12 Insights on Hydrogen

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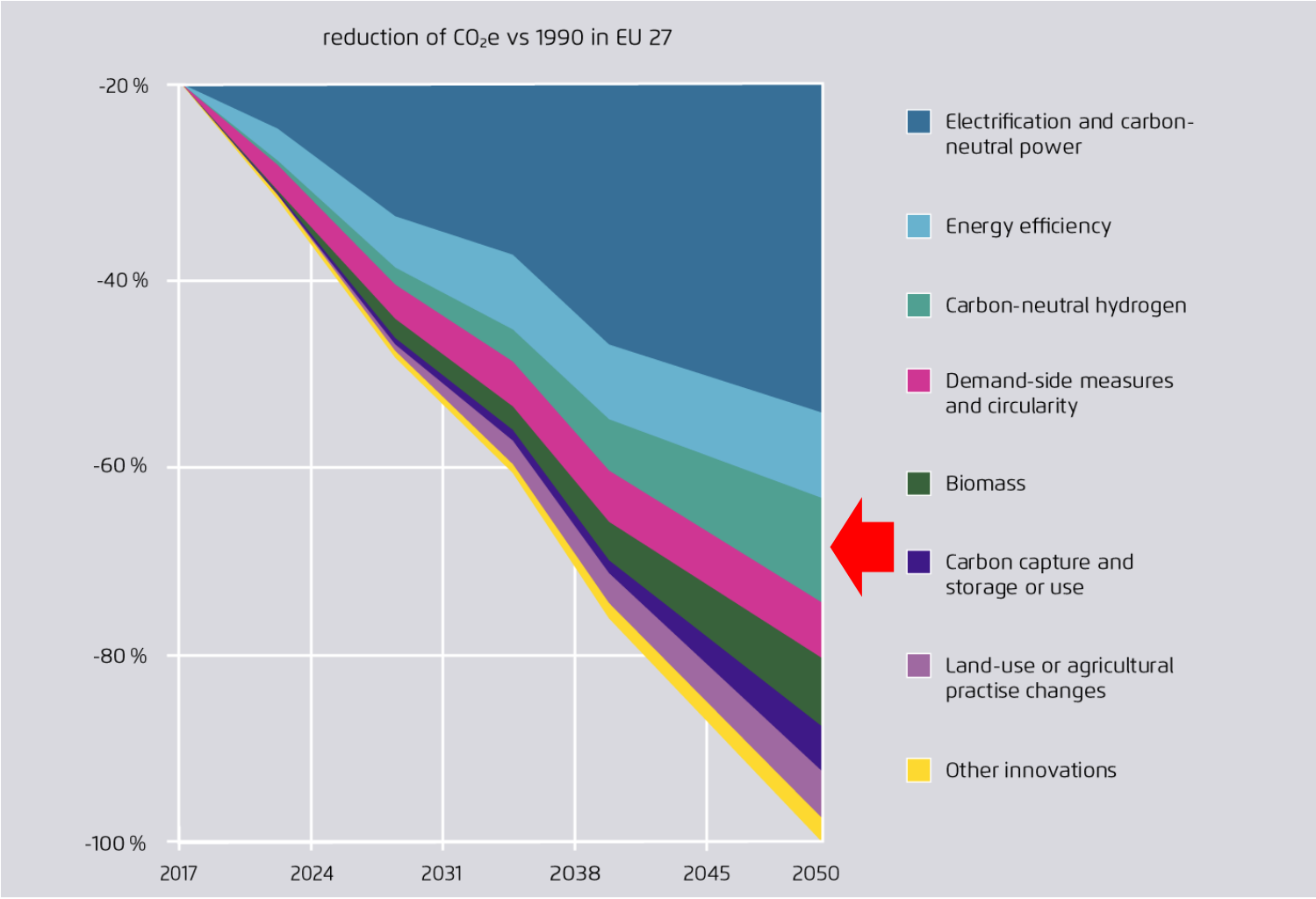
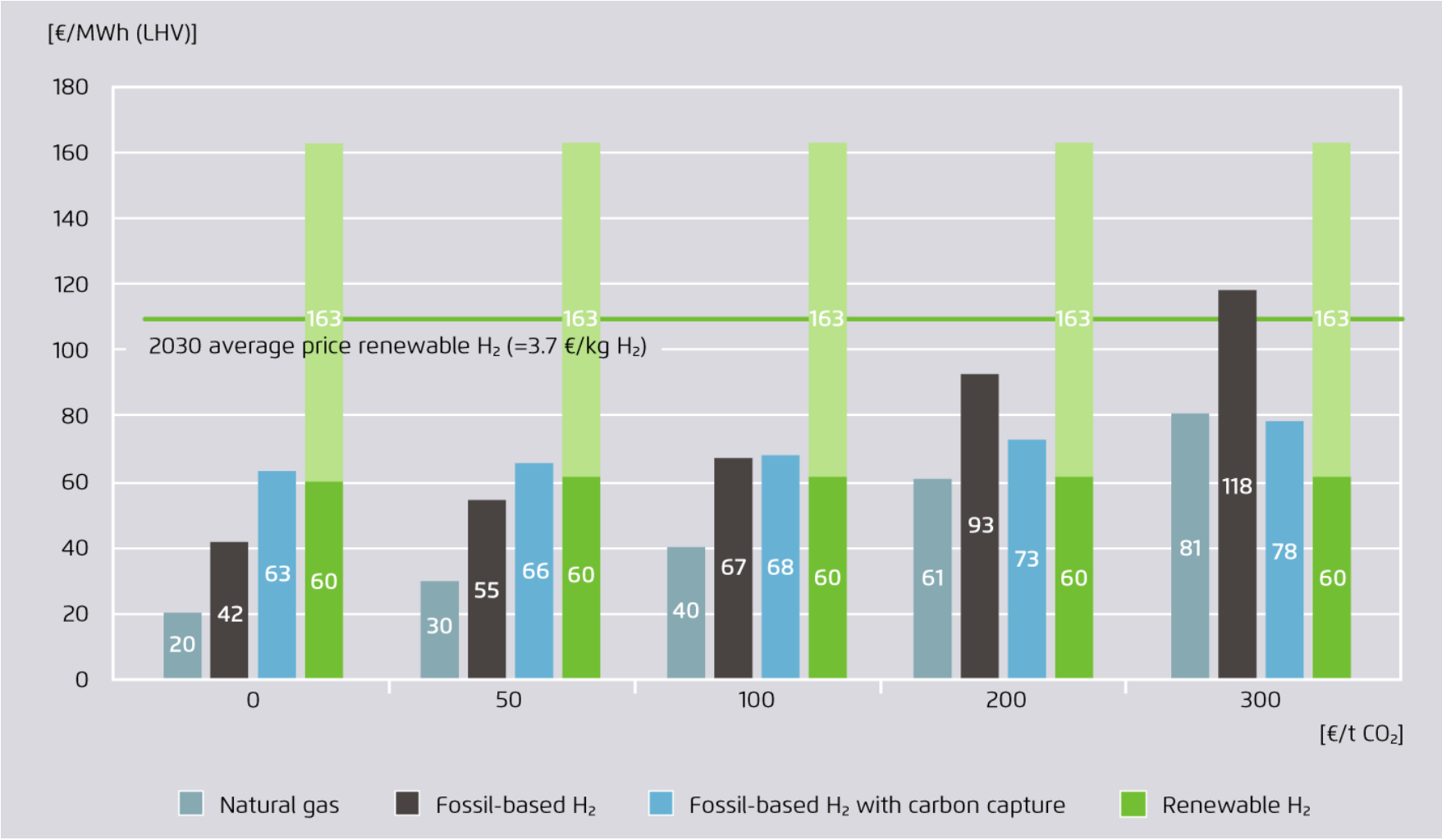
Hydrogen in a net-zero Europe

