A Target Model for Hydrogen

Challenges of an Emerging Hydrogen Sector

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24 January 2025

The uncertainties of the development of hydrogen

Infrastructures, supply and demand … How to develop it in a coherent way?

Initial optimism was gradually impacted by implementation difficulties!

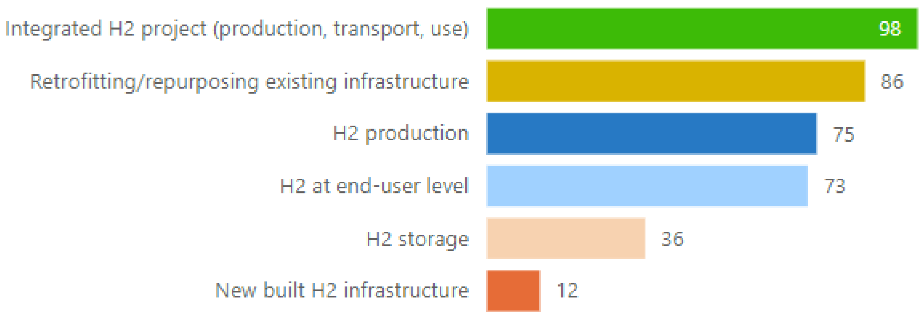
Source: The Economist

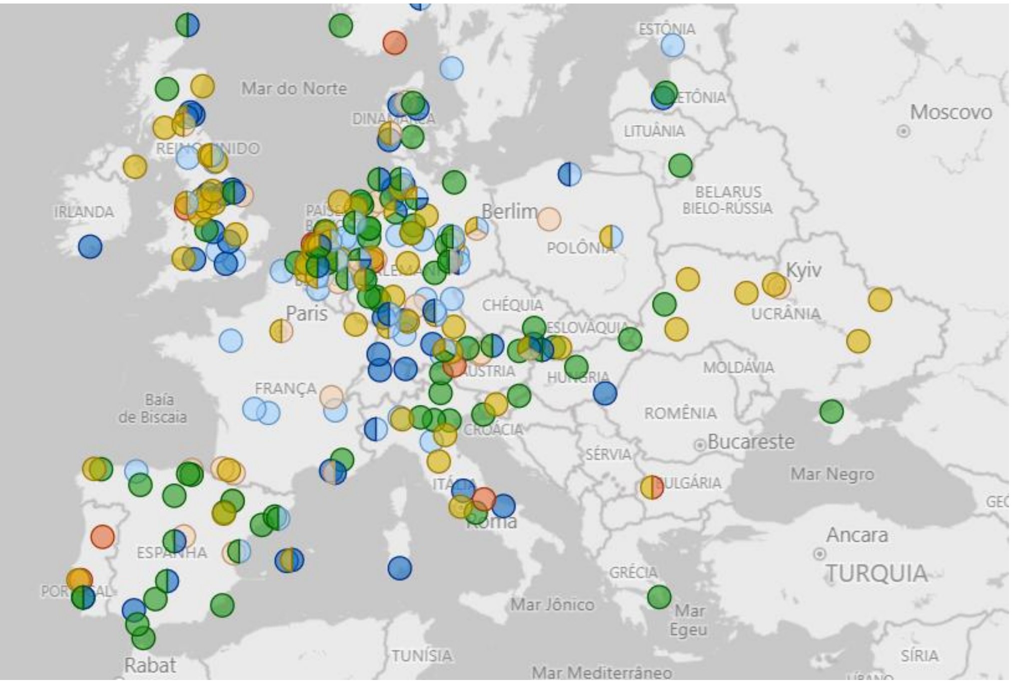
Hydrogen Projects

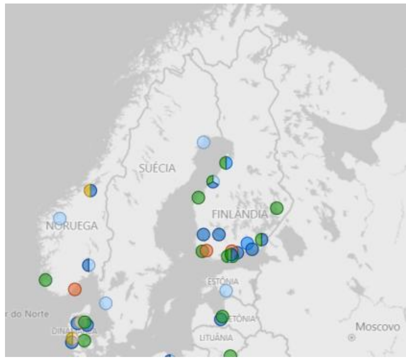
How to best ensure a coherent hydrogen development through all the value chain?
The Bottom-up perspective: Hydrogen valleys

A majority of H2 projects are “hydrogen valleys”:

- Focus on local hydrogen projects
- Repurposing of existing infrastructure creates important regulatory challenges
- Projects have different stages of maturity and viability is still uncertain







Source: ENTSOG

How to best ensure a coherent hydrogen development through all the value chain?

