ENERGY SYSTEM INTEGRATION: RESEARCH CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

These are unprecedented times for the future of Europe: the need to drive the post-COVID recovery on a sustainable path and the parallel preparation of the 2021-2027 EU budget and R&I programmes have the potential to give a real boost to the achievement of the European climate-neutrality objective by 2050.

EU policymakers have confirmed their commitment to drive the economic recovery through sustainable, green investments and digital development by reaching an agreement on a bold EU budget and Recovery Plan. Despite the heavy cuts to the Horizon Europe budget, the energy sector remains one of the main areas of action to significantly reduce CO2 emissions while boosting economic recovery. As part of the European Green Deal[1], the adoption of new political strategies will help guiding investments and regulation in the fields of energy system integration, industrial policies, circular economy and more.

There is therefore a momentum to identify the R&I challenges and industrial opportunities of tomorrow and to coordinate efforts towards the achievement of new energy and climate priorities in Europe. **The research community has a key role to play**, both in advancing research on identified political priorities, as well as in advising policymakers on the way forward through excellent fundamental research and focus on low TRLs for the advancement of new breakthrough technologies, materials and systemic approaches.

Prepared within the framework of the SUPEERA project[2], this series of policy briefs aims at identifying in latest EU policies relevant to the energy research community concrete R&I challenges towards the achievement of the Clean Energy Transition. The analysis of the policies identified will have the two-fold objective of supporting recommendations towards the EERA membership and the SET-Plan ecosystem at large, as well as to identify potential areas for investments in energy R&I for EU policymakers. Specifically, this paper will focus on the Energy System Integration strategy, published on 8 July 2020 by the European Commission, as a key European Green Deal measure for a cleaner energy sector.

[1] COM(2019) 640 final
[2] https://www.supeera.eu/

Energy system integration strategy: rethinking the system to achieve climate neutrality

The European Commission's Energy System Integration Strategy[3] is a policy document outlining its **vision on how to accelerate the transition towards a more integrated energy system** to achieve higher decarbonisation objectives for 2030 and climate neutrality by 2050.

The strategy is organised around six major pillars that will guide EU actions in the months and years to come. The table below provides an overview of the strategic pillars and the related areas for development as defined by the European Commission in the document. They are reported as identified R&I challenges, as our analysis focuses only on the areas for future EU action with the highest potential for further improvements through research and innovation actions. The measures involving actions outside of the scope of R&D activities, e.g. related to market regulation or deployment of already existing technologies, are not included in this analysis.

Pillar of the strategy	Identified R&I challenges
A more circular energy system, with 'energy-efficiency-first' at its core	1) Apply the **energy-efficiency-first principle consistently across the whole energy system**, including giving priority to demand-side solutions whenever they are more cost effective, but also properly factoring in energy efficiency in generation adequacy assessments. 2) **Increase use of local energy sources in buildings and communities** by applying the principle of circularity and reuse of **waste heat** from industrial sites, data centres, or other sources. 3) Untap use of **wastewater and biological waste and residues for bioenergy production**, including biogas.
Accelerate the use of electricity produced from renewable sources	1) **Tackle barriers preventing massive roll-out of renewable electricity:** high costs for some less mature technologies, lack of public acceptance, underdeveloped supply chains, smarter grid infrastructure at national and cross-border level. 2) Development of technologies for **higher temperature heating** (such as microwave or ultrasound) and for electrifying processes by electrochemistry. 3) **Offshore technology**: become a global leader by increasing offshore electricity production and creating opportunities for the nearby localisation of electrolysers for hydrogen production. 4) **Electric mobility**: develop smart charging and Vehicle-to-Grid (V2G) services to manage grid congestion and limit costly investments in grid capacity.
Promote renewable and low-carbon fuels, including hydrogen, for hard-to-decarbonise sectors.	1) **Unlocking the potential of low-carbon fuels** (biofuels and synthetic fuels), including through hybridisation projects linking biofuels and renewable hydrogen production. 2) Promoting the use of **renewable hydrogen in hard-to-decarbonise sectors**, in particular as a fuel in certain transport applications and as a fuel or feedstock in certain industrial processes 3) **Enabling carbon capture, storage and use to support deep decarbonisation**, including combining it with renewable hydrogen to produce synthetic gases, fuels and feedstock.
Adapt energy markets and infrastructure to a	1) Making **electricity and gas markets fit for decarbonisation**, also by projecting the future mix of gaseous energy carriers – biogas, biomethane, hydrogen or synthetic gases – depending on the chosen decarbonisation pathway.