Share of greenhouse gas emissions abatement in the EU by mitigation measure



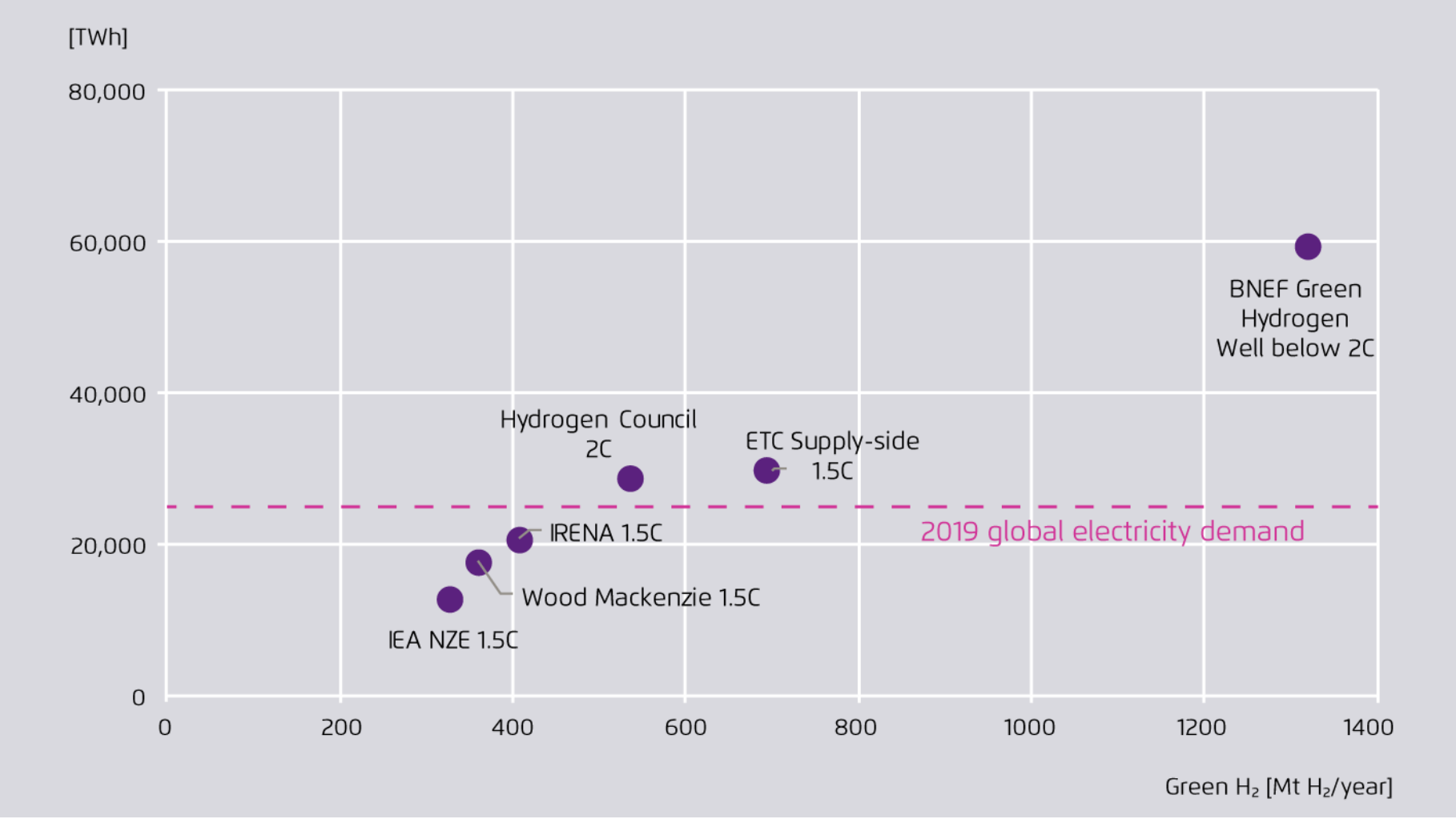
McKinsey (2020)

