ETIP-SNET VISION 2050 – INTEGRATING SMART NETWORKS FOR THE ENERGY TRANSITION

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ABSTRACT

Since 2014, the European Union's strategy is clearly formulated: we need to drive a clean, secure and efficient energy transition to face climate and energy challenges. It is reinforced by the strong commitment of the European Union to the 2015 Paris Agreement. Therefore, in November 2016, the Commission proposed an ambitious "Clean Energy for All Europeans" package. Therein, all relevant meetings, summits and measures started from a simple observation: "It is in everyone's long-term interest to have a rapid and orderly transition towards a cleaner, more sustainable and less carbon intensive energy future." However, this apparently simple observation requires us to consider numerous challenges: i) Moving towards a low carbon energy sector; ii) Creating a pan European integrated energy system and iii) Mobilizing public and private sectors by iv) Maintaining and extending Europe's industrial leadership. The European Commission is working on the long-term vision where all these multidimensional challenges would be addressed by a single coherent plan.

This paper describes the Vision 2050, as elaborated by the European Technology and Innovation Platform of Smart Networks for Energy Transition (ETIP SNET), which gathered research and industry experts, European and National public authorities, European associations and other relevant actors from the energy sector to tackle the key aspects of this very complex challenge.

INTRODUCTION

The Vision 2050 is the basis for defining the specifications for further Research, Development and Innovation (RD&I) needs in the transition from today towards Europe's energy systems of the future, and its three key objectives are:

1) Protecting the environment;
2) Creating affordable and market-based energy services, and
3) Ensuring security, reliability and resilience of energy supply.

Figure 1 shows the differences between the current energy system and the one required to support 2050 energy targets. The latter should be almost fully decarbonized, where distributed power conversion and flexible energy storage take a key role, by contributing to a fully integrated

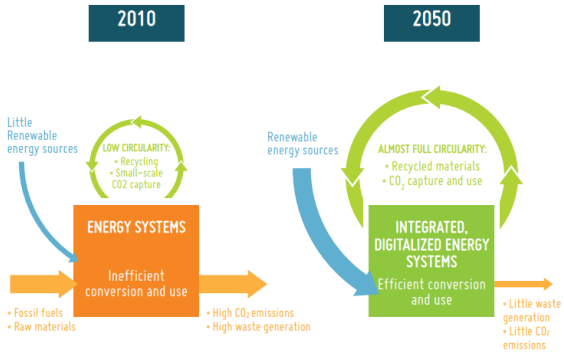

Fig 1. From the past quasi-linear to the circular economy in 2050 [1]

energy system.
The vision directs the transformation of EU Energy policy targets into concrete research and demonstration efforts:

- For mid-term efforts: the 10-year RD&I roadmaps will support the Vision towards achieving fully-integrated, grid-based energy systems with electricity infrastructures as the backbone of Europe's energy markets. Regular updates and significant extensions of any non-resolved, specific RD&I activities will enable Europe to cover gaps by means of distinct projects suitably-funded from all possible public and private sources.
- For short term efforts: The ETIP SNET Implementation Plans will set Europe's RD&I priorities for a smarter energy transition as specified in the ETIP SNET 10-year RD&I roadmaps. Such plans have a time horizon of approximately two-three years. They present the short-term key RD&I priorities to enable the progressively-intensified transition towards reliable, secure, resilient, market-based, sustainable, renewable and circular European energy systems, at affordable costs. This relation is illustrated in Fig 2.

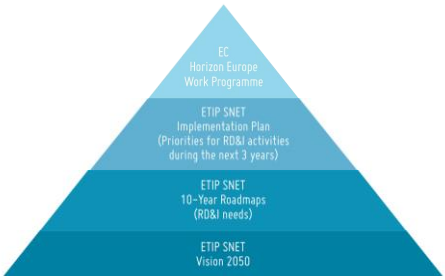

Fig 2. ETIP SNET Vision, Roadmaps and Implementation Plans as basis for EC Work Programmes [1]

ENERGY SYSTEMS FOR EUROPEAN SOCIETY

The Vision emphasises the role of energy and more specifically of clean energy systems to meet citizen needs, fully in line with the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development as set by the United Nations (UN) and the European Union energy policy.

