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HYDROGEN: A DEUS EX MACHINA FOR TODAY'S ENERGY CRISIS?

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Hydrogen is considered as essential for mitigating the negative effects of the current European gas crisis.[1] Yet, the interest in this carbon-free molecule goes back to before Russia's brutal invasion of Ukraine. The "hydrogen story" has been gaining new momentum since 2017, when Japan announced its first national hydrogen strategy aiming to become a so-called hydrogen economy. Many believe that hydrogen is a key ingredient for reaching national climate ambitions and decarbonizing industrial sectors. Since 2017, national hydrogen strategies have been popping up like mushrooms, with some countries positioning themselves as exporters (e.g. Oman, Chile, Morocco and Namibia) while others are gearing up to become importers (e.g. Japan, Germany, the Netherlands, Belgium and South Korea).[2] The EU published its hydrogen strategy in 2020.[3] Since the Russian invasion of Ukraine, the announcements of new hydrogen projects and ambitions seem to accelerate. At the recent COP27 in Sharm-el-Sheikh, hydrogen was once again the *buzzword* and, little by little, the contours of the market are being shaped.

However, a global liquid hydrogen market, as we know today for fossil fuels like oil or natural gas, is still absent. The majority of today's hydrogen consumption is produced and consumed on-site, and almost 95% of that hydrogen is still produced by using fossil fuels without capturing the emitted CO_2.[4] In addition, regulations regarding hydrogen production and trade are lagging. Moreover, there is no consensus among policymakers and industrial sectors on whether a global hydrogen market will evolve and, if so, how? Therefore, the question remains *how* hydrogen is essential to end Europe's dependence on Russian gas today. And, if there is a transition towards hydrogen, what would this mean for Europe's import dependence in the long term?

No relief from hydrogen in the short term

Hydrogen plays a key role in decarbonizing heavy industries and transitioning away from fossil fuels but its role in mitigating the effects of the current energy crisis might be limited. Hydrogen and natural gas are two different gases that differ completely in terms of energy density, both gravimetric and volumetric, as in terms of freezing or liquification temperature. Therefore, different types of tanks, ships, and metals are necessary to deal with the different molecules. In addition, natural gas is an energy source, which means the fossil fuel is extracted, while hydrogen is an energy carrier, which means that the molecule has to be produced. The latter can either be done by the electrolysis of water or through the steam

reforming of natural gas.[a,5] In consequence, natural gas cannot be simply substituted with hydrogen. There is one way in which hydrogen can directly replace natural gas: in the form of synthetically produced methane. This molecule is produced from hydrogen combined with CO_2. However, this process is still very much in an experimental phase and not yet commercially available.

In addition, the consumption patterns of hydrogen and natural gas are completely different. This means that the consumption of hydrogen instead of natural gas would not make any difference to, for example, the high natural gas prices that households are paying today. Almost half of the hydrogen consumption in 2021 is accounted for by the industry as a feedstock (for example for the production of ammonia to produce fertilizer) and the other half by the refining sector. Today, in most OECD countries, natural gas is consumed by households, the power generation sector, and industry. The consumption pattern of both gases is thus dominating different sectors. Because hydrogen is an energy carrier, it can also be used in the future as a fuel for power generation, heating purposes, or road and air transport. However, according to most experts, the use of hydrogen as a fuel will be limited to only a handful of so-called hard-to-abate sectors, namely heavy transport, shipping, and long-haul aviation.[6]

In the short term, the role of hydrogen as a solution for today's energy crisis is thus rather small. Nevertheless, hydrogen is an important part of the energy transition, which will play a role in transferring away from natural gas, whether it is directly in the form of hydrogen production by renewables instead of natural gas, or indirectly in reshaping the fundamental features of the current fossil fuel centred energy market.

(Re)shaping import dependencies

While hydrogen may not solve today's energy crisis in the short term, it does serve as a good candidate for (re)shaping the current energy market and its vulnerabilities. Considering their insufficient renewable energy potential, European countries expect imports of hydrogen. However, the vulnerabilities related to hydrogen imports may not be as strong as with natural gas. This is because hydrogen has an important feature that natural gas does not have: it is an energy carrier. In theory, all countries are capable of producing hydrogen molecules. In consequence, hydrogen production may be less concentrated with a handful of suppliers, as is the case for oil and natural gas. Hydrogen supply could therefore be more decentralized and diversified.[7]

Several studies expect the hydrogen market to evolve in a similar way as the natural gas market in terms of transport. Hydrogen is expected to be transported through pipelines in gaseous form and via shipping in a liquid form, similar to natural gas and LNG.[8] This implies that similar geopolitical risks related to pipelines may develop.[9] Hydrogen importers could be locked into dependence on hydrogen export countries via pipelines. Hereby, hydrogen importers are not only dependent on the supply of hydrogen molecules from export countries, but they are also vulnerable to conflicts with transit countries. This may raise similar problems as Europe experienced with Russian natural gas and its transit through Ukraine. Similar as with LNG, hydrogen in liquid form may offer more flexibility and, therefore, resilience in terms of hydrogen supply. Yet, when hydrogen is transported via a liquid hydrogen carrier, for example ammonia, it still needs to be reconverted into hydrogen. This remains a very costly and energy-intensive process.

