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Hydrogen as an alternative energy source

(#Decarbonization #Fossil Fuels #Belgium #Energy Dependency #Sustainability)

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Belgium and hydrogen: solving decarbonization issues and energy dependency?

Hydrogen has found its place in multiple discussions regarding climate change and energy dependence. It is considered as an alternative to fossil fuels and, leading us to reach climate neutrality and diversify energy sources. However, hydrogen encounters considerable challenges. Barriers such as technological issues, a lack of institutions, along with resistance from civil society are not to be overlooked.

Belgium imports most of its primary energy: "95%" according to recent figures (energyguide.be, 2022), meaning that it is highly energy dependent. However, Belgium plans to play a leading role in the hydrogen market, in order to decrease its dependency on fossil fuel imports. It is believed that Belgium could even become a world leader in the field: "due to the strategic location of its ports, the expertise of innovative companies, research centres and educational institutions, and the infrastructure and industry already in place" (Innovation news network, 2022, p.2). However, hydrogen production comes with challenges: produced partly locally, it will also mainly have to be imported since Belgium does not have enough space for hydrogen installations (Innovation news network, 2022).

Moreover, Belgium's hydrogen strategy will depend on other energy sources such as "solar and wind energy" (Whitehead, 2021, p.1). Therefore, investments in solar and wind farms and partnerships with countries with abundant sun and wind are essential. For example, Belgium has signed a "memorandum" (Werner, 2022, p.2) with Namibia on wind and solar energy, which will allow the two countries to establish "hydrogen production and transport infrastructures" (Werner, 2022, p.2). The Port of Antwerp-Bruges will play a crucial role in the Belgian hydrogen strategy: "the current capacity of Port of Antwerp-Bruges will be expanded from 2026 onwards, to receive the first green hydrogen molecules on its platform" (Innovation news network, 2022, p.2).

Defining hydrogen, energy dependency and sustainability

Hydrogen is: "a chemical that is the lightest gas, has no colour, taste, or smell, and combines with oxygen to form water" (Cambridge dictionary, 2022). Green, blue, and grey hydrogen are the most important types, distinguishable by their production process (Ewing, Israel, Jutt et al., 2020, p.2):

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- "Grey hydrogen is made by extracting hydrogen from natural gas using thermal processes such as steam methane reformation. It offers little to no climate benefit.
- Blue hydrogen is made by extracting hydrogen from natural gas, and then using carbon capture and sequestration technology to store the remaining carbon. It has a low to moderate carbon intensity.
- Green hydrogen is made by extracting hydrogen from water using electrolysis powered by renewable energy. With the lowest carbon intensity, it offers the greatest climate benefit."

Depending on its production process, hydrogen may be a good alternative to fossil fuels for climate protection objectives. Unlike other energy sources, hydrogen is abundant, meaning we would not easily run out of it (Conserve Energy future, 2022, p.4). Using hydrogen would be much better for the environment than using fossil fuels since "the use of hydrogen fuel cells does not release carbon dioxide and other greenhouse gasses or other particulates when renewable sources such as water or solar energy are used in the production process" (Conserve Energy future, 2022, p.5). Moreover, in contrast to diesel or gas for instance, hydrogen is much more efficient. Compared "to a conventional combustion-based power plant that usually generates electricity between 33 to 35% efficiency, hydrogen fuel cells are capable of generating electricity of up to 65% efficiency, having capacity about three times more" (Conserve Energy Future, 2022, p.5). Finally, hydrogen uses are very diverse: "Hydrogen can be employed as an efficient and clean source in various applications namely: fuel cells, transportation, portable applications, power, combustion and heating" (Ishaq, Dincer, Crawford, 2021, p. 26259). As a new energy source, hydrogen could also help solving energy dependency issues and sustainability objectives.

The concept of energy dependency is topical today. The war in Ukraine has increasingly shed light on Europe's dependency on Russian gas. It "can be defined as the amount of primary energy that a country needs to import in order to supply itself, whether in the form of heat, electricity or for transport. Therefore, we are talking about a country's dependence on the outside world for all the energy it consumes" (Narasolar, 2022, p.1). We must find alternatives to be less energy dependent but also, simply because we need replacements for fossil fuels under international climate objectives that steer towards a sustainability transition.

In this sense, research on sustainability transitions makes it possible to analyze how "different types and forms of agency influence the speed and direction of transitions and how they can be engaged, can be empowered, and can more effectively contribute to desired transitions. This includes an interest in processes of institutional change and structuration as well as in roles of radical outsiders, front-runners, or marginalized groups" (Loorbach, Frantzeskaki, Avelino, 2017, p.614).

