terminology is used consistently, while also being clear to all. In a multi-disciplinary context, it becomes more important that everyone speaks the same "language" and understands concepts the same way, even for more generic terms such as "energy" and "systems".

As the draft declaration currently stands, it provides a fairly clear vision on the future of the *electricity system*, however, the overarching goals do not sufficiently support the ambitions of the strategic targets.

To improve on the currently stated targets, the following needs to be addressed in more detail, namely: locality, time and scenario**.** The spatial and time distribution of many of the energy system issues have to be investigated and in this context, the proposed Technology Readiness Level of 7-9 is too high for solving problems, which are way more fundamental in their nature.

Scenario analysis is an important instrument to compare and quantify tools, methods, flexibility etc. To compare different set-ups, the chosen scenarios need to be defined carefully and need to be publically available. Each scenario defines a certain area with details about: local generation, flexibility in demand, available storage and the abilities of the distributed energy management (ICT system). For each scenario the dynamics of energy streams versus their key targets can be observed and allow the scenarios to be compared on equal grounds, e.g. peak load reduction or amount of self-consumption.

The timing and synchronisation of information delivered in any energy related sensing networks also needs to be addressed. After all, any decision made is only as useful as the data available to make it, but the actual energy demand tends to come before the measuring of the related consumption. Independent of this delay, there is the delay of communicating this information to the generation side where it needs to be processed, and then a decision can be made, after which an action can be taken. This action taken can come too late with regards to the actual demand, although they remain related.

Note:

In the remainder of the document, the original text (*in italics*) has comment numbers added in, which refer to the respective comments at the end of the section.

Introduction – Energy Systems

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 and is seen as the starting point to progress towards an energy system approach because of its potential connections with heat, transport, gas, etc. In 2013, 22%[1] *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 renewable variable sources. The share of renewables in electricity would increase from 26% in 2013 to 34% in 2020*[2] *and could exceed 50% by 2030 with an increasing contribution coming from variable sources, as well as biomass and renewable fuels (representing 4.5% in 2013), and considering that the contribution of hydropower stays stable at around 11%. The energy system being characterised by assets with life times of 30-40 years and more* [C1]*, all developments should also be in line with a 2050 perspective.*

Owing to the increasing number of electrical appliances and to the expected uptake of low carbon technologies [C2]*, (e.g. heat pumps and electric vehicles), the share of electricity in the overall energy consumption is expected to rise.*

In parallel, consumers will further increase their expectations and take a more active role in the energy system.

Finally, digitalisation of the energy system is also progressing: systems, processes and devices become more and more (inter)connected opening the way to new services, new market and business models with new players, more integration, increased energy efficiency, and better forecasting models, asset management and operations. This increased digitalisation introduces new risks and requirements for (cyber) security.

[1] Mapping and analyses of the current and future (2020-2030), deliverable N°1, Nov 2015.
[2] Renewable energy progress report, COM(2015) 293 final

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[3]. Collaboration among Member States and among regions has obvious benefits for the coordination 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, design and operation of infrastructures, interconnections inside and between Members States, regulatory environment, harmonisation of standards, and new business models from end to end (energy production to final consumption) [C3].

Comments to "Introduction – Energy Systems":

- [C1] The SET-Plan should carefully address the differences among various asset lifetimes and the implications on decisions taken at system level. Currently, the document assumes lifetimes to be 30-40 years, which is not generally applicable. In some cases this is longer, e.g. nuclear power stations which are kept running for longer than what they were designed for; while some other technologies, e.g. Combined Heat and Power (CHP) and Solar Photovoltaic (PV), have lifetimes closer to 20 years.
- [C2] While electricity is among the higher levels of energy, in contrast to e.g. heat, it is also more challenging to manufacture and some of these low carbon initiatives are only truly low carbon when they are supplied with electricity from renewable sources. While there are clear benefits to aim at producing electricity, more work is needed with regards to the use of other energy forms, such as heat, which are now often wasted, and could be useful e.g. for transport purposes.
- [C3] There are indeed many changes required in various fields to deal with the larger energy challenge. However, there is a large overlap between these various fields, which makes the overall challenge more complicated and therefore there are benefits to supporting research that is truly multi-disciplinary, and move e.g. more towards a flag-ship style project around energy. This would then need to include suitable harmonisation between work at lower TRL levels, to resolve the fundamental questions underlying it all, with work at higher TRL levels to ensure suitable commercialisation. Considering the present challenges related to the Renewable Energy Sources (RES)-based energy integration, including the current overcapacity in electricity production in Europe and the required shift in the energy mix at country level, the SET-Plan should put more focus towards: 1) the development, maturing and demonstrating of technologies, systems and services that allow for balancing and backup of energy across the borders of the Member States (higher TRL levels), and 2) researching, developing, maturing and demonstrating technologies, systems and services for storage and conversion at lower TRL levels.