The Top-down perspective: Hydrogen Corridors

The REPowerEU Action Plan foresees the development of "Hydrogen Corridors":

- Long distance cross-border projects
- Limited impact on integrated H2 projects
- Mainly function as a means to balance potential supply and demand in different regions of Europe
- There are also uncertainties regarding the viability of these long distance projects:
  - Will depend on the real evolution of supply and demand for H2 across Europe
  - Interface between local and long distance infrastructure

Source: REPowerEU Action Plan (EC), 2022.

Hydrogen Network Costs

Table 4: Costs of hydrogen transport by pipeline based on literature

Study	Cost		Distance
	EUR/MWh	EUR/kg	
IEA (2019)	30	0.9	1,500 km
	60	1.8	3,000 km
Navigant for Gas for Climate (2019) *Retrofitted* *New*	3.7 4.6	0.11 0.14	600 km
Joint Research Centre (2021) *Range depends on utilisation factor*	18 - 57	0.55 - 1.72	2,500 km
Hydrogen Council (2021) *Retrofilled (low range) -* *New (high range)*	3 - 28	0.08 - 0.85	1,000 km to 5,000 km
Guidehouse for European hydrogen backbone initiative (2022) *Retrofitted* *New*	3 - 4 6 - 12	0.08 - 0.85 0.19 - 0.35	1,000 km
Agora Industry (2024)	10 - 20	0.30 - 0.60	1,500 km
	45	1.35	3,000 km

Natural Gas Grid Tariffs

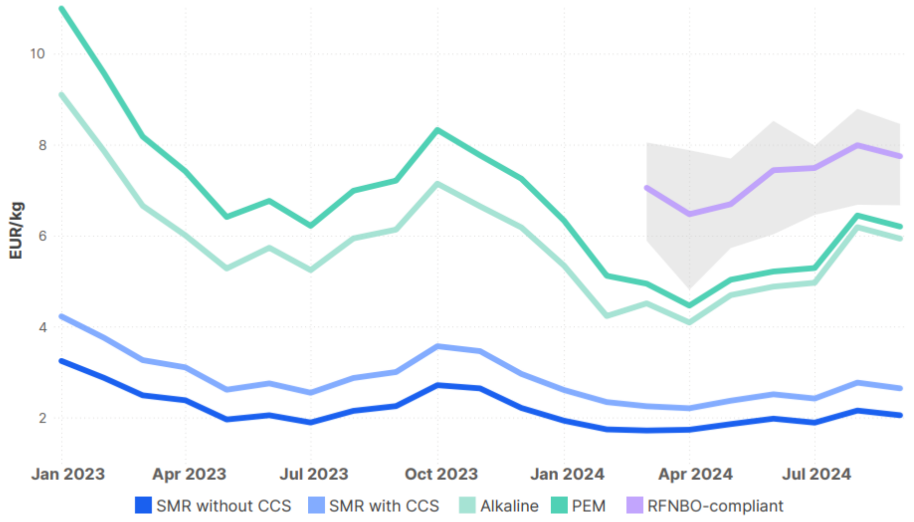
Transmission HP≈ 1€/MWh

Transmission + Distribution MP≈ 3€/MWh

Source: ACER Hydrogen MMR

Hydrogen Production Costs

Figure 20: Evolution of cost estimates of hydrogen produced by various technologies – January 2023-September 2024 – (EUR/kg)



≈ 180€/MWh

≈ 90€/MWh

Source: ACER based on data from S&P Global Commodity Insights.

