CEPS RESEARCH REPORT

IS RENEWABLE HYDROGEN A SILVER BULLET FOR DECARBONISATION?

A critical analysis of hydrogen pathways in the EU

Mihnea Cătuți, Edoardo Righetti,
Christian Egenhofer and Irina Kustova

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Structure of the presentation

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1. About CEPS

Founded in Brussels in 1983, CEPS is one of the leading European think tanks, CEPS is actively involved in research and consultancy work and is regularly ranked among the top ten non-US think tanks.

Projects on sustainable resources and climate policy are carried out by the CEPS Energy, Resources and Climate Change Unit, with expertise on:

- Energy transition
- Decarbonisation of EU energy intensive sectors
- Circular economy policy developments in the EU and beyond
- EU Emissions Trading Scheme & Carbon markets
- Security of supply and its interaction with climate change policies
- External energy and trade policies, circular economy (global value chains)

Value added of CEPS

- Four decades of experience in analysing and debating policies at the centre of the European and International political scene
- Eminently qualified research team of more than 60 researchers drawn from more than 20 different countries
- Complete independence and freedom from any outside influence to set the priorities of the project
- Producing evidence-based research to inform the debate and build institutional knowledge
- Conveying leading experts in the field of energy and climate policies and circular economy to frame the dialogue
- Membership in various international research networks & Extensive outreach thanks to its institutional and industrial membership base - Bringing its extensive membership base and research networks to mobilise key stakeholders from the academic, public and private sectors.

2. General presentation of the report

Contents

3. EU legislative context: why focus on renewable hydrogen?

- European Green Deal and climate neutrality
- Post-COVID 19 recovery funding
- European Commission’s Energy Sector Integration and Hydrogen Strategies
  - 6 GW of electrolysers by 2024 and 40 GW by 2030
- Fit for 55 package
  - Revision of RED II proposes RFNBOs target of 50% for industry and 2.6% in transport by 2030
    - Same sustainability criteria of 70% GHG emissions savings reduction
  - ReFuelEU Aviation initiative also introduces RFNBOs targets as part of SAFs
- Delegated acts of RED II
- Taxonomy for sustainable activities
- Hydrogen and Decarbonised Gases Package

4. The role of hydrogen and the likely sources of demand

- H2 currently used as a chemical feedstock for the production of ammonia and methanol, as well as in the process of crude oil refining
- According to the European Commission's plans, while about 2 % of today's EU final energy demand comes from hydrogen, its share could reach more than 15 % by 2050
  - fears of a 'hydrogen bubble'
- Direct electrification of end-uses remains one of the efficient means and is expected to increase from the present level of around 24 % to at least 60 % by 2050
  - but there are limits to this trend
  - hydrogen will most likely be necessary in sectors that have few other credible decarbonisation options