Overarching goals

In the frame of this SET-plan initiative, efforts will focus on the electricity system and its connections with other energy networks. Indeed, today, it integrates already a high share of renewables (26% of renewables in 2013, 10% being variable renewables) with high growth perspectives and offers a number of possibilities to connect to heat, gas, fuel and transport networks (e.g. with electric vehicles). The power system is therefore expected to play a central role in the de-

[3] 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

carbonisation of the energy system. The energy transition will be based mainly on dispersed electricity generation and distributed load controls.

A system approach [C4] *is therefore needed to guide research and innovation activities in view of designing and developing a portfolio of appropriate solutions which helps maintaining system* ***reliability,*** *while being in line with four interacting and evolving goals:*

- *The power system must be* ***increasingly more sustainable****, viz. a power system maximizing efficiency and clean energy resources in support of the above European policy goals;*
- *The power system must be* ***more flexible*** [C5] *by enhancing the grid hosting capacity for RES and by responding to variability and uncertainty of operational conditions at several timescales: from short time scale resulting from new variable loads and stochastic generation to long time scales resulting from a wide range of possible energy scenarios.*
- *The power system must become* ***more customer-centric*** *by ensuring transparency to customers and energy producers who search for customised services and value propositions provided by new market players, based on dynamic prices and a fair cost allocation, in order to strengthen EU economic competitiveness;*
- *The power system must throughout this energy transition continue to pursue* ***economic efficiency*** *by relying on market forces and efficient market design for the competitive parts of the system, while maximizing social welfare and keeping infrastructure costs (CAPEX and OPEX) under control for the regulated parts.*

The above goals are indeed interdependent: the optimized power system enables a greater flexibility and effective capacity of the electricity system which, in turn, allows connecting effectively and efficiently an ever-increasing share of variable renewables (wind and solar) and coping with new consumption profiles coming, for instance, from electric vehicles. Conversely, system flexibility can be reached both from the upgrading of the entire electricity value chain (generation, transmission, distribution and customers, and energy storage), but also from the reinforcement / creation of new links with other energy networks [C6]*, via for example power to heat, power to gas / fuel and connections 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 (including interconnections),*
- *Storage, connections with other energy networks,*
- *Demand response,*
- *Flexible backup and generation.*
- *Technologies for together with the required market-paradigm shift enabling the integration of prosumers, ensuring their independence and the ability to influence their load curve.*

At the same time, network operators must face a technology transition in the years to come. Keeping the system reliable, at the likely different levels requested by the different economic agents, means a power system that is observable and controllable while welcoming a growing number of such agents, using dynamic prices and customer-centric market design. The existing power system has been designed by implementing a "cyber ICT layer" on the top of a "hardware (equipment) layer". The future power system's cyber layer will cover the whole continent, and, at the same time, will reach, whenever possible, each agent in order to observe and help them optimizing their behaviors. This new cyber layer may also contribute to mitigate/delay infrastructure investments, thanks to integrated intelligent infrastructure monitoring strategies enabling life extension and exploitation.

Comments to "Overarching goals":

- [C4] The power system is defined as a system where a "system approach" is required. The definition of "a system" now, is different from what the energy systems of the future require. Currently, the term system is used for e.g. a single appliance or generating source (e.g. a CHP system). However, the next generation of energy system(s) should really be a system of systems, which work as one integrated system, where all the individual systems interact to optimise the overall system. This system-of-systems structure may need to be divided into different hierarchical levels, but should operate in the same manner at each level.