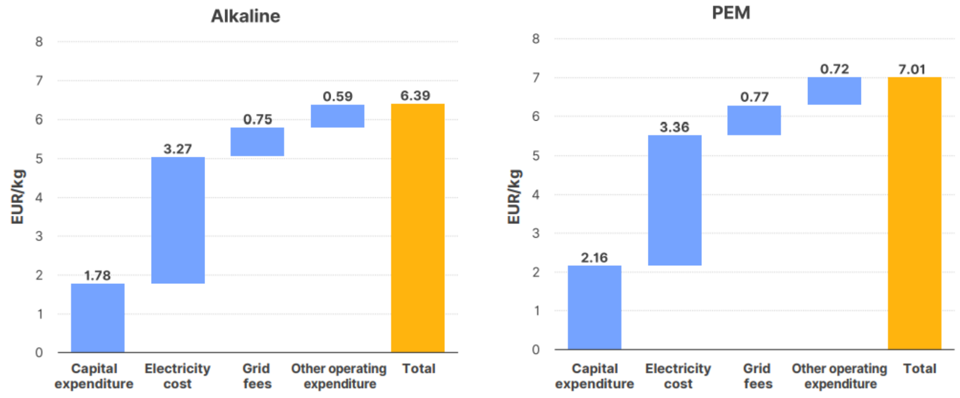
Note: S&P Global Commodity Insights estimates cost based on a methodology that considers, among other parameters, the electricity input costs, and the capital and operational expenditures. Estimates on RFNBO compatible costs are available from April 2024 onward.

$H_2 PEM ≈ 4 x $TTF ≈ 18 x $HH

$H_2 SMR ≈ 2 x $TTF ≈ 9 x $HH

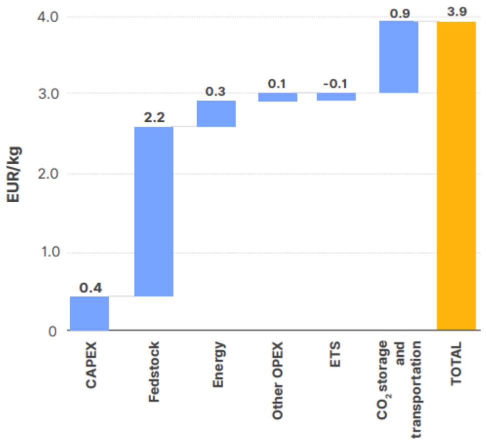
Hydrogen production with SMR costs around the same as onshore wind generation 10 years ago

Figure 21: Breakdown of hydrogen production costs for alkaline (left) and PEM (right) electrolyser (EUR/kg)



Source: ACER, using the LCOH calculation tool of the European Hydrogen Observatory.

Figure 22: Breakdown of hydrogen production cost for SMR with carbon capture (EUR/kg)



Source: Hydrogen Europe 2024.