4. The role of hydrogen and the likely sources of demand

Table 1. Likely uses of hydrogen as a decarbonisation solution by sector

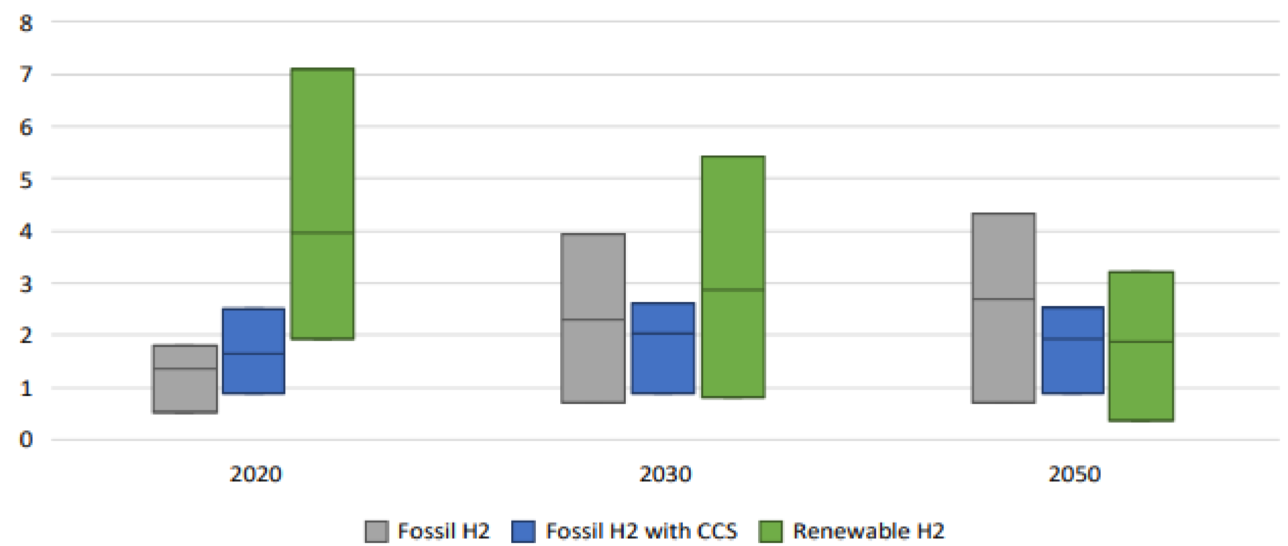
Future uses of hydrogen	Very likely					Very unlikely
Industry	Feedstock for ammonia and basic chemicals	Reduction agent in DRI for primary steel	High temperature heat			Low-temperature heat
Transport	Long-haul aviation Maritime shipping			HDV	Rail transport LDV	Passenger vehicles
Power		Long-term electricity storage				Baseload power
Buildings		Existing large-scale district heating systems			New district heating systems	Individual dwellings

