CHALLENGES AND BENEFITS OF GREEN HYDROGEN PRODUCTION UTILISING RENEWABLE ENERGY THROUGH THE GRID

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ABSTRACT

Hydrogen plays a vital role in the global transition to sustainable energy and is a critical enabler for achieving net-zero emissions economies. Hydrogen enjoys many characteristics that makes it ideal in the energy transition: It can act as an energy carrier, allowing the transfer of energy from one place to another and can boost the decarbonization of entire industrial sectors and combat climate change. Hydrogen production from renewable energy (RE) enables the storage of RE sources and enables the flexibility to transfer energy across sectors and locations [1]. Hydrogen also helps in balancing the power network by integrating unstable renewable sources into the energy system, hence achieving a stable energy supply. Hydrogen is being considered as a very important vector for decarbonizing energy systems towards 2050. The European Green Deal, published in 2019, enacts the European Union (EU) policy shift towards net-zero emissions [2]. Hydrogen has been identified as a key building block in the European energy transition, which requires full assessment of its limitations and uncertainties, relevant to its versatility as an energy carrier, and as a feedstock to produce other fuels and industry products [2]. Currently most of hydrogen is produced from fossil fuel, which entails the emission of CO2 gases, or utilization of Carbon Capture and Storage (CCS), which adds to the cost of production. However, there are other challenges and uncertainties associated with this transition, especially the marginal abatement costs of reducing the last 10-20% CO_2 emissions [3]. The best alternative is the production of green hydrogen utilizing renewable energy from the grid, however, there are also challenges and benefits to this approach which are discussed briefly in this work.

Challenges to the energy system due to green hydrogen production

Producing green hydrogen through electrolysis of water using renewable power from the grid puts more pressure on the grid and creates challenges to the energy system such as:

1. Energy Losses: If large-scale hydrogen production puts additional strain on the grid, it could lead to increased energy inefficiencies.
2. Infrastructure Challenges: Scaling-up hydrogen production requires infrastructure development, including additional compressors, etc. This can strain existing grid resources.
3. Environmental Considerations: There may be emissions associated with the production process even in the case of green hydrogen production such as hydrogen leakage [4].
4. Grid Congestion: If hydrogen production increases significantly without proper planning, it could lead to grid congestion and affect overall reliability.

Benefits to the grid due to green hydrogen production

Increased hydrogen production from the power grid can also create some benefits that support the power grid such as:

1. Grid Balancing: Hydrogen can act as a responsive load, balancing supply and demand by absorbing excess electricity during off-peak hours and releasing it during peak demand.

2. Enhanced Grid Stability: Integrating hydrogen systems can enhance grid stability, especially when dealing with variable renewable energy sources, using hydrogen to generate electricity through fuel cells when the supply of RE is interrupted [5].
3. Reduced Curtailment: By utilizing excess renewable energy for hydrogen production, we can reduce curtailment (wasted energy) and maximize resource utilization [5].

Assessing the requirement for new hydrogen installations

In this work, the following aspects were recognized as highly important to assess the requirement for new hydrogen installations:

1. Needs for new renewable energy generation and grids to support new hydrogen installations.
2. Assessment of the technical ability of hydrogen systems to provide flexibility/grid services to the energy system.
3. Evaluation of the economic benefits of providing grid services vs. normal operation
4. Evaluation of energy storage (H2 and/or electrical) for flexibility in production and cost containment
5. Consideration of actual use-cases to assess e.g. the local grid constrains and operation modes of the hydrogen systems.

Concluding remarks

It is important to assess the technical ability of hydrogen to provide grid services as well as to evaluate the economic benefits of providing grid services and comparing that to the normal operation by comparing the costs of implementing grid services, including infrastructure and operational expenses, with the expected benefits such as revenue, cost savings, reliability improvements, in a cost-benefit analysis, using proper tools. This also involves analyzing cost savings, revenue generation, reliability improvements, and environmental impact. Life cycle analysis (LCA) techniques are instrumental in evaluating the environmental impact of hydrogen energy systems.

Energy storage (H2 and/or electrical), for flexibility in production and cost containment, are also evaluated using actual use-cases to assess e.g. the local grid constrains and operation modes of the hydrogen systems.

This work aims to provide input to the hydrogen sector by informing strategic decisions, fostering innovation, and promoting a greener, more resilient energy landscape. Guidelines generated from the research results are instrumental to assist decision makers in planning for increased green hydrogen production.

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