[3] COM/2020/299 final

more complex, integrated energy system	2) Develop system flexibility by means of small and large scale storage technologies to appropriately handle varying production and consumption balancing needs
Achieving a more integrated energy infrastructure	1) Facilitate **integration of various energy carriers** through infrastructure planning, including both the development of new infrastructure and re-purposing of existing ones. 2) Consider **alternatives to network-based options**, especially demand-side solutions and storage. 3) Develop **new dedicated infrastructure**, including those for large-scale storage and transportation of pure hydrogen; CO2-dedicated infrastructure, transporting CO2 across industrial sites for further use, or to large scale storage facilities.
A digitalised energy system and a supportive innovation framework	**Further unleash the potential of digitalisation** in relation to: 1) **dynamic and interlinked flows of energy carriers;** 2) **provision of data** to match supply and demand at a more disaggregated level and close to real time; 3) enabling a **flexible energy consumption** to contribute to the efficient integration of more renewables.

Short-term measures should not take over the research for long-term solutions

The table above summarises some of the main areas for action, where research can play a substantial role to bring forward energy system integration towards the 2050 climate objectives. Yet, the key measures planned by the Commission services for the implementation of these strategic areas rarely mention Research and Innovation as an important means to further address the energy system integration challenge. However, Horizon Europe as well as other R&I oriented funding programme (Innovation Fund, Invest EU, LIFE) are specifically mentioned as tools for advancing the strategic actions identified mainly in relation to the promotion of renewable and low-carbon fuels, including hydrogen, and for the electrification of low-temperature process heat in industrial sectors.

Easily deployable innovation measures, and the relative changes to legislation to make them possible in the short-term, have the potential to provide a boost to the energy transition and the green recovery, however they should not take over research for long-term solutions.

For instance, research on technology and methods to integrate fluctuating renewable energy sources in the energy system can improve aspects related to the limited predictability of **renewable energies** feed-in.

With reference to the development of the **hydrogen market** in Europe, innovative and robust open cross-sectoral modelling is needed to identify the optimal share of hydrogen in the overall energy system. Models should be formulated in a technology-neutral way, including considerations on the associated infrastructure needed, or on the roles and potentials of other energy vectors so to avoid missing other relevant options. Accessible and reliable databases with the relevant datasets for cross-sectoral modelling should be developed, especially industry- and processes-related datasets.

Similarly, the development of an integrated all-renewable **energy market**, its design and regulation, will need to ensure system adequacy, short-term (operational) efficiency and an optimal mix of different energy sources, energy carriers and flexibility options. Therefore, analyses on market structures and incentives for system friendly investment will need to be continuously developed.

This research goes hand in hand with the need for a long-term vision for **energy infrastructures** in Europe that could combine electricity, hydrogen, heat, liquid fuels and other energy carriers in the best suited mix to connect energy sources with consumers. The development of new technologies should also consider already at the start social and energy system aspects, as well as their indirect cross-influences on other technologies.

Conclusions

The Energy System Integration strategy put forward in the wider framework of the European Green Deal identifies clear areas for coordinated actions in the years to come to move from an energy system developed vertically and in silos to a truly integrated and efficient circular system. It does not mean that it is a task for system researchers and developers to do alone in their silo, but in close dialogue with developing the contributing technologies. The concrete measures indicated in the document to follow up on each strategic area of actions provide additional clarity to the path undertaken to achieve the objectives set.

Yet, the measures implemented will have to ensure that long-term research at low TRLs is supported in the upcoming Horizon Europe Framework Programme, as well as in other innovation-driven funding programme to both benefit from research advancements in the field as well as to inform knowledge-based policymaking to meet long-term climate objectives.

The publication of a new impact-oriented **clean energy research and innovation outlook** for the EU presented in the strategy is also welcome as a useful tool to capitalise on existing research and to ensure that finding to R&I take up innovative challenges for the future of Europe.