Key Messages

The Role of Hydrogen

Facts about System Integration

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Facts about System Integration

Hydrogen is enjoying a period of renewed attention in Europe and around the world. Yet, hydrogen currently represents a modest fraction of the global and EU energy mix and is still largely produced from fossil fuels – notably natural gas and coal – resulting in the release of 70 to 100 million tonnes of CO_2 annually in the EU[1]. For hydrogen to contribute to climate neutrality its production needs to expand to a much larger scale, become fully decarbonised and find a cost-effective place in the electricity system.

Achieving the EU's climate neutrality objectives in a timely, cost-effective manner while ensuring secure and affordable energy requires a well-integrated energy system that links different sectors and harnesses synergies between electricity, gas, hydrogen, transportation and industry. In this 'one system of interconnected systems', electricity becomes the dominant vector for clean energy production. The Pan-EU cyber-physical grid plays a central role in transporting energy from renewable energy sources (RES) and serving multiple sectors.

Enabling a smarter, more integrated and optimised 'one energy system view' requires an appropriate regulatory framework for hydrogen as well as for each of the elements that constitute the electricity system. This framework must provide a level playing field for different energy carriers to compete on and must support coordinated decarbonisation.

ENTSO-E has formulated recommendations for policymakers on:

› The new roles of hydrogen

Hydrogen is a tool for reaching decarbonisation targets and not an end in itself

› Where we are now and the next steps towards bigger hydrogen

The business case to use hydrogen in an electricity system operation support function does not currently exist

› Planning and operating hydrogen in 'one system of systems'

A unified system perspective (one system view) is necessary

1 Source: A hydrogen strategy for a climate-neutral Europe, European Commission, 2020

The new roles of hydrogen

Hydrogen is a tool for reaching decarbonisation targets and not an end in itself

› **Hydrogen is a tool for reaching decarbonisation targets and not an end in itself. It should be benchmarked against other available options.**

An overarching objective of the EU is to reach carbon neutrality by 2050 to remain in line with the Paris Agreement. To do so, Europe must reduce its GHG emissions by at least 55 % by 2030. Hydrogen in its fossil form ('grey' or 'black' hydrogen) has been used as a feedstock in industries such as petrochemicals and fertilisers for many years. The widespread use of a new decarbonised form of hydrogen across different sectors must be benchmarked against other possible options that could have the same decarbonisation impact.

› **Direct electrification should be prioritised as the most energy efficient solution. Molecules such as hydrogen should be used to support decarbonisation in sectors of the European economy when direct electrification is not technically viable or cannot be implemented cost-efficiently.**

Decarbonisation efficiency, in keeping with the "Energy Efficiency First" principle, can be effectively achieved while complementing other energy efficiency measures by electrifying applications and processes – where technologically feasible and cost-efficient. Electrification reduces primary energy demand, allows direct use of electricity from RES and can in many applications represent the most economically competitive option for the future. Hydrogen from electrolysis is CO_2-free but only if sufficient electricity from RES or nuclear energy is available in addition to the CO_2-free production that would be required by other electrification trends. Moreover, hydrogen application's decarbonisation efficiency depends on the conversion losses and lower efficiency of hydrogen end-use technologies.

› **Decarbonising the already existing hydrogen demand will be key in accelerating technological maturity, reducing costs and rapidly extending its deployment into other harder to reach applications and sectors.**

Some specific applications of hydrogen, including in the steel, chemical, aviation and shipping industries, are considered hard to abate. In these cases, the use of electricity or other forms of renewable energy is not technically possible or cost-efficient. These sectors can be decarbonised with hydrogen. Furthermore, from an energy system perspective, hydrogen can play a role as an energy carrier in long-haul heavy-duty road transportation and **as a long-term storage solution that contributes to the adequacy and security of supply.**

Where we are now and the next steps towards bigger hydrogen

The business case to use hydrogen in an electricity system operation support function does not currently exist

› **It is imperative to develop the business case to use hydrogen in an electricity system operation support function. This business case does not currently exist.**

Nevertheless, future hydrogen system elements need to be planned today. Their viability, as well as impact on electricity grids, is case- and country-dependent; no “one size fits all” conclusions can be applied. Each use case must be analysed within its entire framework, boundary conditions and externalities. Such analysis goes beyond ENTSO-E activities.