- [C5] The system should become more flexible. Flexibility is essential from the perspective that one needs to match demand with generation, however with renewable generation, there is variability within the generation itself, and while this can currently be accommodated to a certain degree, there are significant challenges when one would move towards fully renewable generation. While the current trend is to change that towards a flexible demand model, the flexibility of that demand is unlikely to be as high as one would prefer, and therefore there is a "gap" that needs to be filled through the use of storage, and that to overlap short time differences all the way up to more seasonal demand differences. Once again several potential solutions exist, but need to be further studied before being implemented/integrated.
  Considering the lower inertia anticipated in energy systems with a higher penetration of renewable generation, new control and protection mechanisms with lower time constants will need to be developed, which will e.g. require the installation of measurement systems (including energy metering) with higher time granularity, e.g. a reporting rate of 1 frame/s or more. Suitable targets in this area could look at the percentage of High Voltage (HV) substations that are equipped with remote monitoring and control that allow suitable real-time operation.
- [C6] With regards to the interlinking of different energy networks, it will be essential to consider each one of these links to be two-way traffic, and also consider efficiencies of conversion and demand before actual conversions take place. This could be overcome through a hierarchical system-of-systems model, as mentioned above, but this needs to be substantially researched, and then implemented. Overall continuous round-trip conversions should be avoided due to the losses encountered with each conversion.

Strategic Targets

The SET-Plan R&I activities aim at developing, maturing and demonstrating technologies, systems and services up to a technology readiness level (TRL) 7 - demonstration to 9 - pre-commercial [C7]***. These will enable developing and operating the power system with the appropriate level of reliability and economic efficiency, while integrating variable renewables, such as wind and solar generation (see in annex the gross electricity generation from wind and solar in 2013 – EU 28) and substantial customer participation*** [C8]***.***

Monitoring of this overarching target requires:

- ***Flexibility*** *through:*

  1/ *Grid smartening in the sense of* ***grid observability and controllability*** [C9]*, which bring to the system improved forecasting and operation. Benefits will be the potential for less curtailment of distributed generation resources such as PV or small wind installations, for improved management of distribution losses and voltages, and for reducing negative effects or durations of interruptions due to equipment failure. One indicator is the percentage of substations (at Medium Voltage (MV) and Low Voltage (LV) level) equipped with remote control and remote monitoring. Target values for this percentage of substations need to be developed and could vary by Member State, but should be 80% or higher for 2030. Further, as indicator for LV grid smartening, the percentage of separable LV networks that use smart meter data for observability will be tracked. Finally, to capture reliability benefits of observability and controllability, a target will be quantified on reductions in average duration of service interruptions; basis will be CEER annual statistics.*

  2/ *Tools for managing the* ***variability and uncertainty*** *of operational conditions at several timescales. Since Distributed Generation (DG) replaces central generation, self-consumption becomes increasingly important affecting the load profile supplied from the integrated grid. With DG and storage growing in the energy mix and at prosumers' sites, more and more customers can support the paradigm change where loads follow variable generation through demand response* [C10]*, instead of having generation following load as practiced today. Examples of the R&I that can contribute to management of variability and uncertainty include work on transmission and distribution planning under uncertainty, on forecasting methods especially applied on local conditions, on synthetic inertia, or on* *market design for demand response and for the interaction between different partial markets and different grids. In addition, much of the R&I work related to action paper 3 is relevant for this target. To track this target over time, we will combine the TYNDP's and other studies' current and future years' data on capacity available from demand response with yet-to-be developed estimates of customers' price elasticity. Building on 2016 estimate the percentage of peak load available from demand response for 2030, an ambitious target based on successful R&I could be 25%.*

- ***Economic efficiency** is tied strongly on one hand to technological and cost reduction progress – in particular for technologies such as energy storage which support flexibility – and on the other hand to market design and dynamic pricing. R&I needs to contribute to both: its potential technological contributions to cost reductions and their beneficial effects are clear, but also in market design, there are R&I gaps as indicated below. The indicator for the technological development that will be used focuses on the cost reduction for example of energy storage depending on the specific technologies which can achieve 50% by 2030 for the same storage function.[4] Here storage is meant broadly, including e.g. the interaction of heat and electricity networks, power-to-heat and power-to-gas/fuel concepts, interaction of gas, heat and electricity networks.*

- *Finally an **overall indicator** to capture general methodological progress through R&I is proposed: Develop a portfolio of European and/or regional reference tools for electricity network monitoring, modelling and management, available to all network operators, that assist both TSOs and DSOs, jointly, in operational tasks and investment decisions, including the demonstration of integrated management systems for optimised management of the electricity network with other networks (district heating, mobility). In addition, the percentage of methodologies and tools developed in R&I projects should be tracked whose results get implemented within eight years of projects completion in at least two European countries' electricity or related markets. A target value should be set based on recent projects results' implementation* [C11].

