Renewable hydrogen for industrial decarbonisation

Context to the study:

- Complete decarbonisation of all sectors of the economy is essential to limit the global temperature rise to 1.5 C.
- Industries emit 25% of the global GHG emissions by using fossil fuels as chemical feedstock and as a source for high-temperature heat.
- Some industrial processes cannot be decarbonized by renewable electricity.

Summary of findings:

- Renewable hydrogen is one of the alternatives to decarbonise energy-intensive industries (EII's)as it can be used to replace fossil fuels used as chemical feedstock, reducing agent and as source of high temperature heat.
- The large-scale generation and storage of hydrogen for application in the EII's could provide flexibility to the electricity grid.
- The use of hydrogen in the EII's could reduce the cost of electrolyser and other components, making hydrogen cost competitive with fossil fuel alternatives.
- The capital and operating cost of hydrogen-based industrial processes is higher than the fossil fuel-based processes, resulting in increased cost of the products.

Introduction

The industrial sector is responsible for 17% of the total energy related emissions in the EU. Transitioning EU industries towards climate neutrality is one of the main objectives of the EU's industrial strategy [1]. While improving the energy-efficiency and electrification have resulted in substantial emission reduction in the past decade, innovative processes would be required to decarbonise the industrial sector completely. Industries such as iron and steel, chemicals, cement etc. use fossil fuels as chemical feedstock and as a source of high-temperature heat. Renewable hydrogen, produced from the electrolysis of water, using renewable electricity could decarbonize the hard to abate industrial processes like ironmaking, ammonia and methanol production, petrochemical refining, and can be used as a source for high-temperature heat generation for industrial processes [2].

Application of hydrogen in Industrial processes

At present, 70 Mt/yr. of hydrogen is produced globally [3]. Majority of the hydrogen is produced through the steam methane reforming (SMR) of natural gas, and coal gasification, which leads to the release of 830 Mt CO2 annually [2]. The EU Hydrogen strategy [4] has set an ambitious objective of producing one Mt of renewable hydrogen annually in the EU in the first phase (2020-2024) [4]. Renewable hydrogen could directly replace hydrogen produced from fossil fuels. Yara and Nel are setting up a 5 MW electrolyser plant to study the feasibility of green ammonia production in Norway [5]. New industrial processes, such as hydrogen direct reduction of iron ore (HDRI) to produce green steel are also being explored in the EU. A pilot plant has been commissioned in Sweden under the HYBRIT project, and industrial level production is planned to take place by 2030. In Germany, an existing blast furnace has been converted to replace carbon with hydrogen in the reduction process [6]. More than thirty industrial partners have formed a consortium to explore the feasibility of using hydrogen as a source of high-temperature heat in the industrial processes [7].

Why should we start with hydrogen in the Industries?

There are many benefits with the introduction of renewable hydrogen in the industries, before expanding it to other demand sectors like transport, building heating etc. First, industrial hydrogen demand can be met by on-site hydrogen generation avoiding the cost

ENSYSTRA

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of expensive transport and distribution infrastructure in the short and medium term. Second, industries have experiences with safe handling of hydrogen and can help with the development of safety guidelines for other sectors to follow. Third, large-scale integration of renewable hydrogen with industrial processes could result in eduction of costs for electrolysers due to economies of scale, which could make renewable hydrogen more cost competitive in other demand sectors. The alternative decarbonization technologies for the industrial sectors are more expensive or are at a nascent stage of development (e.g. molten metal electrolysis of iron ore, carbon capture and storage). The switch to hydrogen in industrial processes, can provide a strategic advantage to the EU industries, as EU industries can leverage a well-developed hydrogen value chain compared with the rivals in other regions. In addition, the integration of renewable energy generation with the industrial scale renewable hydrogen production, may reduce renewable energy curtailment and make the electricity grid more flexible.

Renewable hydrogen application in the Industries: Challenges

While using hydrogen in the industrial processes has numerous advantages, its implementation in the industrial sector has a few challenges.

Availability: We can take an example of the steel sector to illustrate the issue of availability of large amounts of renewable hydrogen in the short and medium term. Replacing coke with hydrogen in the iron-making process would require 4 MWh of electricity per ton of liquid steel. An additional 390 TWh of renewable electricity would be required to produce the hydrogen required for the steel produced in the EU in 2019 [7].

Higher capital and operating costs: Industries operate in cost-sensitive international commodity markets. The capital cost of installing and commissioning new hydrogen based industrial processes is higher than that of the conventional processes. Electricity costs constitute major proportion of the operational costs. The operational costs could be higher than fossil fuel-based technology costs in most regions in the EU. The low efficiency and lifetime of electrolysers increase the operational costs. The higher capital and operating costs could result in an increase in the cost of the product, up to 30% in the case of steel produced through the hydrogen direct reduction route.

Technical challenges: There are still technical challenges related to the integration of renewable hydrogen in the industrial processes. In HDRI based steelmaking, there are still technical challenges related to heating of hydrogen stream to the reactor temperature, addition of carbon in the steelmaking process and storage of hydrogen at a large scale. The search for appropriate catalysts for electrochemical synthesis of ammonia at room temperature and pressure is still ongoing.

Policy recommendations

- → Prepare detailed roadmaps for the development hydrogen generation, storage, and distribution infrastructure at national and EU level to ensure that industries can develop their transition strategies.
- → Develop trade agreements with other countries to ensure availability of renewable hydrogen.
- → Create demand for climate-neutral or green products through public procurement and provide incentives for creation of markets for these products in the form of subsidies or tax-incentives.
- → Impose carbon border taxes to ensure that industrial products in the EU are competitive.
- → Provide funding for demonstration of hydrogen based industrial processes at a large scale and financial support for fostering partnerships.

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