› **A properly designed regulated environment is necessary to support the development of hydrogen technologies, especially in the early phase when the market is not yet ready to invest.**

Ownership and operation of electrolysers are investor-driven, TSOs should, however, be involved in line with the legal framework, especially during the take-off-phase. Furthermore, TSOs and regulators should be involved in designing the integrated energy system’s architecture, including the size, type and location of the electrolysers.

› **The EU and Member States should consider the role and impact of European production vs. imports.**

Depending on such factors as the renewable potential, future demand and production costs within European countries, some countries will be net exporters of green hydrogen while others will need to rely on imports from within or outside of Europe. Therefore, adequate and common planning criteria for the development of hydrogen infrastructures could be needed to transport hydrogen within Europe. Imports will be either green hydrogen or hydrogen-derived carriers (including synthetic methane, ammonia and methanol). This needs to be a part of the energy policies at the European level and within Member States.

› **Scale up new technologies and step-up R&D efforts**

This will be critical to unlocking an integrated energy system’s full potential by **optimising the use of existing infrastructure, ensuring secure and reliable operation of electricity networks despite energy transition challenges and operating optimally across various sectors and technologies** without increasing the overall energy system’s CO_2 emissions, thus achieving a climate-neutral Europe.

Planning and operating hydrogen in 'one system of systems'

A unified system perspective (one system view) is necessary

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As much as possible, RES energy should be used directly in a clean form of electricity to avoid transformation losses from converting electricity into other carriers and/or a gas for storage. This is a precondition to establishing a secure, energy- and cost-efficient integrated energy system.

› Making hydrogen a flexibility provider to the electrical system will require structural investments beyond the electrolysers (hydrogen grids and storage).

The need for flexibility in the electrical system is rising as additional RES are being connected. By allowing the flow of electricity between regions, the electricity network itself provides flexibility. Further flexibility can be provided by a portfolio of complementary technologies such as flexible power plants, flexible electricity demand, and pump-hydro/electricity-storage. Hydrogen fired power plants will be capable to provide electricity on demand and thus play a role in maintain today's security of supply standard in a future RES-based energy system. Moreover, electrolysers capable of meeting current flexibility requirements, when they are connected to the electricity grid, are among the new technological solutions offering flexibility services for the power system. To become a flexibility provider for the electricity system, the **hydrogen system will require its own structural investments in flexibility such as a hydrogen grid and storage, downstream of the electrolysers**.

› The operational mode of electrolysers connected to the grid will play a crucial role in the cost and decarbonisation of future integrated energy systems.

Depending on how they are operated, electrolysers can become consumers of system flexibility instead of providers (which is of crucial value for the system). This would further stress the quickly growing flexibility needs across the electricity system. A trade-off between electrolysers' economic aspects (CAPEX, OPEX, load factor) and the needs of the system is needed in any future business case.

› The location of electrolysers is a strategic structural question. Appropriate coordination between hydrogen and the electric network system operators is needed to ensure that new assets effectively decarbonise the system without increasing costs.

The location of an on-grid electrolyser determines whether electricity or hydrogen must be transported from the RES generation site to hydrogen demand centres. Defining for each asset the best location will depend on different factors such as the availability of cheap and abundant RES, transport options (electricity or molecules), industry's commitment to use and store hydrogen, the supply's energy security and infrastructure efficiency. Electrolysers' locations will play a crucial role in how they interact with the electrical system and whether they cause or relieve potential network bottlenecks and congestion. Hence, the installation and system supporting operation of electrolysers should be incentivised at locations suitable for this purpose.

› Multisectoral planning of the development of assets with a gradual bottom-up approach from regions to Europe will maximise the potential benefits of hydrogen investments.

In the future energy system, different network elements between various infrastructures **will need to be developed and operated in a coordinated way. A multisectoral planning approach**[2] to system planning will allow for delivering technically sound and cost-efficient solutions to challenges (e.g. need for grid reinforcement) as well as means to leverage opportunities (e.g. additional flexibility) from the use of electrolysers. The deployment of a future hydrogen infrastructure, new and repurposed, should also follow a stepwise approach (from local clusters, to regional clusters and then Pan-European), based on clear industry commitments. This approach could facilitate optimising locations and operational patterns while enabling a unified view on energy infrastructure planning.

2 See ENTSO-E roadmap for coordinated multi-sectorial planning, 2020

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