Impact of carbon pricing on the economics of hydrogen and natural gas in 2030



Agora Energiewende & Guidehouse (2021); Assumes natural gas price of €20/MWh, capture rate for fossil-based H_2 with CCS of around 75%.

Renewable electricity needed to produce green hydrogen in global energy scenarios for 2050



IRENA Coalition for Action (2021), BloombergNEF (2021)
Note: ETC = Energy Transition Commission; IRENA = International Renewable Energy Agency; IEA = International Energy Agency; BNEF = BloombergNEF.

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1. Role of hydrogen for climate neutrality is crucial but secondary to direct electrification: analysts agree, but not all lobbyists

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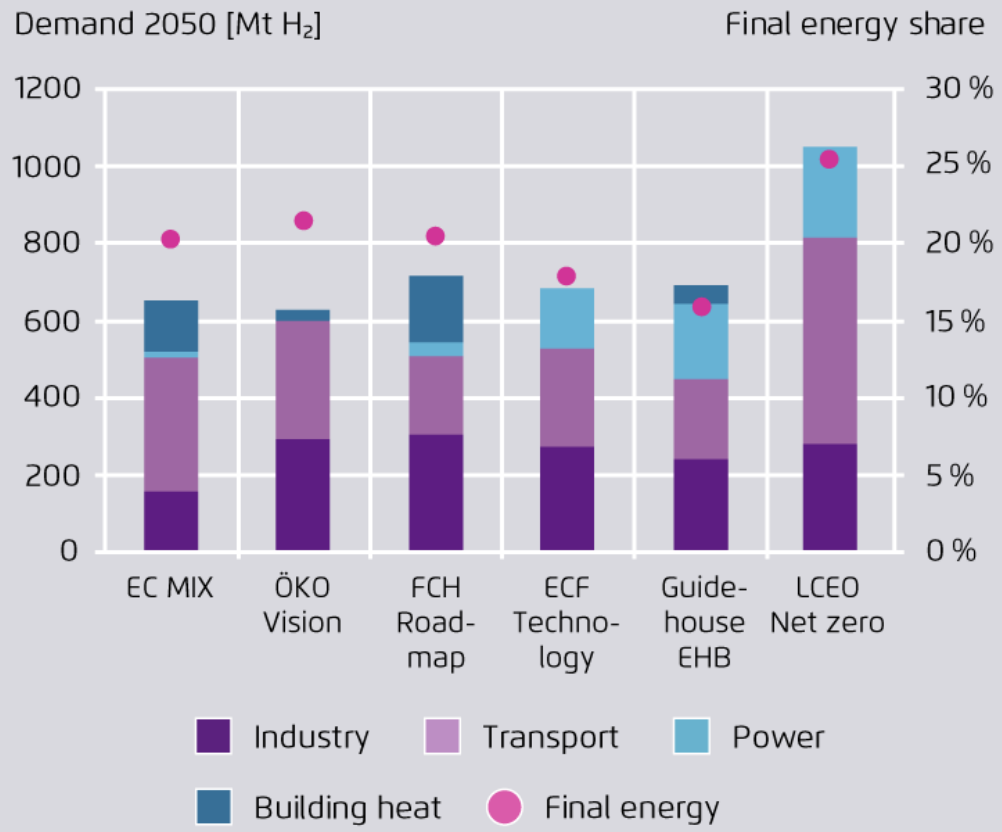
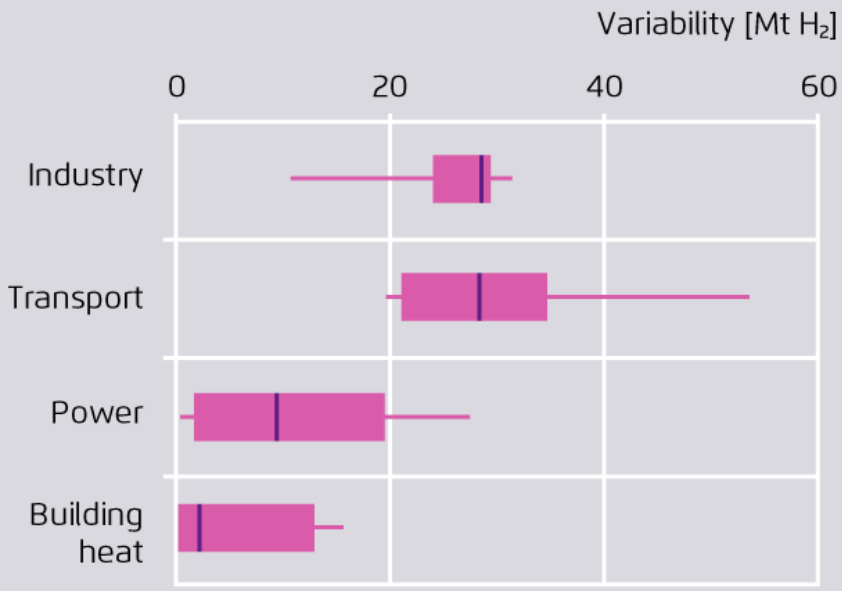
Estimates of EU27+UK H_2 demand in European net-zero scenarios for 2050 — Figure 5





