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Hydrogen and Its Role in Post-Pandemic Recovery. Case Study of Portugal

Abstract: The article aims to analyse the potential role that hydrogen could play in the post-pandemic recovery of Portugal and its climate policy. The article focuses on reducing greenhouse gas emissions and creating new workplaces. The basis for analysis is the Portuguese hydrogen strategy, published in May 2020 and other strategic documents. In the first part of the article, climate goals adopted by the European Union and Portugal are described and analysed. Then the hydrogen strategy of Portugal was analysed from the perspective of hydrogen contribution to the emission reduction by 2030. The article describes the role of hydrogen in the Portuguese economy, paying particular attention to the 2020–2030 horizon, but also covers a period till 2040. The second part analyses the impact of COVID-19 on the Portuguese economy. Based on the International Energy Agency's estimates, the potential for creating new workplaces is described.

Keywords: *hydrogen, Portugal, GHG emissions, labour market, COVID-19*

Introduction

On May 21, 2020, the Council of Ministers of Portugal approved a national hydrogen strategy (Estrategia nacional do hidrogenio, EN-H2). As for now, the document is in the public consultation phase (Secretaria de Estado Adjunto e da Energia, 2020). In a press release, the Council underlined the COVID-19 pandemics confirmed the necessity of decarbonisation and ensured it would not stop pursuing the goal of climate neutrality in 2050 (The Council of Ministers of Portugal, 2020). The publication of the Portuguese hydrogen strategy took place almost one month before the European Commission released a similar document for the European Union, which finally took place on July 8, 2020. The European Commission also presumes that establishing a hydrogen economy could create new workplaces, which could help in post-pandemic recovery (European Commission, 2020). Hence, some institutions

perceive hydrogen not only as the 'fuel of the future' but also as a substantial part of climate policy and post-pandemic economic recovery. It seems that Portugal shares this view. Thus, the scope of this paper is to analyse what role could hydrogen play in pursuing the climate goals and economic recovery after the pandemic crisis.

The role of hydrogen in decarbonisation has been a subject of study for years. The most important research directions have been the role of hydrogen in decarbonising the electricity sector (Baldwin et al., 2021) or as energy storage (Parra et al., 2019). It is argued that the most suitable role for hydrogen in the energy sector would be balancing unstable renewable sources and storing the surplus of the energy produced by them. Also, the role in the decarbonisation of industries, for example, the steel industry (von Scheele, 2021) or the transport sector (Newman, 2021; Gunawan, 2021), is of big interest in current research. In the first case, hydrogen is perceived as a viable and potentially competitive substitute to coke coal in steel-making. In the case of transport, it seems that hydrogen has an advantage over electric vehicles in heavy freight and is also adaptable for public transport purposes. Yet, Portugal and its hydrogen sector have not been the subject of extensive scientific research. There is literature available on pilot programmes conducted in Portugal (Pimenta & Fernandes, 2008; Marszałek-Kawa, 2004) and forecasts for refuelling infrastructure development (Ala et al., 2021). To the best of the author's knowledge, there has not been any comprehensive study analysing the interaction between hydrogen technologies development and the labour market.

Methodology

The scope of the paper was to determine what percent of the greenhouse gas emissions of Portugal could be reduced by implementing hydrogen technologies. The secondary scope of interest was the interaction between the development of the hydrogen economy and labour market and the potential to create new workplaces. The basis for the analysis is strategic documents published by Portuguese state institutions – PNEC2030 and EN-H2 – and official data on greenhouse gas emissions for 2017. The forecasted hydrogen production and attached to that estimated emission reduction has been deducted from the amount of GHG left to achieve Portugal's emission goals. Interaction with the labour market has been calculated according to the International Energy Agency estimates that aim at the correlation of implementing new energy technologies with creating new workplaces. Potential jobs were compared to the latest available unemployment data to show the relative potential of hydrogen technologies in this field.