Comments to "Strategic targets":

- [C7] As mentioned earlier, there is a substantial amount of work to be done at levels lower than TRL level 7, since current technologies cannot achieve everything mentioned within this document, and due to a lack of funds in this area in the past, the correct fundamental research results are not available for suitable further development.
- [C8] It is essential to indicate how the "substantial customer participation" will take place, as while it is crucial, there is large variety in customers and so this large spectrum would need to be covered.
- [C9] Grid observability and controllability, requires that the aspect of this controllability and observability are defined as to what should be observable and controllable. Secondly, how sub-stations are defined and the involvement of prosumers in the process should be investigated. The document currently also lacks clarity with regards to the second point, on variability and uncertainty, and on how both changes (first and second point) would need to work in unison considering they are supposed to happen simultaneously.
- [C10] The concept of demand response should be considered more widely than the technical and economic aspects. Social aspects, as for instance the implications of having tariffs that depend on consumption and the relation to the economic circumstances of the various consumers, should be considered as well. Secondly, while demand response may be a partial solution, it cannot overcome the full scale of variability related to renewable generation as well as seasonal and regional differences. Hence, other solutions will also be required.
  Another important aspect in the context of demand response is storage. As till date, there are only a very limited set of technologies that have the right features to be used for efficient storage, and development in this area is also limited to the usual items, while true innovation in this area is crucial. This is particularly true considering the variability in renewable generation and the limited ability to tempt all customers towards a demand response model.
- [C11] There is need for more independent research to be performed providing for a more general solution, in contrast with the current solutions "with very limited scope". While there is support for

[4] Measurement details to be developed

relevant parties to meet regularly and discuss the needs of the sector at large, however the current projects do not always address and represent the views of the full community.

- The move from centralised to decentralised generation requires the grid to change quite substantially, as it currently has more or less an inverse tree structure, with the branches becoming thinner towards the bottom. However, with decentralised generation localised consumption should be promoted, leading to a model of local networks that are aimed to be self-sufficient, but are still interlinked with the neighbouring "cells" for those cases where they are not fully self-sufficient. Changing over from one model to another will require careful consideration to reduce the economic impact of these essential changes. Till date very limited work has been done in this area, while it is crucial to move towards a decentralised generation model, which is naturally more suitable as the amount of renewable generation grows.
- When interconnecting different energy networks, there is a need for a suitable framework around the possible economic implications, since in most settings these networks are owned and maintained by different companies. Aiming towards a more demand response type system could mean that those interactions are not necessarily mutually beneficial, which could mean that competition takes over from technical reasons, while no longer keeping the consumer central.
- Additional benefits could be achieved in certain energy systems when they are equipped with low voltage Direct Current (DC) networks. Considering there is a growing amount of DC loads (essentially all electronic based devices), the installation of Low Voltage (LV) DC networks within offices and domestic settings can certainly bring substantial benefits, since only a single Alternating Current (AC) to DC converter is required, which can be fully optimised towards set efficiency standards.
  While there are worldwide existing standardisation efforts dedicated to LV DC microgrids, the measurement and control equipment for these networks to ensure the operation of a not yet defined "performant DC microgrid" is another field of "lower TRL" research that needs to be performed.

Potential further actions towards additional and improved indicators

To assess the flexibility of the electricity system and especially the magnitude of its connections with other energy networks, an EU-28 modelling system, relying on scenarios, is needed. The current best pan-European modelling system for this is the electricity TYNDP, as described above. However, common scenarios with the gas TYNDPs as well as strongly improved system adequacy forecasting methodology are being developed and are likely to become useful to track our R&I targets soon. This will lead over the coming years to improved ability to model and track the system's capacity to operate with much higher share of production from variable renewables, the modelling of all flexibility mechanisms such as demand-response, storage with re-electrification, power to-x (energy transferred to other networks), and flexible generation. There may also be improvements in the ability to investigate the impact of interconnections between EU Member States networks and of greenhouse gas savings (already strong in the TYNDP) and the impact of local grid (microgrids) and power to heat solutions.

The capabilities to assess safety, stability and security is also evolving strongly in the EU, partly due to ENTSO-E's new adequacy methodology[5] and partly to the network codes' prescribing binding schedules to develop certain target values and methodologies. This should enable us over the coming years to define additional indicators 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 nonetheless non-trivial issues, requiring studies as well as the inclusion of data security aspects (cybersecurity).

Particular approaches could also be explored to assess deferral of traditional grid reinforcements against increased intelligence. Regarding services to the grid, the assessment is less straight forward but one could explore assessing the extra cost and spread it over the volume of energy serviced as an indicator.
A further direction for defining complementary targets would address R&D to lower the cost and improve the efficiency of technologies that enable more efficient transport of electricity in AC/DC and high-voltage/low-voltage conversion.