JRC (2020), Guidehouse (2021a), COM (2020) Note: EC MIX = European Commission, Impact Assessment SWD (2020); Öko Vision = Öko-Institute; FCH Roadmap = Fuel Cell and Hydrogen Joint Undertaking 1.5C; ECF Technology = European Climate Foundation "Net Zero by 2050"; Guidehouse EHB = Gas for Climate "European Hydrogen Backbone"; LCEO Net Zero = Joint Research Centre "Low Carbon Energy Observatory". Final energy share is calculated by subtracting non-energy demand, adjusting transport to 75 % of demand and power to 40 % of demand.

No-regret applications

Green molecules needed?	Industry	Transport	Power sector	Buildings
No-regret	· Reaction agents (DRI steel) · Feedstock (ammonia, chemicals)	· Long-haul aviation · Maritime shipping	· Renewable energy back-up depending on wind and solar share and seasonal demand structure	· Heating grids (residual heat load *)
Controversial	· High-temperature heat	· Trucks and buses ** · Short-haul aviation and shipping · Trains ***	· Absolute size of need given other flexibility and storage options	
Bad idea	· Low-temperature heat	· Cars · Light-duty vehicles		· Building-level heating

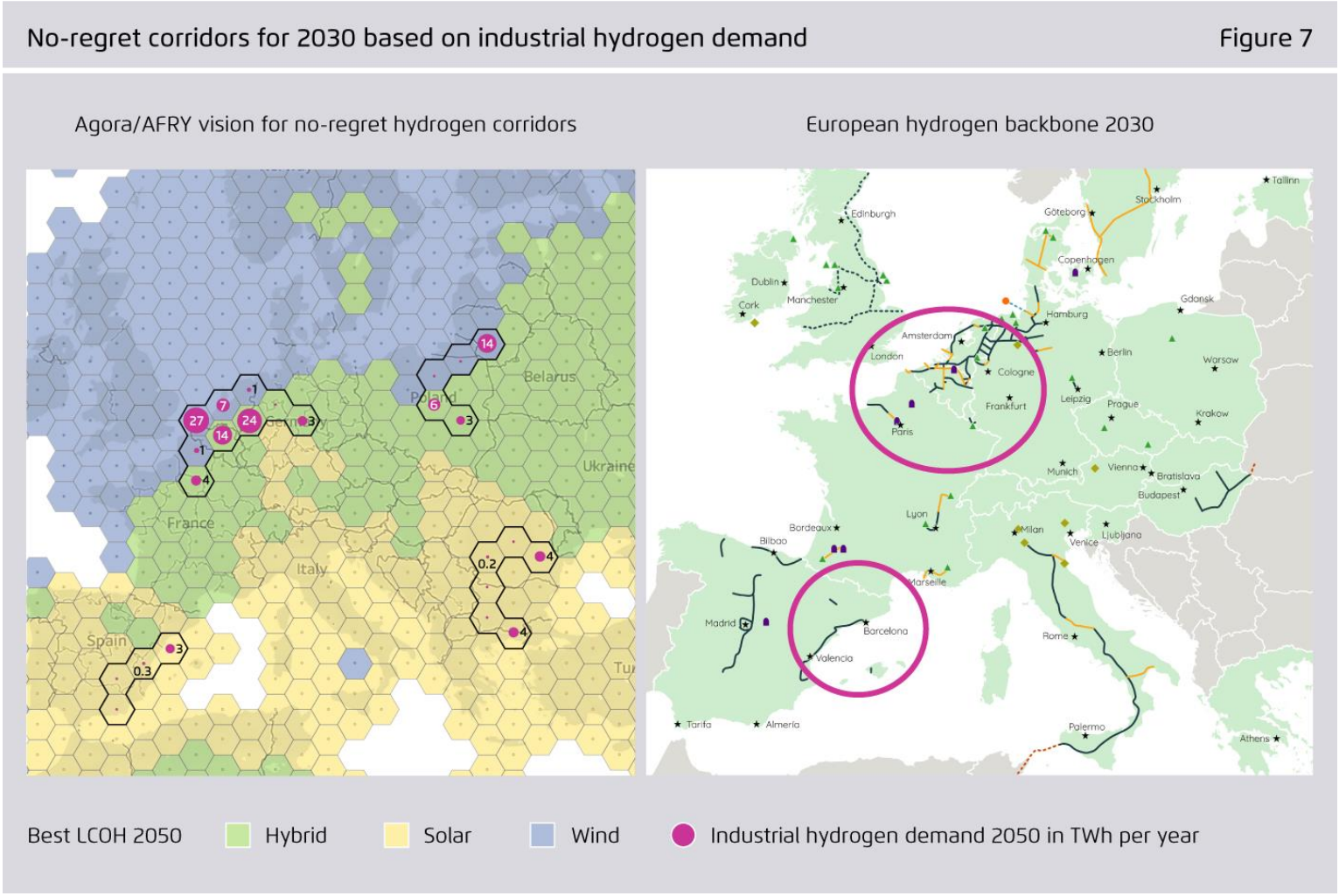
* After using renewable energy, ambient and waste heat as much as possible. Especially relevant for large existing district heating systems with high flow temperatures. Note that according to the UNFCCC Common Reporting Format, district heating is classified as being part of the power sector.