Hydrogen and Its Role in Emission Reduction in Portugal

3.1 Analysis of climate goals of the European Union and Portugal

The climate goals of the European Union are defined in three time perspectives – 2020, 2030, and 2050. From the perspective of establishing a hydrogen economy and post-pandemic recovery, it seems that only the latter two should be considered. The superior goal of the European Union is to become climate-neutral by 2050. The greenhouse gas emissions (GHG emissions) will be reduced by 80–100% compared to the reference year 1990. By 2050, renewable energy sources (RES) will also reach an 80% share in electricity production and 50% in final energy consumption. Additionally, the dependence on energy imports will be reduced from 55% to 20% (European Commission, 2019). The intermediate goals for 2030 aim to reduce GHG emissions by 55% compared to the reference year 1990, 32% RES share in total energy consumption and increase energy efficiency by 32,5% (European Commission, 2021).

Also, Portugal has its own climate goals. The National Plan for Energy and Climate 2030 (Plano Nacional Energia e Clima, PNEC 2030) was presented in January 2019. It aims to reduce GHG emissions by 45 to 55% by 2030 compared to the reference year 2005. It is worth mentioning that in 2005 GHG emissions of Portugal were at its peak with 85 million tons of CO_2eq annually. To compare, in 1990, the reference year for the European Union, the emissions amounted to about 60 million tons of CO_2eq annually (REA, 2020). It means that by 2030 Portugal aims to reduce its emissions by 38 to 47 million tons of CO_2eq annually, and its emissions in that year should amount from 38 to 47 million tons of CO_2eq annually, which means a reduction only by 22 to 37% in comparison to its emission level in 1990. The reason for the discrepancy is the growth of emission level that occurred between 1990 and 2005 and hence, a higher reference level. Moreover, Portugal aims to increase the RES share in electricity production to 80% by 2030 (PNEC2030). To compare, in 2018, RES generated 52,2% of electricity produced in Portugal, and their share in final energy consumption was 30,3% (EN-H2). Portugal aims to reduce its energy dependence to 65% by 2030 from 77,9% in 2018. Another goal is to reduce the consumption of primary energy and, at the same time, boost domestic production (PNEC2030). In 2016, Portugal also announced its goal to become climate neutral by 2050, which was confirmed by Programme for Carbon Neutrality 2050 (Roteiro para a nautralidade carbónica, RNC2050). Before proceeding to the analysis of hydrogen's role in the decarbonisation of the Portuguese economy, there is one interesting remark to be made. Both PNEC2030 and EN-H2 were published at the moment when the GHG emissions of Portugal totalled 70.6 million CO_2eq annually (REA, 2020). It means that at that time, Portugal reached around 25% of its 2030 emission reduction goal. Hence, emissions to be reduced in the next decade, 2020–2030, total 23–32 million tons of CO_2eq annually – two or even three times as much as it had been reduced between 2005

and 2017. Therefore, one can expect that GHG emissions in the next decade will be reduced faster than during the next two decades, 2030–2050.