Sources: Own assessment, based on Agora Energiewende (2021), p. 10; McWilliams & Zachmann (2021), p. 7; Belmans and Vingerhoets (2020); European Commission (2018).

5. Renewable hydrogen supply

- Almost the entirety of the current hydrogen production is sourced from fossil fuels at the moment
- General expectation that the currently more costly renewable hydrogen will experience cost reductions to levels below those of fossil-based alternatives after 2030

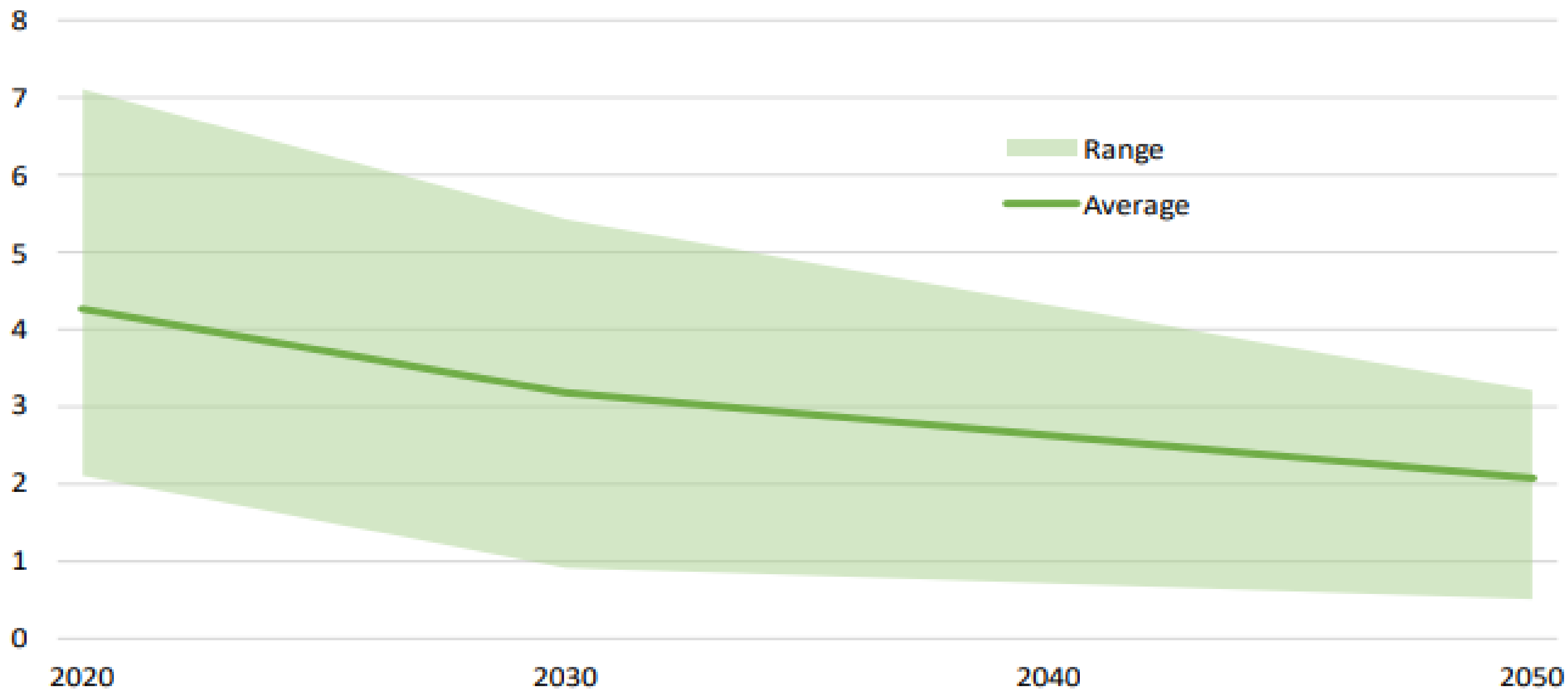
Figure 1. Ranges of LCOH for different technologies (€/kgH_2)