** Series production currently more advanced on electric than on hydrogen for heavy duty vehicles and buses. Hydrogen heavy duty to be deployed at this point in time only in locations with synergies (ports, industry clusters).

*** Depending on distance, frequency and energy supply options

2. We should anchor hydrogen infrastructure around no-regret industrial and power demand

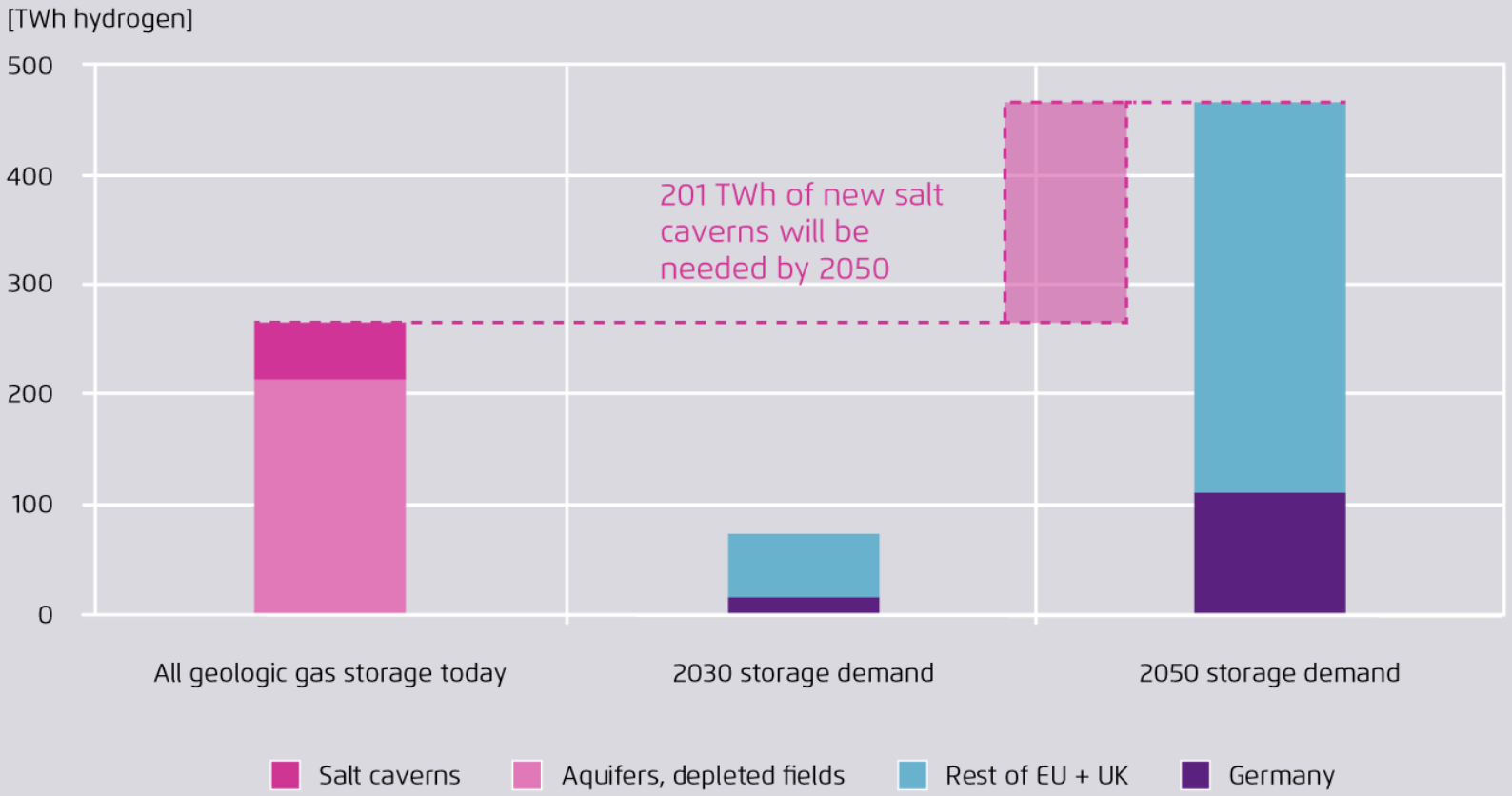
No-regret corridors for 2030 based on industrial hydrogen demand — Figure 7



Agora Energiewende & AFRY (2021), Guidehouse (2021b) Note: Only those hydrogen pipelines that are resilient to the future levels of hydrogen demand and the technology assumptions used here have been considered to be “no-regret”.

