

Role of green hydrogen in energy transition: opportunities and challenges from technical and economic perspectives

The recently created WG C1.48 will address the relevant issue of expanding the green hydrogen in the Electricity supply and demand chain.

Hydrogen demand is expected to ramp up steeply in the coming decade from ~80 Mt in 2020 up to 160 Mt in 2030 (according to qualified consultants' studies). The wide range in demand can be explained by significant deviations in cost reductions throughout the hydrogen supply chain, as well as different outlooks on the adoption speed of hydrogen technologies. Up to 2030 hydrogen demand will remain centered on industrial feedstock, however there will be some minor demand for heavy long-distance transportation, high-grade industrial heating and some seasonal storage applications for wind and solar over-supply. However, by 2050 hydrogen applications could become more diversified, with a strong demand for long distance freight transportation, turning into a standard fuel for industrial and residential heating, in addition to its role in bulk-long duration storage of variable renewable generation V-RES, as cost parity between electrolysis and steam methane reforming (SMR) is expected to be achieved before 2050.

Today the main energy carriers across the energy sector are natural gas, oil and electricity. However, a new paradigm can be formed with hydrogen as an energy carrier replacing oil and natural gas, as well as, for long submarine links, electric cables. Coupling electricity and hydrogen supply & demand sectors can help to optimize both sectors and provide a valuable flexibility resource to balance much faster dynamics in electric networks.

Modern electrolyzer technology supports fast reaction time and ramping making it a possible candidate for fast frequency control while simultaneously working on a seasonal cycle. Scaling up electrolyzer plants from few MWs to hundreds of MWs may require (depending on their location along the supply chain) a dedicated connection to high voltage transmission grid. Grid code compliance at plant level will be one of the key aspects to address. Provision of new flexible system services, such as congestion management or frequency response, is another aspect that needs to be examined as potential source of revenue stream for the plant owners while deferring or substituting investment in grid expansion.

Having these factors in mind, and also considering possible step developments of the green hydrogen technology which may shorten its commercial full feasible use, the main objectives of this new Working Group are: (a) collect and analyze numerous studies related to technical and economic aspects of hydrogen supply chain and use, as well as supporting national policies and implementation strategies; (b) present different use cases in industry, transport, heating sectors and as energy storage and other system services including renewable electric energy supply needs, land and water requirements, and (c) recommend technology solutions for grid code compliance and enable market-based provision of various local and system wide flexibility services by large scale electrolyzer plants.

The following topics will be explored and elaborated within the Working Group:

Overview of hydrogen supply chain, which includes production, conversion, transport and storage. Special attention to pipeline/ship transport feasibility and comparison to power line transmission in terms of efficiency.

Forecasting hydrogen demand and a corresponding amount of renewable electric energy supply and installed capacity which can be translated in land requirements. Regions/countries can be classified as potentially self-sufficient or having deficit or surplus in terms of hydrogen production by means of wind and solar generation to achieve full decarbonization of all sectors.

Identification and analysis of specific use cases in terms of economic value of green hydrogen (drivers, break-even compared to alternatives, load factor depending on operating modality).

Review of technologies for scaling up electrolyzer plant capacity, including interface to transmission or distribution grid, power quality management, cost efficient and reliable on-site connection to the grid.

Evaluate a future role for green hydrogen and its derivatives (synthetic gases and liquids, e.g. ammonia) as:

- > a. Clean feedstock and fuel to replace conventional, fossil fuel based "grey" hydrogen production such as SMR or combustion/chemical reactions of hydrocarbons by green hydrogen in petrochemical, iron/steel, heating and long-haul freight transport segments which are hard to decarbonize by a direct use of electricity.
- > b. Long-term energy storage (weeks, months) for a seasonal balancing of variable RE sources. Low-cost storage is only achievable if using underground reservoirs – salt caverns, depleted gas fields, etc. which do not have an even geographic distribution. Identifying optimal sites, their connection via gas or transmission networks as well as operating principles. Analyzing a complementarity between various energy storage technologies such as batteries, pumped hydro and hydrogen.

- > c. Alternative energy carrier for transporting renewable energy converted to hydrogen over long distances solving temporal and spatial mismatch of VRES and demand. The transport options may include liquid hydrogen tankers, trunk pipelines, etc. Special focus on off-shore wind conversion to hydrogen offshore (electrolyzers installed directly on off-shore platforms) or on-shore (electricity first transmitted to shore).

Identify region/scenario dependent optimal mix of interconnectors, storage including hydrogen and demand response in collaboration/follow-up with WG C1.44. Location of electrolyzers (next to electricity production or to hydrogen consumption) is a major issue

Overview of governmental policies and implementation strategies in different regions (inputs will be provided by regional WG representatives), Guarantees of Origin (GoO) and green gases taxonomy, allocated budgets and support schemes, technology development focus areas and applications of highest priority.