

RETHINKING THE WAY TO DECARBONIZE THE ENERGY SYSTEM: PROSPECTIVE STUDY OF HYDROGEN MARKETS ATTRACTIVENESS

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Overview

To fall in line with decarbonisation targets expected worldwide, most energy mixes must undergo transformations with country-specific energy transition pathways. “*Renewable energy sources are at the forefront of the drive to decarbonize the power system*” [1], mainly solar and wind which are expanding rapidly. Unlike electricity production from conventional energy sources, intermittent renewable energy is largely non-dispatchable. Its production is variable and sometimes hard to predict. This uncertainty caused by renewable production may trigger new challenges to the power system safety and the electricity supply quality.

In order to optimize the power system from an economic and technical perspective, flexible resources are needed. They can be provided by the power system itself (interconnections, storage, flexible dispatchable power plants, or demand side management), but additional flexibility will be required in order to absorb greater amounts of renewable energy, which are expected in the years to come. In this context, rethinking the way the energy system is managed may be crucial.

In this perspective, hydrogen systems can be key enablers to promote promising synergies between sectors. Indeed, producing low-carbon hydrogen from low-carbon resources such as renewable energy (wind, solar, biogas) or nuclear energy [2],[3], or from natural gas coupled with carbon capture and storage, offers a new approach to energy storage, and makes it possible to link the different energy sectors together due to hydrogen versatility [12]. As a matter of fact, hydrogen demand is expected to grow significantly in the forthcoming years due to various kinds of demands, both as a chemical product and an energy carrier [1],[4].

This paper investigates the opportunities provided by hydrogen demands and usages in different regions.

Methods

Hydrogen is both a chemical product and an energy carrier. First, it can be used in its traditional markets. Today, it is mainly present as a chemical product with 80% of its global consumption attributed to refineries and ammonia production [1]. However, in the future, this trend is expected to change with an increasing use of hydrogen as an energy carrier.

The first part of the study is a prospective analysis carried out to identify the future markets for hydrogen. Market segmentation is then proposed. Hydrogen systems allow a wide range of applications. The focus is put on three key markets, which are 1) industrial markets, 2) hydrogen for mobility use, 3) and injection in natural gas networks [1],[5],[6],[11].

The aim of this paper is then to evaluate the potential “attractiveness” of each of the hydrogen market segments identified. The “attractiveness” of a given market is defined through two market indicators:

- The prospective market volume that provides some insights about the amount of the outlets for hydrogen,
- The market target price that informs about the accessibility of the market: the highest the market target price, the easiest hydrogen supply will be able to compete.

These two indicators are derived from prospective scenarios design. As regards the market target price, development of target price models will be realised according to the considered market. The target price will be defined based on the main current competitors for existing markets. Price projections (e.g. for electricity, oil and gas) are based on the IEA scenarios [7]. For mobility, both the existing competitors (fossil fuel cars) and the emerging ones (mainly the electric mobility) will be considered.

Regarding the prospective market volumes, national scenarios will be analysed for different countries [8],[9],[10] in order to evaluate the prospective market volumes for each area. The carbon mitigation potential will also be taken into account, namely through the CO₂ price, to assess the sensitivity of the market attractiveness to the public environmental policies.

The analysis will be conducted for different time frames (2030, 2040) and geographic areas (USA, Europe, Japan and China) with a ranking of the most promising identified regions.

Results

From a short term perspective, industrial markets will continue to play an important role in driving hydrogen production worldwide. These markets are already mature and represent nowadays the majority of hydrogen consumption.

In the mid to long term, mobility usage (mainly via fuel cells) provides the most promising perspectives for hydrogen use. As a matter of fact, this is the market segment demonstrating the highest market size, together with the highest target price in 2040, hence most accessible. This sector is rather sensitive to the engine efficiency, the competition with low carbon mobility (electric cars, battery sizes/autonomy), and the oil and carbon prices which are decisive to enhance the hydrogen competitiveness compared to fossil fuels. Among the studied geographic areas, the most promising regions for these market segments are Japan and Europe.

The injection of hydrogen in the gas networks can be a significant step towards interconnecting the energy sectors, thus rethinking the energy system and the way to decarbonize it. However, competitiveness on this market segment is tough since gas is an inexpensive energy carrier in most regions, and is expected to remain so.

Conclusions

Hydrogen systems are promising pathways to foster the transition towards a decarbonized energy system. Thanks to its versatility, hydrogen enables to link different energy sectors allowing a multi-sectorial decarbonisation (electric system, mobility, gas network...).

The “attractiveness” of market segments may vary from one geographic area to another due to local contexts (oil and gas prices, renewable energies penetration, policy support). However, the expansion of hydrogen systems will be largely driven by government incentives otherwise their economic competitiveness may take much more time to be settled. In particular, the carbon price as well as oil and gas prices will be determining drivers. Hydrogen infrastructure development is also important in order to start the market expansion.

Future works will investigate the low-carbon production of hydrogen to answer the hydrogen demand. One key aspect will be to consider the balancing services provided by hydrogen production to the electric system, in the context of increasing renewables.

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