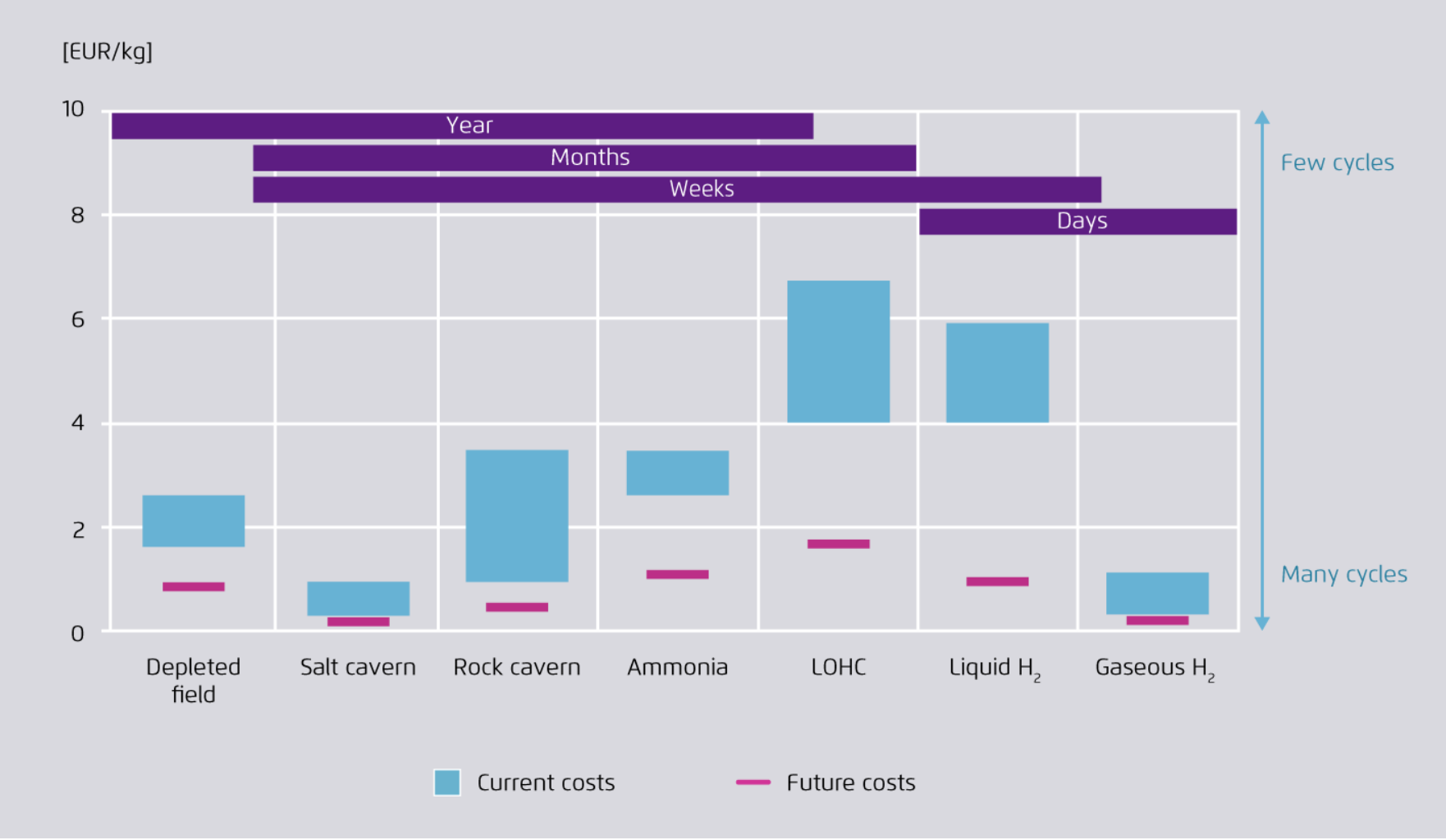
3. We need significantly greater amounts of new large-scale geological hydrogen storage

European hydrogen storage requirements and potentials Figure 10



GIE & Guidehouse (2021)