Sources: Piebalgs et al. (2020), Aurora Energy Research (2020; 2021), Agora Energiewende and Guidehouse (2021), Trinomics and LBST (2020), IEA (2019; 2021), DNV GL (2021), Oxford Institute for Energy Studies (2021), Dos Reis (2021), IRENA (2019) and Hydrogen Council (2021b).

Expected cost reductions for renewable hydrogen in the EU

Figure 2. Range and average levelised costs of renewable hydrogen in the EU (€/kgH_2)



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Technologies and economics of electrolysis

Table 2. Comparison of different electrolyser technologies

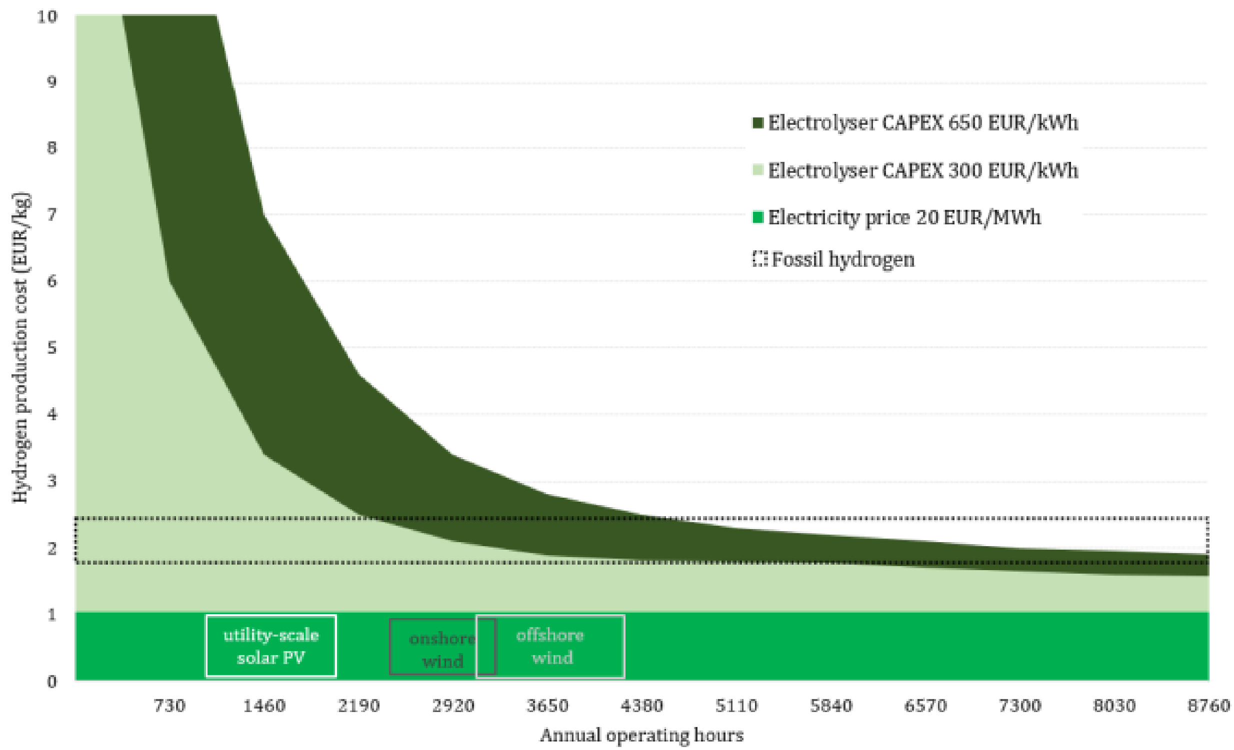
Electrolyser technology	Alkaline			PEM			SOEC		
	Today	2030	2050	Today	2030	2050	Today	2030	2050
Capex (EUR/kW)	180 - 1235	105 - 750	70 - 615	617- 1590	575 - 1325	175 - 795	1765 -4940	705 -2470	440 - 880
Efficiency (%)	63 – 70	63 - 72	72 - 80	56 - 63	61 - 69	67 - 74	74 - 81	74 - 84	77 – 90
Stack lifetime (thousand hours)	50 - 90	72 - 100	100 - 150	30 - 90	60 - 90	100 - 150	10 - 30	40 - 60	70 - 100
Operating temperature (°C)	60-90			50-80			650-1 000		
Operating pressure (bar)	1-30			30-80			1		