Ensuring security, reliability and resilience of energy supply

In 2050, locally available energy resources are used to their full economic potential. Energy systems' planning and operation processes ensure high overall system reliability, a holistic approach to system security of supply is applied across all energy systems, and the reliability and resilience of energy systems are part of an integrated strategy for all modes of energy systems use.

Protecting the environment

In 2050, the mitigation of environmental impacts from energy systems is supported by Technologies and market-based incentives allowing for fossil-free EU energy systems. Energy generation, storage, power conversion, and consumption equipment, grids and Information and Communications Technology (ICT) equipment, monitoring and control (automation) devices, all designed and manufactured to be almost fully recyclable. Europe as a global leader for carbon-neutral energy systems, based on an integrated energy systems' policy harmonised across European countries.

Affordable and market-based energy services

Citizens can make informed choices about any energy-related need, with tailored information services and infrastructures using continuous, secure and robust high-speed communication technologies for energy-related applications. Prosumers can sell and purchase anytime their energy, through integrated infrastructure for all energy carriers (including storage and power conversion) with the electricity system as the backbone. Imbalances between electricity generation and demand are handled automatically using market-based mechanisms which consider forecasted weather conditions and system operational states and available energy from storages. Enhanced smart metering systems will enable the transition to higher granularity of the information exchange and ultimately unlocking the path towards local energy communities. Smoothly interacting, resilient and reliable grid-based energy management systems are operational at all network levels to handle energy-related needs for all types of grid users and at all time-scales. This includes the provision of redundant or backup-energy if there are deviations from the planned as well as the resilient and reliable handling of any operational grid issues.

TOWARDS INTEGRATED ENERGY SYSTEMS IN 2050

Achieving the IEA (2017) "Beyond 2 Degrees Scenario" (B2DS) in 2050 will require moving toward a low-carbon economy with major innovations and deployments in energy efficiency, renewable energies, fuel switching, and Carbon Capture and Use (CCU). This will require fundamental changes to energy systems with all available technologies in order to reach the goal of a carbon-neutral power sector by 2050. Major changes are necessary for mobility and for heating and cooling; many of them imply intensified electrification with the integration of renewables. Furthermore, low-carbon energy systems will require a high level of integration to supply all sectors of

the economy, leading to a complex "system of systems". This high level of integration will be achieved through the deployment of power conversion units enabling the coupling among all energy carriers and the installation of storage units for each energy carrier, thus enabling higher security of supply. This will be facilitated by integrating storage and power conversion with the various energy carrier grids using the electricity system as its "backbone", and electricity will be stored by conversion of Power-to-Gas (PtG), Power-to-Heat (PtH), and Power-to-Liquid (PtL). Other examples of energy storage include centralised and distributed stationary batteries as well as a plethora of batteries on board electric vehicles (EVs) that can deliver services to the network. Finally, moving towards a low-carbon economy will require fully integrated energy systems able to supply at all times low-carbon energy for all sectors (households, tertiary sector, industry, agriculture and transport) from the different energy sources (hydropower, solar, wind, geothermal energy, marine energy, biomass, biogas, biofuels, and nuclear – as the only remaining non-circular electricity generation source), as well as integrating surplus heating and cooling from industrial and commercial processes.

THE BUILDING BLOCKS OF VISION 2050

In 2050, integrated energy systems (IES) consist of four inter-Connected and inter-related layers that drive economic growth and global competitiveness for Europe, presented in Fig 3.:

- The market layer allows for exchanges between market players (generators, retailers, aggregators, consumers, grid operators, conversion and storage managers…).
- The communication layer supports the vertical and horizontal integration of energy systems and the relaying of information with the market.
- The physical system layer consists of automated energy infrastructures (generation, power conversion, storage and networks) designed to meet citizen needs.
- The digital infrastructure layer supports network operations to manage the integrated energy systems with higher levels of automation, vision and accountability.