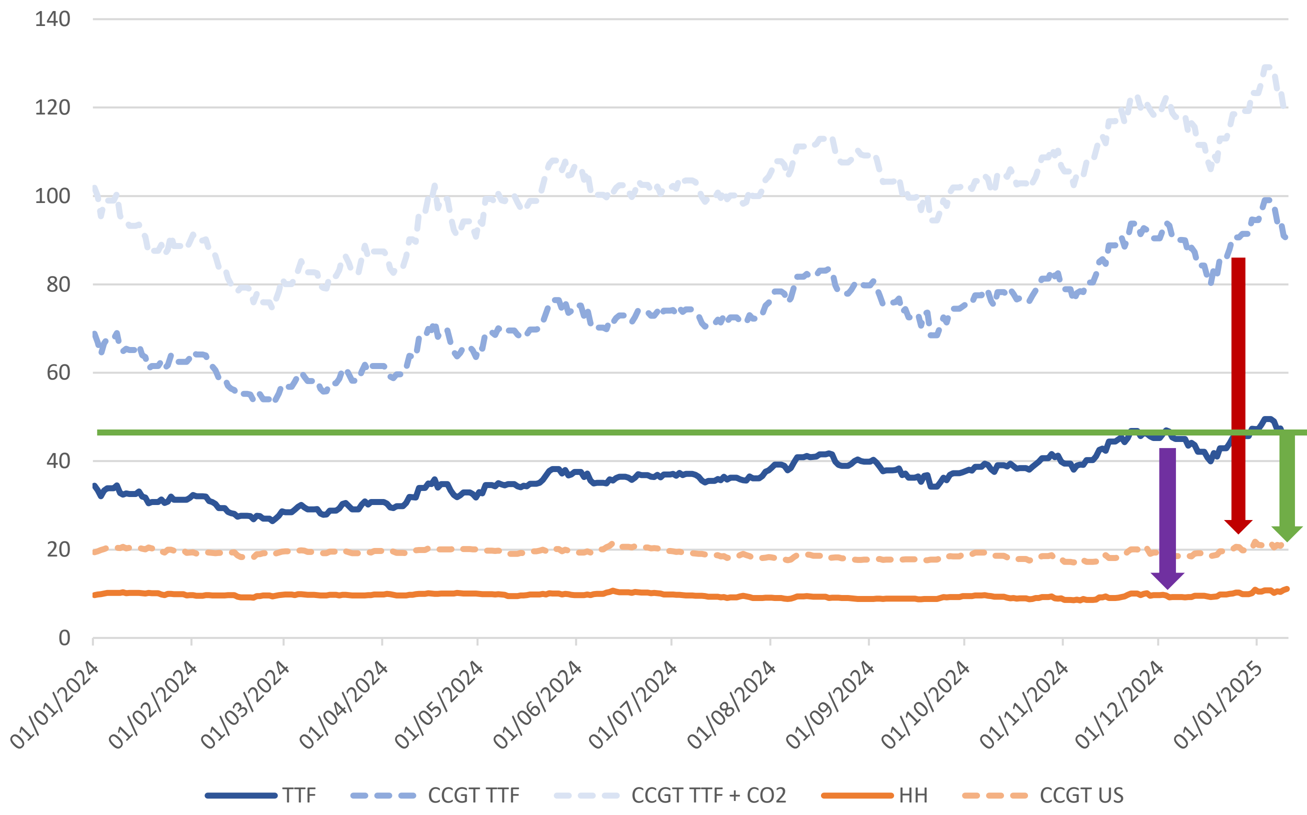
Source: ACER Hydrogen MMR

Gas and Power Competitiveness

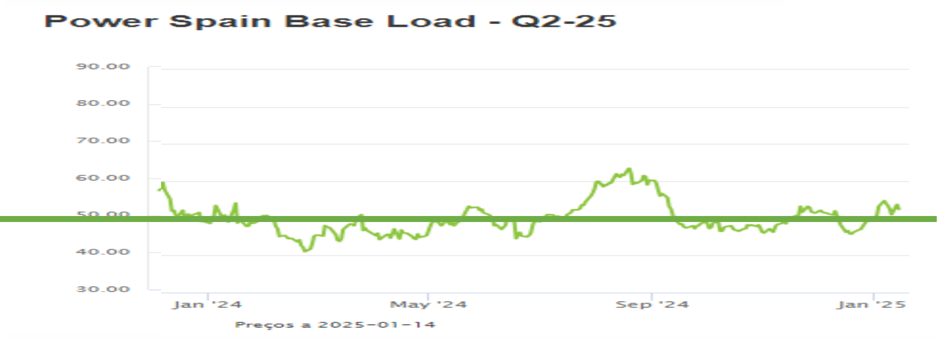
In the Power Sector there is an alignment between Decarbonization through renewables and Competitiveness.
Power price decoupling from fossil fuels (Natural Gas) is a reality.
Would it be possible in the Gas Sector through hydrogen?