Technological barriers to hydrogen development

Storage and safety are the main technological barriers to large-scale hydrogen production. Numerous technologies have been developed, yet "not been sufficiently tested for their industrial implementation" (Litvinenko, Tsvetkov, Dvoynikov et al., 2020, p. 430). In the matter of storage, the prominent possibilities are liquified hydrogen or compressed hydrogen gas. However, they are very costly, energy-intensive, and face logistical challenges (Romm, 2004): they demand high temperatures or pressures, complex and time-consuming materials, and hydrogen requires to be released at a too

slow pace (Service, 2004). Compressed hydrogen is expensive and requires sophisticated materials and components (Romm, 2004). It also takes up much more space to store (Service, 2004). A final issue is the significant loss of hydrogen in long-term storage caused by evaporation that leads to a pressure rise in the tanks and triggers a pressure relief valve (Litvinenko, Tsvetkov, Dvoynikov et al., 2020). Other means of storage should therefore be considered.

The issue of safety cannot be left out. According to Joseph J. Romm, hydrogen is highly flammable and difficult to detect since it does not have any odour nor is it visible. This has already generated accidents with people stepping into hydrogen flames unintentionally. Moreover, high-pressure storage tanks can break, and rules need to be followed meticulously when hydrogen is used. About 22 percent of hydrogen incidents are caused by hydrogen leaks that go undetected when used by professionals. This means that safety breakthroughs will have to be made if hydrogen is to be manoeuvered by the general public (Romm, 2004).

Institutional barriers

Institutional obstacles to hydrogen development concern market institutions, with price issues, and political institutions, with a lack of international cooperation and standards, along with a lack of awareness among citizens.

Hydrogen is expensive due to "the infrastructure of exporting and importing countries, the different production pathways, the distances of hydrogen distribution, the mode of transport, and the end-use demand" (Scita, Raimondi, Noussan, 2020, p.10). In contrast with fossil fuels, hydrogen has a low energy density, making it challenging to transport and store, hence the elevated costs. Moreover, efficiency losses can occur during hydrogen production, further driving up the price (Scita, Raimondi, Noussan, 2020). Furthermore, producing hydrogen is very energy intensive and therefore costly (Service, 2004, p.959). Changing the whole gas network for hydrogen distribution will approximatively cost over "£22 billion" (Phillips, Fischer, 2021, p.27).

In the prospect of using hydrogen to meet zero-carbon societies, international cooperation should be ensured. In order for actions such as storing, transporting and producing hydrogen to run smoothly, governments must trust one another: "the future hydrogen economy will be shaped by the diplomatic relations between importer and exporter countries" (Scita, Raimondi, Noussan, 2020, p.14). According to the same authors, a hydrogen market requires international cooperation and international standards. Without these, each country will start setting up its own rules with the risk of "free riding and unfair competition". Currently, the lack of regulation "limits the diffusion of hydrogen, restraining its potential". Countries must also include coordinated safety standards, operational guidelines, and an assessment of the environmental impact of the technologies used (Scita, Raimondi, Noussan, 2020).

Another blockade is people's concern when it comes to hydrogen. Most of the public does not truly perceive what renewable energy is, how it is produced, nor how it could be beneficial, leading to fears and negative views of clean energy. Hence the importance of putting educational institutions in place, since hydrogen will not go far without public's support (Ingaldi, Klimecka-Tatar, 2020). To this end, improving people awareness requires "increasing the transparency of social and environmental

factors, using simple and more readable language" (Ingaldi, Klimecka-Tatar, 2020, p.6). If such institutional measures are not developed, they will reinforce behavioral barriers.

Behavioural barrier

Public resistance to hydrogen can be explained in multiple ways. First, as discussed by Manuela Ingaldi and Dorota Klimecka-Tatar, lack of knowledge and the fear of novelty are at play. People feel more comfortable when sticking to their habits, thus with the familiarity of traditional technologies. Second, some main concerns remain about the safety and the costs of the technology. Overall, as long as those are not solved, the population will appear to be favourable to hydrogen (Ingaldi, Klimecka-Tatar, 2020). On safety, the use of hydrogen at home is still unclear. How would that work, and would citizens be at ease with such a change? Considering the manipulation of hydrogen for heating and cooking, the most unsettling aspect of hydrogen is its invisibility. When preparing your meal on a gas hob, seeing the blue flame indicates the heat level as well as of the proper function of the device. Hydrogen could be a danger for children as they would not be able to see the threat of the flame anymore and will therefore easily burn themselves. The visible gas flame is also a reminder to turn it off. With an invisible flame, people would be much less likely to react. As a result, people are not too enthusiastic about the idea of cooking with hydrogen as they do not want to jeopardize their security. Although there attempts to make the flame visible by mixing hydrogen with other elements, this however needs to be an economically viable solution. (Scott and Powells, 2020). For heating, their opinion differs, as ways of knowing the boiler works often rely on a sound (Scott and Powells, 2020).

Conclusion

Hydrogen has undeniably much potential. The transition of our societies to hydrogen-based energy is a promising solution regarding energy dependency and the climate crisis. Belgium would particularly enjoy such transition as a highly energy-dependent country and as a country concerned by global warming. However, before imagining the future, all the above-mentioned barriers must be overcome.

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