Sources: Compilation based on data from Agora Energiewende (2019), European Commission (2020), Gas for Climate (2020), IEA (2019), IRENA (2019; 2020).

Technologies and economics of electrolysis

- Investments in renewable hydrogen are generally CAPEX-intensive
- With medium load factors, the CAPEX becomes less important in determining the cost of producing renewable hydrogen
  - the price of electricity becomes the dominant cost factor
- Trade-offs related to the location of the electrolyser

Figure 5. Graphic representation of the relation between the load factor and LCOH

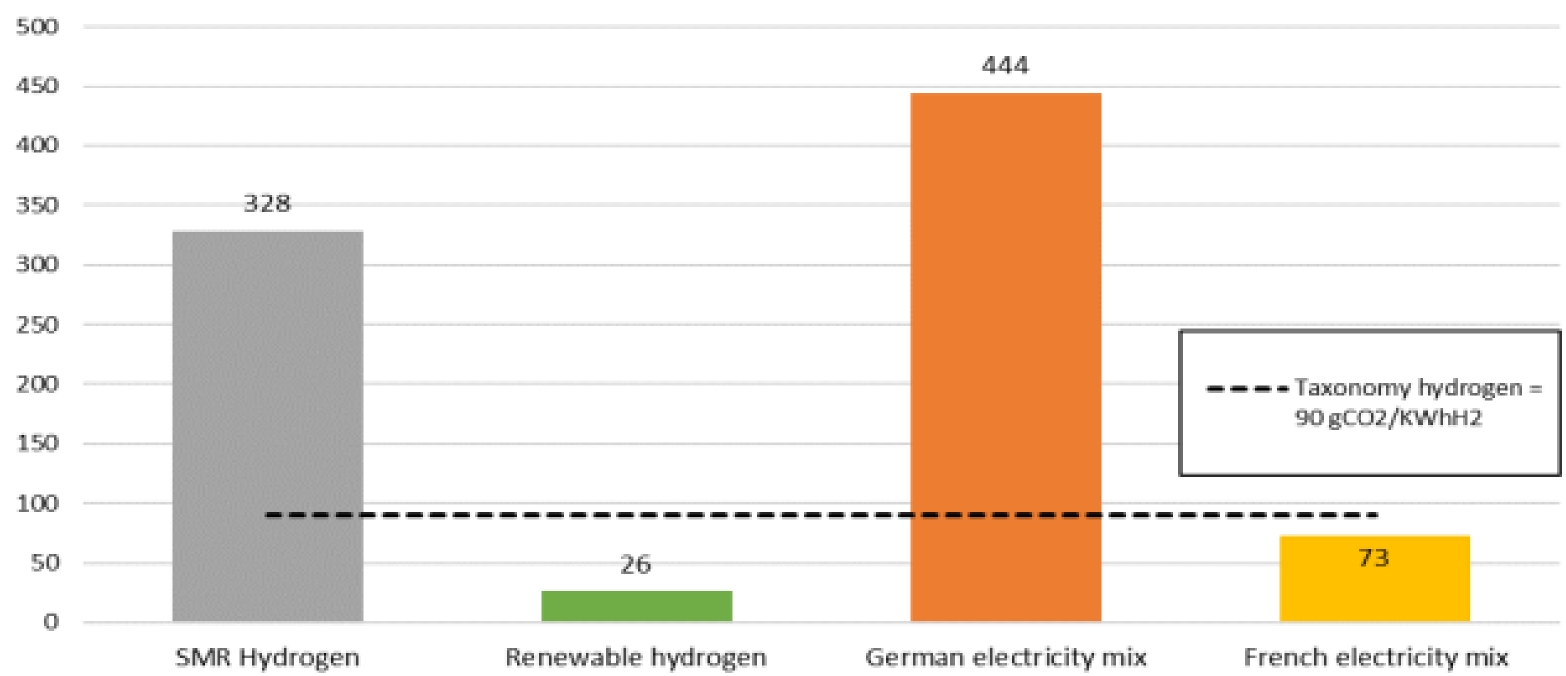


Source: Own calculations; similar renderings have been done by IRENA (2020) and Agora Energiewende (2021).

Note: Figures for illustrative purposes only are based on an alkaline electrolyser; efficiency 68 %; discount rate 8 %; lifetime 20 years; interest rate 8 %.

Certification and the additionality principle

Figure 3. Carbon intensity of different types of hydrogen ($gCO_{2e}/kWhH_2$)



Source: EEA (2021), European Commission (2020).

Certification and the additionality principle

- The principle of additionality seeks to ensure that the electricity for hydrogen production is only sourced from new renewable capacities that would not have been developed otherwise
  - Fears that the power used to produce hydrogen would be compensated by dispatching additional fossil fuel-fired capacities
- The requirements for geographical and temporal connections between electrolysers and renewable energy capacities will influence the amount of available renewable H2
  - Could go against a ‘whole-system’ approach
- System-level matching approach proposes a looser form of connection
- A very loose application of the additionality principle could even fail to properly certify the renewable credentials of hydrogen
- Ensure parallel certification of low-carbon electricity-based H2 while maintaining the integrity of the renewable label

SWOT analysis of renewable hydrogen

	Strengths	Weaknesses
Internal	▪ Climate-neutral and scalable energy carrier ▪ Technology readiness level ▪ Electrolyser costs will keep decreasing ▪ Costs expected to reach lower levels compared with fossil alternatives ▪ Flexibility on the geographical location of the electrolyser	▪ Conversion and efficiency losses associated with production ▪ High current production costs compared with alternatives ▪ Economically inefficient at low electrolyser load factors ▪ Regulatory difficulties for certifying renewable credentials
	Opportunities	**Threats**
External	▪ Expectations of cost reductions for renewable electricity ▪ Contribution to the decarbonisation of hard-to-abate sectors ▪ System integration (curtailed electricity, storage, synthetic fuels) ▪ Commitments to climate neutrality	▪ Lack of value recognition compared with alternatives ▪ Potential impact of regulation on load factors and climate credentials ▪ Reliance on the availability of renewable capacities and relation to the electricity market