Analysis of Portuguese Hydrogen Strategy

Portugal's hydrogen strategy describes in detail the assumed share of hydrogen in individual sectors of the economy. According to EN-H2, it would have the largest share in the natural gas transmission and distribution network, where it could already be present in 2025 at the level of 1-5%. In 2050, its share in the network could already reach 80%. In the transport sectors (road and domestic maritime transport), hydrogen could represent 5% in 2030 and 25% in 2050. The same share is expected for industrial consumption. Hydrogen would account for around 2–5% of Portugal's final energy consumption in 2030 and around 20% in 2050. The installed production capacity is also an important aspect. In 2025, it could reach a maximum of 500MW, in 2030 a maximum of 2GW, and in 2050 – 5GW. It is worth comparing these numbers with the assumptions of the EU strategy. The European Commission plans to install 6GW of production capacity for hydrogen produced from RES by 2024. If the 500MW target is achieved, Portugal could account for a maximum of approx. 8% of EU generation capacity. The European Commission has also set a target of 40GW of installed capacity in the European Union in 2030 (European Commission, 2020), which means that Portugal could account for up to 5% of the installed new generation capacity in the EU this year. However, it should be emphasised that in EN-H2, various scenarios for the share of hydrogen were included. The PNEC_MA and PNEC_ME scenarios are based on the assumption of the development of the hydrogen market in Portugal at the current pace, as a result of which, in the more optimistic PNEC_ME scenario, Portugal would consume 0.73 TWh[1] while producing 0.82 TWh in 2030, and a decade later, consume 5.94 TWh, with own production of 2.79 TWh in 2040. In the "baseline" H2_BASE scenario, Portugal would consume 4.78 TWh in 2030 and 13.06 TWh in 2040, respectively, of hydrogen producing 10.59 TWh in 2030 and 31.1 TWh in 2040. The next two scenarios also take the production of 10.59 TWh and 31.1 TWh in the discussed time horizons as a starting point. However, they assume different values for domestic consumption. The H2_EXPORT + scenario assumes the maximisation of exports, with reduced own consumption (2.4 TWh in 2030 and 7.86 TWh in 2040), while the H2_EXPORT- scenario assumes higher own consumption (8.9 TWh in 2030 and 23, 35 TWh in 2040) with reduced exports. The most ambitious scenario is the H2_DUPLO scenario, which assumes the consumption of 9.6 TWh of hydrogen in 2030 and 17.48 TWh in 2040, with production amounting to 20.61 TWh in 2030 and 41.12 TWh in 2040, respectively. Thus, as the comparison of the individual scenarios shows, Portugal assumes hydrogen exports in each of them from the surplus of production.

The share of hydrogen exports, in turn, translates into its share in the reduction of emissions. It is because exported hydrogen does not count toward Portugal's emission

[1] All volumes refer to TWh of hydrogen.

reduction. Thus, according to the General Directorate for Energy and Geology (Direcão-Geral de Energia e Geologia, DGEG), the scenario that gives the greatest emission reductions is the H2_EXPORT- scenario, which assumes the greatest possible use of hydrogen in the decarbonisation of the domestic economy. By 2030, it would allow reducing emissions by about 2 million tons of CO_2eq, and by 2040 by almost 9.5 million tons of CO_2eq. The second scenario that would allow for the largest emission reductions is the H2_DUPLO scenario, which would reduce fewer than 4 million tons of CO_2eq by 2030 and about 7 million tons of CO_2eq by 2040. The H2_BASE baseline scenario is expected to reduce about 1 million tons of CO_2eq by 2030 and over 2 million tons of CO_2eq by 2040. The scenarios that would result in the smallest emission reduction are maximising exports H2_EXPORT + and PNEC_MA, which could reduce emissions by only 1 million tons of CO_2eq in 2040. The table below summarises the different scenarios and their potential impact on reducing emissions.

Table 1. Summary of key scenarios presented in EN-H2 from the perspective of consumption and production of hydrogen and its impact on emission reduction

	H2_BASE	**H2_EXPORT+**	**H2_EXPORT-**	**H2_DUPLO**
CONSUMPTION (TWh)	4.78	2.4	8.9	9.6
PRODUCTION (TWh)	10.59	10.59	10.59	20.61
EMISSION REDUCTION BY 2030 (million tons of CO_2eq)	1	0.5	2	4
SHARE IN REMAINING EMISSIONS TO BE REDUCED BY 2030 (%)[2]	3,1 – 4,2	1,5 – 2,1	6,1 – 8,4	12,2 – 17,2

Source: EN-H2 and author's own accounts.

3.3 Key Findings

From the above summary, it is clear that hydrogen may play a role in Portugal's achieving its 2030 emission reduction target. The final share will depend largely on the scenario chosen and the volumes of hydrogen produced for export. The share of hydrogen in meeting the emission reduction target may vary between 1.5% and 17.2%. However, considering the above list, it should be assumed that the share of hydrogen in reducing greenhouse gas emissions will most likely amount to several percentage points.