- Higher CAPEX (RES2Power & Power2H_2) turns it more complex!!!
- Efficient technology Power2Usefull Energy makes it more difficult!!! Gas2Heat vs RES2Power2Heat vs RES2Power2$H_2$2Heat

Gas Prices Q2-25 (TTF & HH) and Marginal Cost of CCGT (€/MWh)



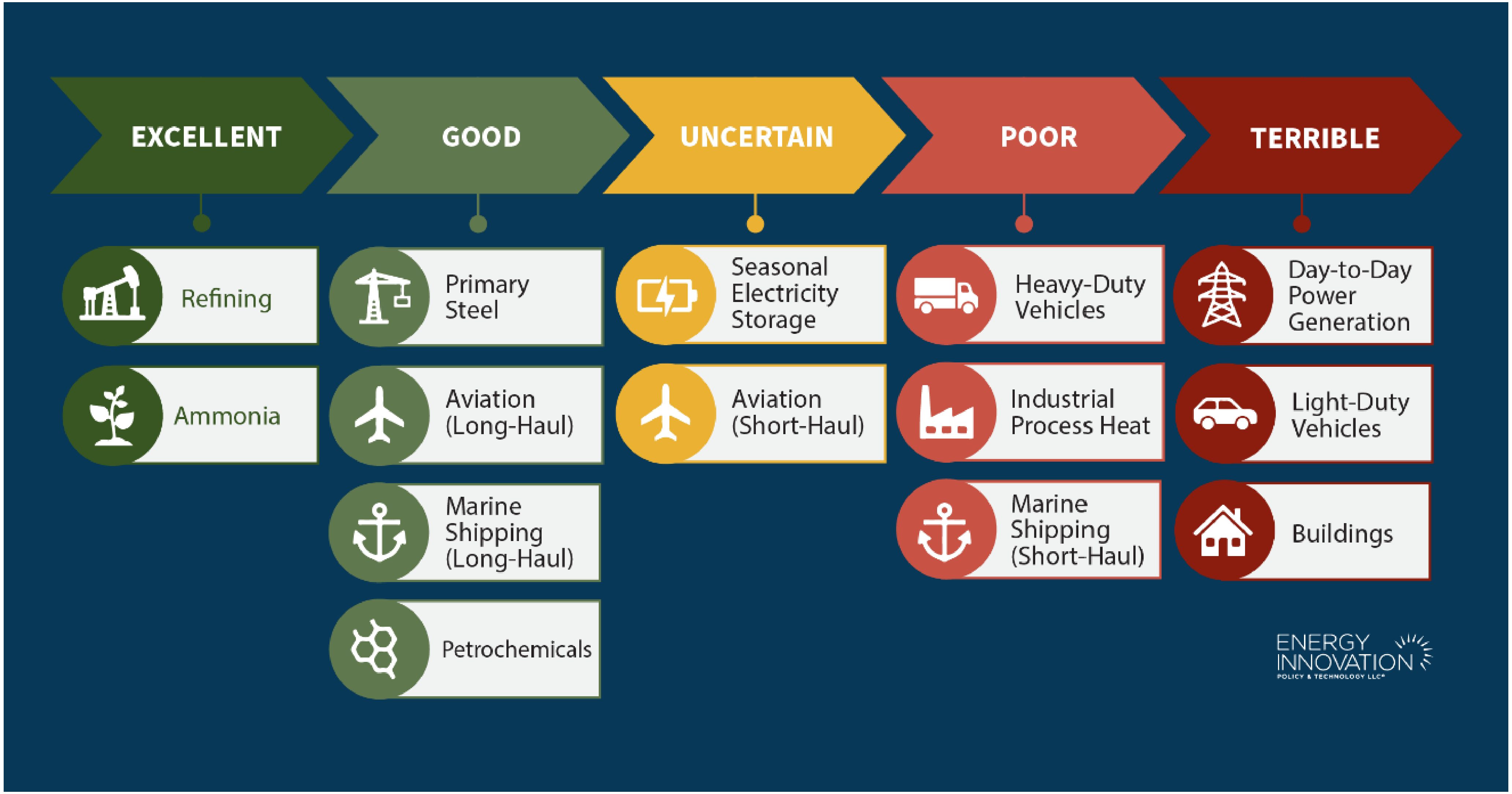
Power Price OMIP Q2-25



POWER GAP current situation < GAS GAP
POWER GAP without Renewables = 2x GAS GAP

Hydrogen Demand

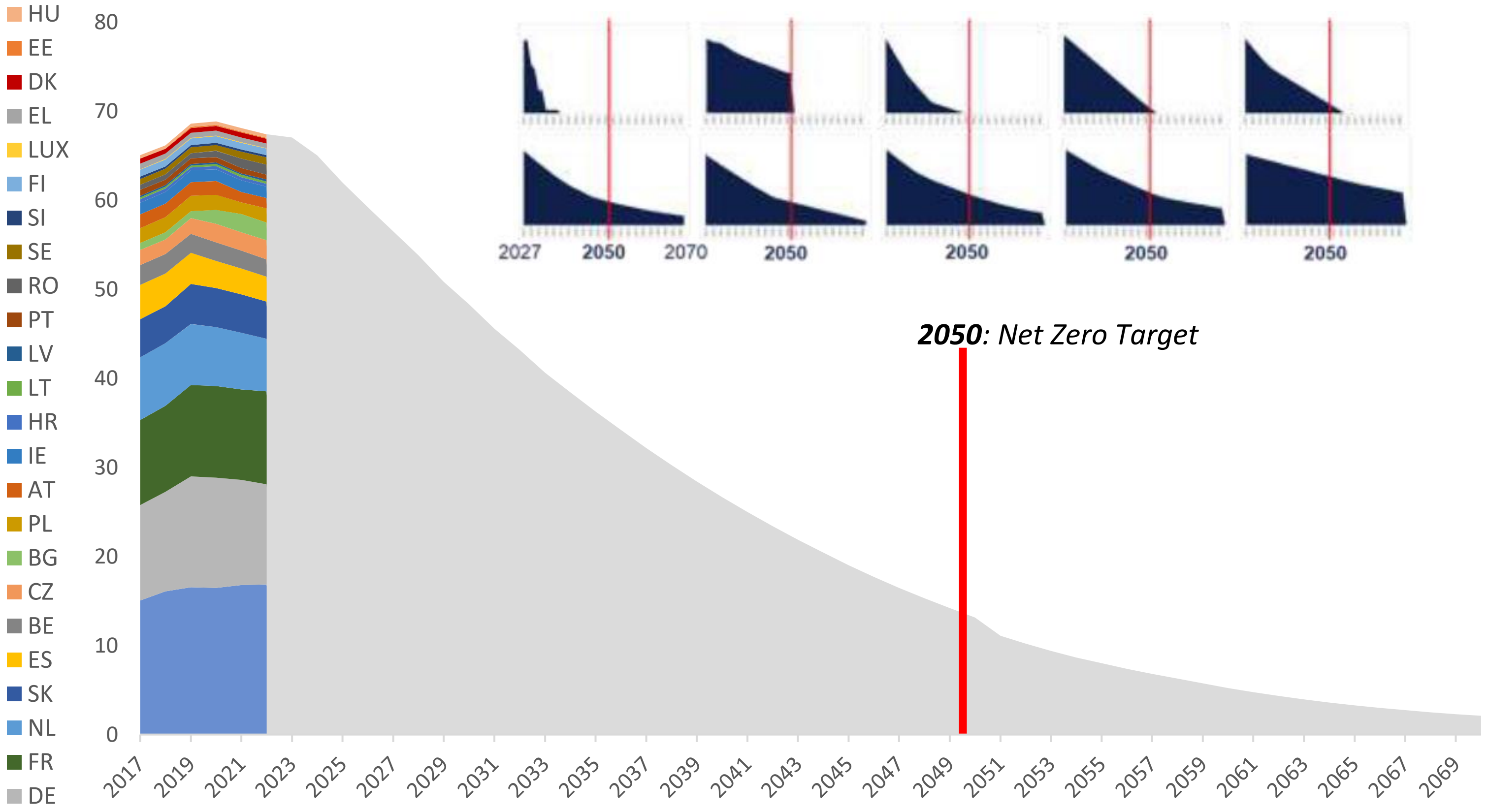
Figure 1. Hydrogen's competitive prospects for decarbonization by end-use sector