[a] In theory, hydrogen can be produced from the gasification of coal as well, but steam reforming is the most commonly used method to produce hydrogen today.

Today, several European countries have concluded agreements with hydrogen exporters to secure their future hydrogen supply. For example, Belgium concluded a memorandum of understanding with Oman regarding cooperation on green hydrogen production in Duqm.[10] Similarly, Germany has agreed with Namibia to kick off cooperation on future hydrogen imports from Namibia.[11] Yet, these early agreements on hydrogen imports have not been isolated from geopolitical tensions. A deal on green hydrogen cooperation between Germany and Morocco concluded in 2020 was halted in 2021 because of rising tensions around the sovereignty of the Western Sahara and Berlin's support for the contested region.[12] This shows how hydrogen trade does not take place in a geopolitical vacuum, even if there are technically more partners available to import hydrogen from. Moreover, the early years of hydrogen trade may be characterized by mostly bilateral trade and long-term contracts[13], making early hydrogen trade still vulnerable to supply disruptions, since a liquid market is still absent.

Furthermore, in its External Energy Strategy, the EU aims to conclude hydrogen partnerships with "*reliable*" countries and with "*social, economic and environmental needs in mind*".[14] However, recent studies have shown that the current hydrogen agreements with for example Morocco, Namibia and Mauritania risk reproducing and enforcing today's inequalities, rather than including the Global South in a just and sustainable energy transition.[15] Besides those inequalities, questions are also being raised around agreements that are being concluded with countries that are violating human, women, and labour rights.[16] The Belgian Minister of Energy Tinne Van der Straeten claimed at the last COP27 in Egypt that social norms should be taken into consideration when setting up partnerships with hydrogen-producing countries. This stands in contradiction with the recently concluded hydrogen cooperation agreement between Belgium and Egypt, a country that repeatedly violates human rights according to a recent report by Amnesty International.[17]

However, political friction with hydrogen partners may have a less significant impact on Europe's energy security since the import dependency rate may be lower than with natural gas. According to the REPowerEU plan published in May 2022, the European Commission foresees a hydrogen demand of 20 million tons of hydrogen by 2030, with half of it produced locally and the other half imported.[18] This stands in contrast with Europe's current import dependency of natural gas of 84% in 2021.[19] In addition, since hydrogen is an energy carrier and not an energy source, hydrogen can technically be produced anywhere (also by importers) and countries will be more resilient to supply disruption because they can produce their own hydrogen in case of shortages.

A *deus ex machina*?

Hydrogen plays a key role in decarbonizing large industries that today still rely predominantly on fossil fuels. Switching to renewable-based hydrogen instead of natural gas based hydrogen would directly reduce the dependence on (Russian) natural gas. Yet, the impact of hydrogen on today's energy crisis may be limited because producing hydrogen at home with renewable energy, or importing hydrogen from countries that have abundant renewable energy resources, still faces a lot of challenges. Only 4% of all hydrogen projects that are being planned have reached the final investment decision. This means that the bulk of the currently proposed hydrogen projects are still in an early stage. In addition, there are a lot of uncertainties regarding hydrogen demand, trade regulation, certification, and available infrastructure. Therefore, the role of hydrogen in solving the current energy crisis is rather small.

Nonetheless, hydrogen may offer more relief in the mid-term in terms of import dependencies and energy security in general. It remains therefore crucial to start setting up a future hydrogen market today. National governments play a key

role in de-risking hydrogen investments and establishing subsidy schemes to facilitate investment, R&D, and demand creation.[20] Further, there is a strong need for international cooperation to set international hydrogen standards that include all parts of the value chain, and to create hydrogen partnerships to secure future supplies.

To conclude, setting up hydrogen trade and related import dependencies may reintroduce old uncertainties and vulnerabilities. However, the latter might be less far-reaching as with natural gas today. Hydrogen is a conversion and not an extraction business, more countries can produce the molecule and this inherently brings more security of supply. Considering the planned imports, it remains important to choose future hydrogen partners wisely. This means taking geopolitical and sustainability factors into account, rather than solely importing hydrogen from the cheapest producer. This will not only improve the European countries' security of hydrogen supply, but also make a more inclusive and sustainable energy transition possible.

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