[2] The item describes the percentage of reductions in emissions remaining to meet the 2030 target. The target was the emissions at the level of 38-47 million tons of CO_2eq (45-55% reduction compared to the 2005 level) and the current Portuguese emission level was adopted according to the latest available data for 2017, i.e., 70.7 million tons of CO_2eq. Hence the remaining emissions to be reduced are 23.7-32.7 million tons of CO_2eq.

Hydrogen and Its Role in Economic Recovery

Other important aspects that should be addressed when analysing the role of hydrogen in the implementation of energy and climate policy and economic recovery after the crisis related to the coronavirus pandemic are the economic and social dimensions. The aspect related to investments and new jobs created by implementing hydrogen technologies seems particularly important. According to the International Energy Agency (IEA) estimates, every million dollars invested in new hydrogen technologies generates 6–8 new jobs (IEA, 2020). According to the assumptions of EN-H2, in Portugal, by 2030, EUR 7 billion will be allocated to the development of hydrogen technologies, corresponding to an investment outlay of USD 8.26 billion. Therefore, assuming IEA estimates, this would mean the creation of approx. 49.5–66 thousand jobs in Portugal. It seems especially important in the context of the shrinking labour market during the coronavirus pandemic. According to the Portuguese National Institute of Statistics (Instituto National de Estatística, INE), there were 289.6 thousand working-age unemployed people in May 2020. However, INE predicted an increase in unemployment in June 2020 to 350.9 thousand unemployed (INE, 2020). Therefore, it is worth noting that new jobs that could be created due to the development of hydrogen technologies would account for approx. 17–22.8% of people unemployed in May 2020. Compared to the estimates for June 2020, this ratio would be approx. 14.1–18.8%. It does not imply the percentage of workplaces covered by the hydrogen industry in 2040, as it is impossible to forecast the unemployment rate at that time, but rather shows the proportion and potential of the industry. However, it should also be considered that employment in related sectors could decrease with the move away from fossil fuels. It is also impossible to predict how many workers from these sectors could find employment in hydrogen projects. In addition to the EUR 7 billion to be absorbed by investments in hydrogen technologies by 2030, the Portuguese government plans to allocate around EUR 900 million over the same period to support these investments. As an important financial aspect, the expected savings from the decrease in natural gas imports should also be mentioned. Portugal would save between €300–600 million by 2030 from smaller natural gas purchases (EN-H2). It is worth noting that in the second quarter of 2020, the gross domestic product of Portugal decreased by 14.1% compared to the first quarter of this year and by 16.5% compared to the corresponding period in the previous year. In 2019, Portugal recorded a GDP growth of 2.2% and a budget surplus of 0.2% of GDP. According to the Portuguese government, in the first half of the year, the country recorded a budget deficit of EUR 6.7 billion in connection with the coronavirus pandemic (Eurostat, 2020). It is a tenfold increase compared to the corresponding period in the previous year.

Summary of Main Conclusions

In conclusion, Portugal has been hit hard by the crisis related to the coronavirus pandemic, as shown, among others, by GDP and unemployment indicators. Despite the crisis, the Portuguese government has announced that it will pursue an ambitious energy and climate policy. Published in May 2020, amid the coronavirus pandemic, the hydrogen strategy is one of its implementation tools. The analysis carried out in this article showed that the implementation of hydrogen technologies to the extent assumed in the strategy could result in a reduction of Portugal's greenhouse gas emissions at the level of 1.5% to even 17% of the emissions remaining to achieve the 2030 climate target. The implementation of hydrogen technologies may also bring benefits to the recovery of the economy after the crisis by creating new jobs. The analysis showed that by 2030 49.5–66 thousand jobs could be created, which would represent around 14–18% of unemployed people in Portugal. In addition, the implementation of hydrogen technologies would entail investments of EUR 7 billion and support programs worth EUR 900 million, which could also positively affect the condition of the Portuguese economy. Thus, the example of Portugal shows that hydrogen could play an important role in the reconstruction of European economies, as well as in the implementation of ambitious energy and climate policy.

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