[5] Midterm Adequacy Forecast (ENTSO-E) 2016

Furthermore, it can be explored over the coming months to what extent a target to demonstrate by 2030 cost-competitive energy storage systems that can balance electricity production on a seasonal basis (e.g. 6 months) can be realistically defined [C12].

In this context it is important to recall that actual system costs will depend on the way the network operators, who are dependent on the cost recovery regime in place, and especially how the many different market players will deploy the new technologies (pace, scale, asset loading profile, consumer acceptance, etc.) [C13].

Comments to "Potential further actions towards additional and improved indicators":

- [C12] Looking at energy production and consumption on a seasonal basis is key, especially within a context of renewable generation, but then the time frame considered should really be one year at least. Achieving this target from the start may be ambitious, but one should certainly aim to build up the time frame over time.
- [C13] While there is a substantial need for changes to the network, there is potentially also a role to be played by governments through incentives, which are well thought through to ensure they motivate, but do not lead to abuse and adverse effects later on. Such incentives could also be used to drive a full country into the correct direction, independent of the energy company. Within this framework it is also essential that suitable data is gathered and made available to all parties. This data can then be used to improve on the existing models for new developments. Such accurate, high time granularity load curves for a large set of users in different European regions are currently not available and are essential for future improvements.

Next steps

The stakeholders agree to develop within 12 months any missing details of target values and indicators, as well as a detailed implementation plan for the delivery of these targets, determine joint and/or coordinated actions, identify the ways in which the EU and national research and innovation programs could most usefully contribute, identify the contributions of the private sector, research organizations, and universities, identify all issues of a technological, socio-economic, regulatory or other nature that may be of relevance in achieving the targets, and report regularly on the progress with the purpose to monitor the realisation of the targets and take rectifying action where and whenever necessary.

The stakeholders intend to use the European Technology and Innovation Platform on "Smart Networks for Energy Transition" that was set up on 27 June 2016, which builds on the Set-Plan EEGI, Smart Grid Technology Platform, EERA and includes additional stakeholders (e.g. EASE), as the main vehicle for discussing and agreeing on the implementation plan.

Comments to "Next steps":

- EUA-EPUE, as the European platform representing universities in energy research and education, can have an important role in advocating for fundamental research activities, as well as promoting the development of knowledge for a low-carbon society, with a particular focus on multidisciplinarity.

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Annex: Gross electricity generation from wind and solar per EU Member State in 2013

	Gross electricity generation	Wind	Solar	Total wind + solar	% wind-solar/gross electricity
	2013 (TWh)				
EU-28	**3261.5**	**235.0**	**85.3**	**320.3**	**9.8**
BE	83.5	3.6	2.6	6.3	7.5
BG	43.8	1.4	1.4	2.7	6.2
CZ	87.1	0.5	2.0	2.5	2.9
DK	34.8	11.1	0.5	11.6	33.5
DE	633.2	51.7	31.0	82.7	13.1
EE	13.3	0.5	0.0	0.5	4.0
IE	26.1	4.5	0.0	4.5	17.4
EL	57.2	4.1	3.7	7.8	13.6
ES	283.6	53.9	12.7	66.6	23.5
FR	572.5	16.0	4.7	20.7	3.6
HR	13.4	0.5	0.0	0.5	3.9
IT	289.8	14.9	21.6	36.5	12.6
CY	4.3	0.2	0.1	0.3	6.5
LV	6.2	0.1	0.0	0.1	1.9
LT	4.8	0.6	0.1	0.7	13.7
LU	2.9	0.1	0.1	0.2	5.2
HU	30.3	0.7	0.0	0.8	2.5
MT	2.3	0.0	0.0	0.0	1.3
NL	100.9	5.6	0.5	6.2	6.1
AT	68.3	3.2	0.6	3.7	5.5
PL	164.6	6.0	0.0	6.0	3.6
PT	51.7	12.0	0.5	12.5	24.2
RO	58.9	4.5	0.4	4.9	8.4
SI	16.1	0.0	0.2	0.2	1.4
SK	28.8	0.0	0.6	0.6	2.1
FI	71.3	0.8	0.0	0.8	1.1
SE	153.2	9.8	0.0	9.9	6.5
UK	359.2	28.4	2.0	30.5	8.5