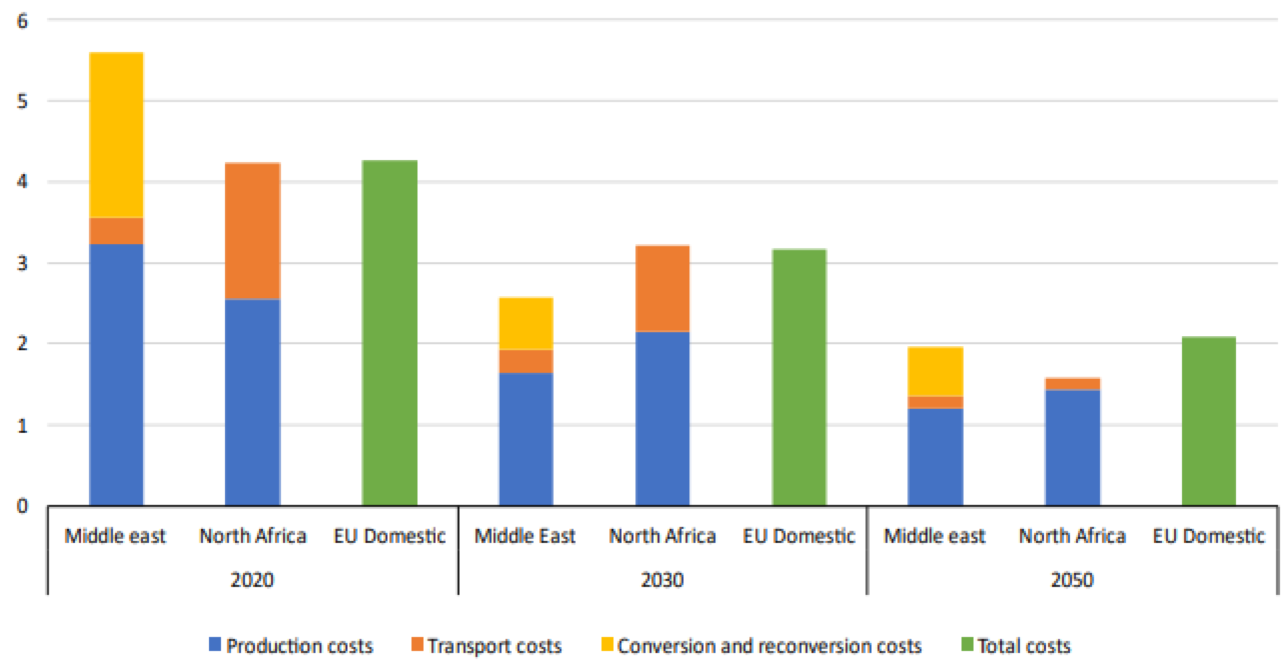
Renewable hydrogen and the electricity market

- Reaching a 55 % reduction in GHG emissions by 2030 will require at least 60 % of the electricity to be sourced from renewables, compared to 37% today
- For the 40 GW of electrolysis capacity, 80-120 GW of additional solar and wind capacities would be needed
- Already-strained electricity market
- Fears that hydrogen production and support policies could affect electricity prices, competition for renewable resources, grid congestion and renewable electricity targets
- A successful hydrogen strategy would most likely need to be integrated and interlinked with renewables policy and the internal electricity market

Imported renewable hydrogen

- Desirability of renewable hydrogen imports rests on two determinants: the costs associated with production and transport and the climate credentials of imported hydrogen

Figure 6. Levelized costs of imported vs domestic renewable hydrogen (€/kgH_2)



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Nuclear energy-based hydrogen

- Two main ways in which nuclear energy could contribute to electrolytic hydrogen production: on grid and on-site
- High load factors, similar GHG emissions savings, less land utilisation
- Several new innovative concepts could provide additional advantages for electrolysis
- Challenges related to certification and association with safety and non-climate environmental concerns

7. Conclusions and recommendations

- Demand for hydrogen should not be overestimated
- Hydrogen needs to be produced with minimal GHG emissions. There appears to be a preference in the EU for renewable hydrogen
- But the certification requirements and difficulties to further deploy RES capacities could impact availability
- The decarbonisation of the electricity mix and the deployment of renewable hydrogen production need to be developed together, for example in NECPs
- Still, the EU will likely turn to other sources of low-carbon hydrogen as well
- A robust certification framework will be needed for attesting the climate credentials of hydrogen, irrespective of source (including imports)
- Ensure integrity of renewable labelling while also allowing parallel certification of low-carbon electricity-based hydrogen that meets the 70 % GHG emissions savings requirement and the carbon intensity set out in the taxonomy

https://www.ceps.eu/ceps-publications/is-renewable-hydrogen-a-silver-bullet-for-decarbonisation/

@CEPS_ThinkTank

Thank You!

mihnea.catuti@ceps.eu

1 Place du Congres, 1000 Brussels
Tel: (+32 2)229 39 11