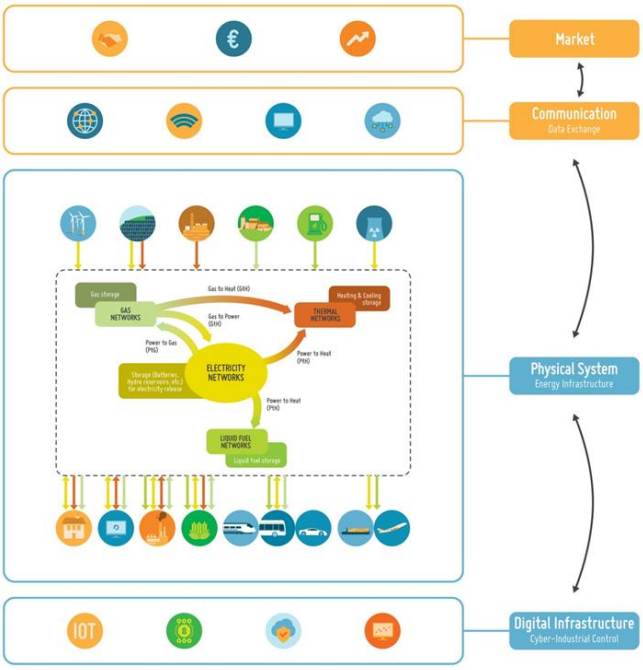

Fig 3. The four layers of integrated energy systems [1]

Consequently, the Vision 2050 relies on the following building blocks:

- **Enhancement of the integration of the different energy networks** at any scale and considering the most cost-effective way and using new infrastructures for mobility.
- **Higher degree of automated management and contro**l of all energy network users.
- **Efficient wholesale markets** in a context of nearly 100%-renewable energy mix and fluctuating, non-dispatchable generation.
- **Development of local markets** providing high quality of service and economical supply for local prosumers.
- **Digitalisation** [2] **as a major role in integrated energy systems**, supporting the provision of new services, while ensuring data privacy and ownership for all stakeholders and enhancing cybersecurity. The information is generated and collected by connected devices (Internet of things, IoT). A large amount of data is provided by smart meters and sensors in the network for real-time monitoring and control. Analytics are used to generate information to support network operators and market stakeholders to improve the efficiency of energy markets. Connectivity allows for the exchange of massive data between humans, devices and machines, including machine-to-machine (M2M) through digital communication networks.

- **Development of electricity infrastructures: the automation of the entire power system and customer plants** is the key for the large scale integration of the distributed energy resources and a prerequisite for the successful market design, the effective implementation of digitalisation, and for the effective use of the available pan-European grid capacities; All of this should be completed in a fashion which demonstrably occurs in the correct place at the correct time for best economic impact.
- **Storage and conversion technologies are deployed widely** with all the possible couplings between electricity, gas and heating and cooling networks, and infrastructures to tap into local resources.
- **Energy is used more efficiently within several sectors:**
  1) Buildings, by the improvement of the management of the energy demand, including waste heat recovery and integration for economies of scale,
  2) Industry: diversification of heat and electricity supply from renewables, including waste heat recovery.
  3) Mobility: utilisation of electricity, liquid carbon-neutral fuels and gases; and
  4) ICT: minimisation of the energy consumption, re-use non-avoidable waste heat in district heating networks.

THE FRAMEWORK FOR VISION 2050

The Vision 2050 calls for a framework:

- **Maintaining and enlarging the European leadership in the world economy** through its expansion in integration of energy conversion processes with storage, distribution and transmission of all energy carriers, RD&I activities and standardisation processes;
- **Adapting education and training** to consider the high system complexity and automation requirements by developing new programs and simulation tools for students and professionals;
- **Fostering new businesses creating jobs,** thus supporting growth thanks to the digitalisation of the energy system and the development of new energy markets;
- **Accelerating deployment of the results from RD&I projects** along the value chain (test, demonstration, validation) by adapting the funding mechanisms addressing in particular high-risk innovation.

CONCLUSIONS

To reach the goals set out in this Vision 2050, there is an urgent need to act today in a fully coordinated way, thereby considering the RD&I priorities and needs of the ETIP SNET stakeholders and beyond. This requires a fully-coordinated participation of all stakeholders in all energy systems areas, avoiding silo visions, missions, roadmaps and implementation plans. The ETIP SNET is engaged to facilitate the coordination and to provide guidelines and recommendations to stakeholders including National governments, to guide their way towards achieving the integrated Vision 2050. The ETIP SNET is now developing the Mission-oriented objectives towards 2030, as well as the next ETIP SNET 10-year RD&I Roadmap.

ACKNOWLEDGMENTS

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