Source: Energy Inovation LLC, Hydrogen Policy's Narrow Paths

Phasing-out of Natural Gas: stranded assets and death spiraling

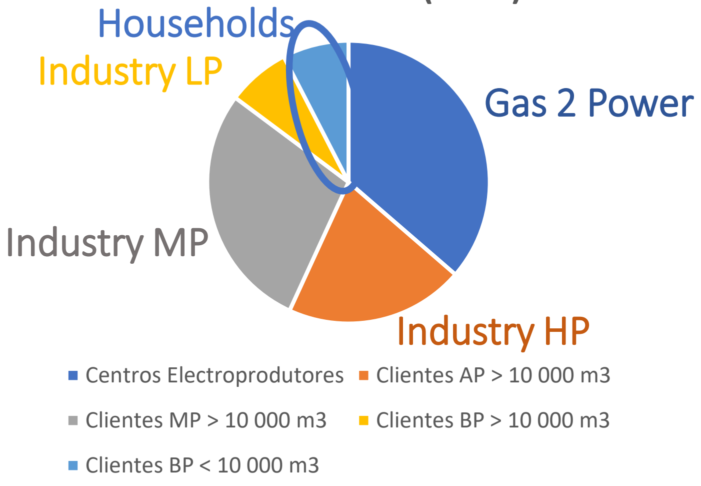
Selected evolutions of Gas TSO RAB in different EU member states:



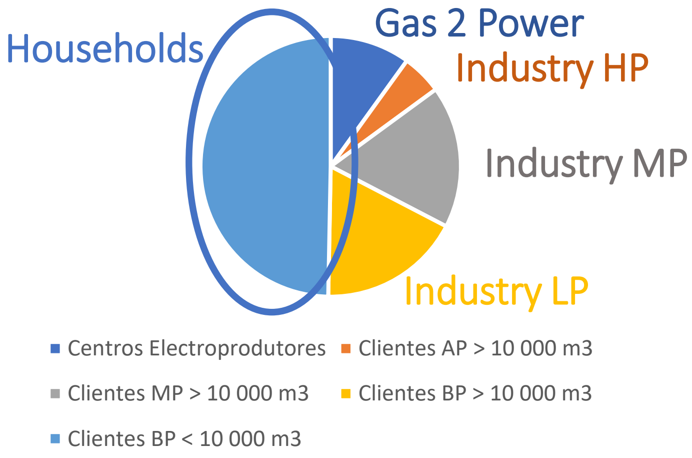
Evolution of Gas TSO RAB in the EU without new investments, 2017-2070 (€MM)

Source: ACER

Demand of Natural Gas in Portugal for Gas Year 2023-2024 (GWh)



Income of Gas Network Access Tariffs in Portugal for Gas Year 2023-2024 (millions €)



Source: ERSE

Gas Decarbonisation and H2 Package

Faced with these different scenarios in the development of the H2 sector and the initial mismatch between supply and demand, NRAs will have a fundamental role in ***managing uncertainties*** *and* ***promoting efficiencies*** *at an early stage.*

The Gas Decarbonisation and H2 Package offers NRAs tools to deal with these uncertainties:

- **Transition period until 2033**: NRAs will decide on derogations in order to stimulate the development of hydrogen markets
- **Blending** targets at interconnection points
- NRA participation in the **network development plans** at H2 TSO and DSO level and in the **decommissioning and repurposing** of phased-out natural gas infrastructure
- Duration of **H2 capacity contracts** up to 20/15 years
- Consultations with adjacent NRAs for the definition of **tariff methodologies** of shared IPs
- Approval of **financial transfers** between regulatory asset bases
- Decisions on **inter-temporal cost allocation** mechanisms

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THANK YOU!

