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Life Cycle Assessment of hydrogen: from feedstock to storage systems

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PURPOSE OF THE ABSTRACT

As part of the climate transition plans, significant efforts are currently being made to develop the hydrogen sector. Indeed, in the near future hydrogen should be used extensively to decarbonize the chemical and petrochemical industries, as well as to be used as a non-carbonaceous fuel in heavy transport, or to be used as an energy carrier to 'store' the excess of electricity produced by intermittent energy sources such as solar or wind power. [1]

However, since there are hardly any natural sources, hydrogen must be produced first. There are many industrial methods for generating hydrogen, depending on the feedstock (e.g., natural gas, coal, biomass, water, etc.) and its production process (e.g., steam reforming, electrolysis, etc.). According to these parameters and the electricity necessary for these industrial processes, a color code is added to the hydrogen: for instance, green as the most decarbonized one, grey when it is obtained from fossil fuel or blue when a carbon capture and storage step is added.[2] In addition, France, which has developed massive use of nuclear energy, is currently trying to label this source as green.

Then, hydrogen must be stored and delivered to its points of use, whether it is an industrial site or a mobile device. However, it has a lower volume density compared to that one from gasoline, i.e. 4 kg of H2 at 20 °C and 1 bar is about 48 800 L. To that purpose, suitable pressure resistant containers must be produced, i.e. from 4 to 700 bar and down to several tens of °K, or material-based storage techniques can also be considered such as adsorbent (i.e. MOF-5) or so-called chemical hydrogen as ammoniac for instance.[3]

Thus, the cost and the environmental impacts of the production and storage of hydrogen remain an important challenge, varying according to the technological choices, the quantity to be delivered and the uses. Life Cycle Assessment (LCA) is a well-established methodology to evaluate the environmental impacts of product systems.[4] Several LCA studies have been published to assess the environmental impacts of such technologies,[5],[6] and a harmonization of LCA protocols and libraries has been proposed to facilitate their comparison and increase their robustness.[7] In this communication, we will present LCA based comparisons of environmental impacts on production and storage of hydrogen up to its point of use. It includes hydrogen from steam reforming or electrolysis from solar or wind power as well as different electricity mixes. We also discuss the greenness potential of these different technologies according to the global warming potential (GWP) as well as other impacts such as land competition potential (LCP) for example.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS
Life cycle assessment | Hydrogen

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