Levelised cost of hydrogen storage

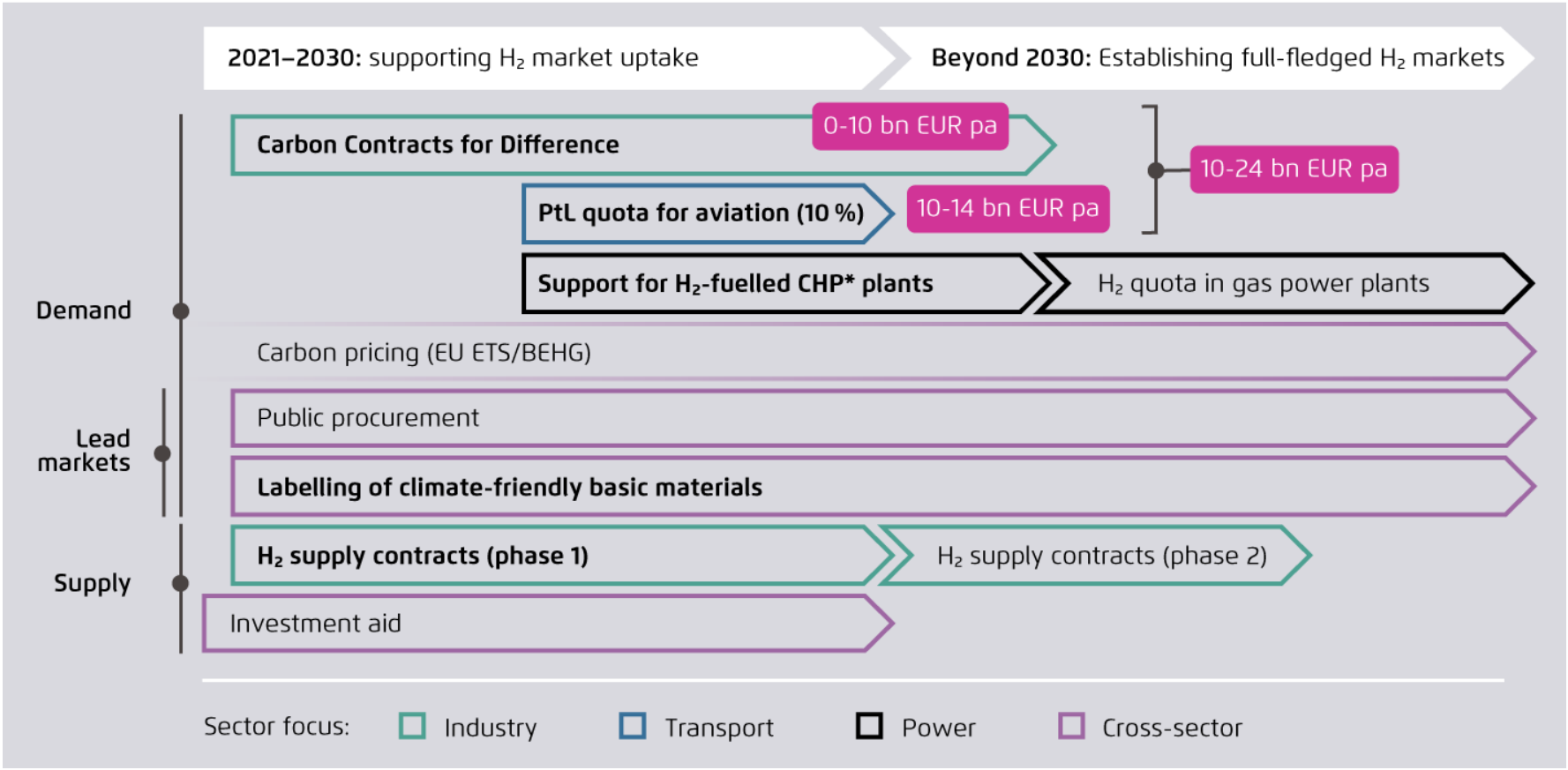


BloombergNEF (2020), J. Doomernik et al (2020) Note: LOHC = Liquid organic hydrogen carrier

4. We're going to need policy instruments for supporting renewable hydrogen in no-regret applications

Support instruments for renewable hydrogen and costs of support for CCfDs and the PtL quota in the European Union