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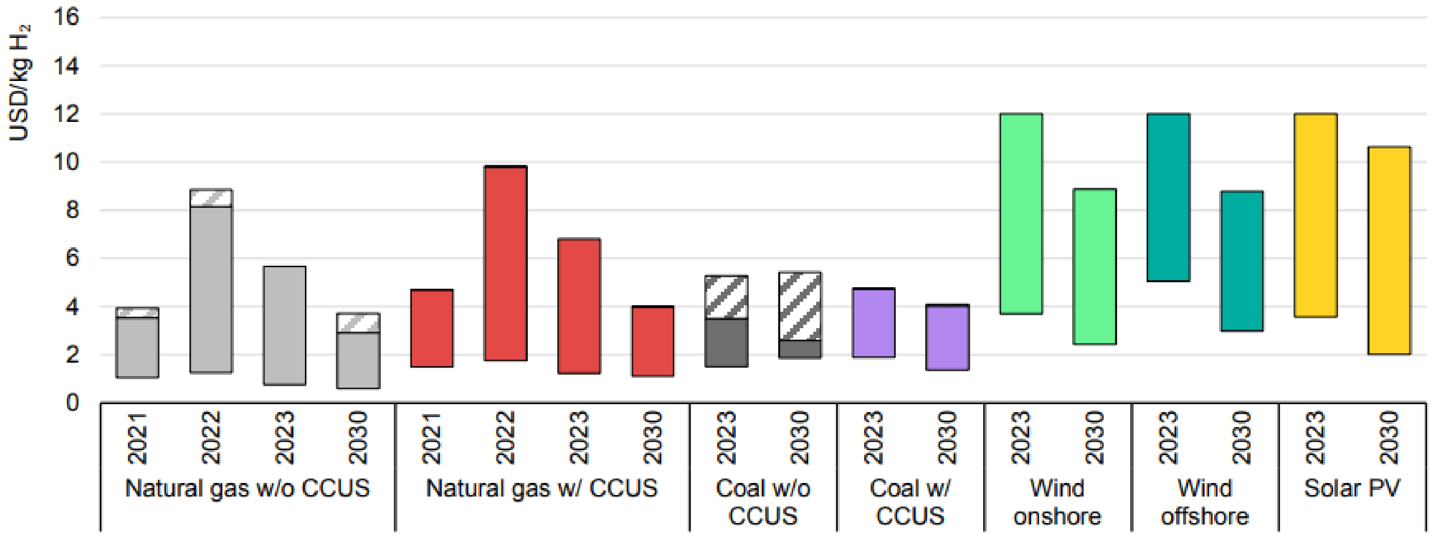
Hydrogen Production Costs

Figure 3.11 Hydrogen production cost by pathway, 2023, and in the Net Zero Emissions by 2050 Scenario, 2030



Notes: CCUS = carbon capture, utilisation and storage; w/ = with; w/o = without. Cost ranges reflect regional differences in fossil fuel prices, renewable costs, CO_2 prices, technology CAPEX and OPEX as well as cost of capital. Natural gas price is USD 5-21/MBtu for 2021, USD 6-51/MBtu for 2022, USD 3-35/Mbtu for 2023 and USD 1-15/MBtu for 2030 NZE. Coal price is USD 9-270/t for 2023 and USD 1-120/t for the NZE Scenario in 2030. The levelised production cost of solar PV electricity is USD 20-120/MWh for 2023, USD 14-90/MWh for the NZE Scenario in 2030, with capacity factor of 12-35%. Onshore wind electricity levelised production cost is USD 23-110/MWh for 2023, USD 22-100/MWh for the NZE Scenario in 2030, with a capacity factor of 15-53%. The offshore wind electricity levelised production cost is USD 55-230/MWh for 2023, USD 36-145/MWh for the NZE in 2030, with a capacity factor of 32-67%. Electrolyser CAPEX is USD 950/kW for the NZE Scenario in 2030 and includes the electrolyser system, its balance of plant and EPC, installation cost and contingencies; electrolyser capacity factor assumed to be the same as the renewable power plant. The cost of capital is 6-20%. The dashed area represents the CO_2 price impact, based on USD 15-140/t CO_2 for the NZE Scenario. Renewable-based hydrogen production costs are capped at USD 12/kg H_2. Water cost is not included. Other techno-economic assumptions are included in the Annex.

Sources: Based on data from McKinsey & Company and the Hydrogen Council; NETL (2022); IEA GHG (2017).

Source: IEA, Global Hydrogen Review, 2024