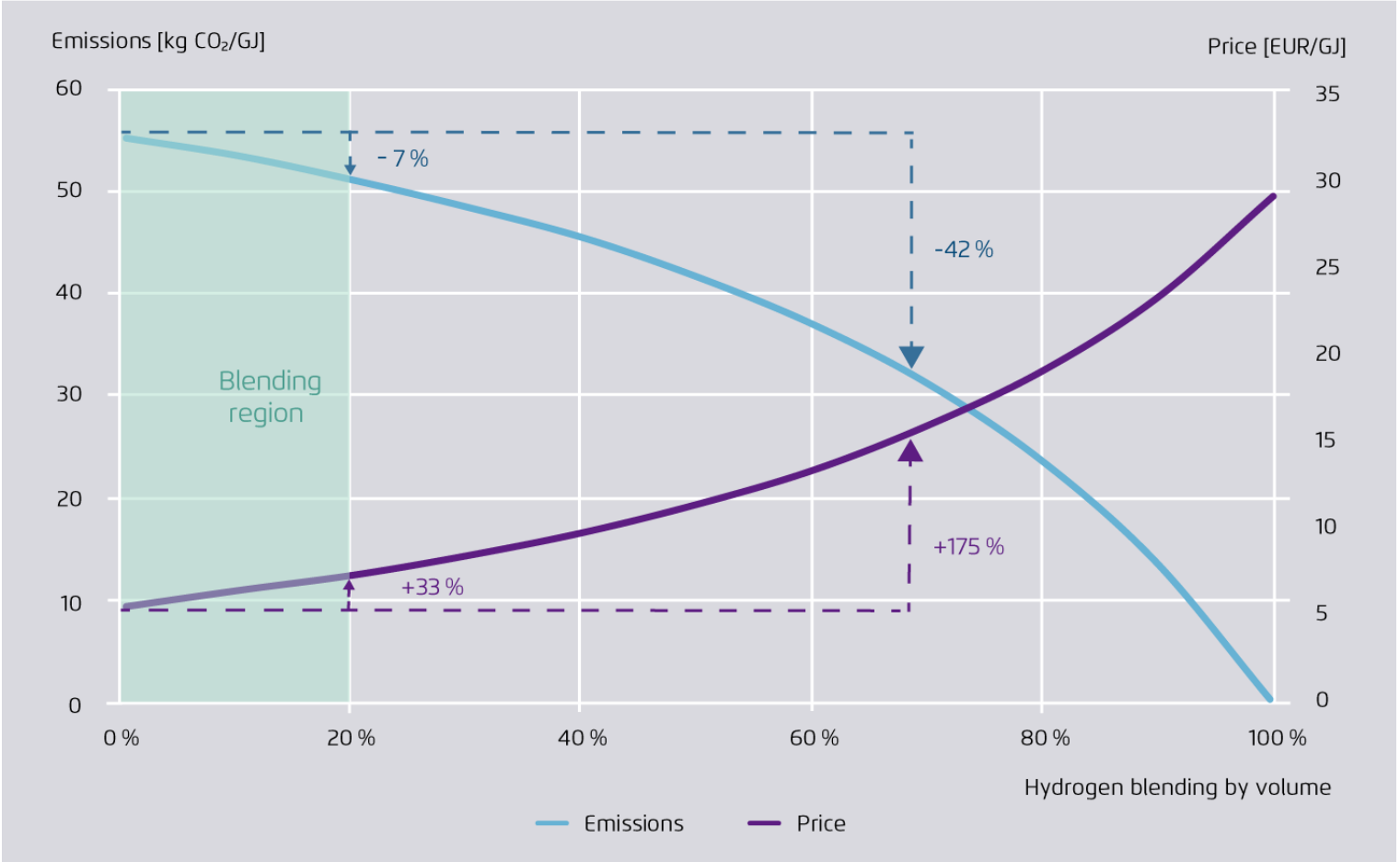
Figure 11



Agora Energiewende and Guidehouse (2021) Note that the PtL quota increase further after 2030. Also, Guidehouse assumes an aviation quota of only 5 % by 2030.

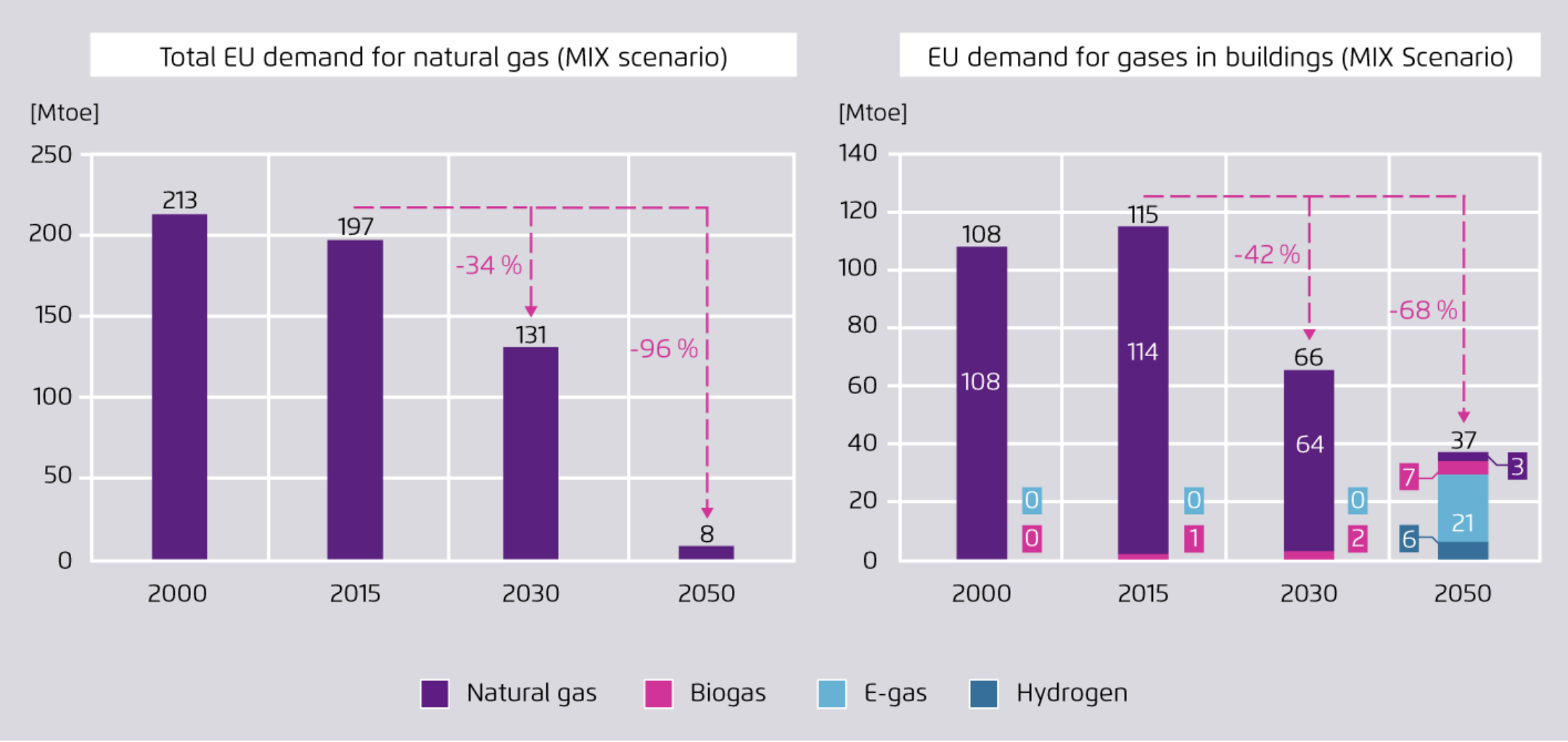
5. There is no credible financing strategy for hydrogen use in households

Blending abatement costs, 2030 Figure 12



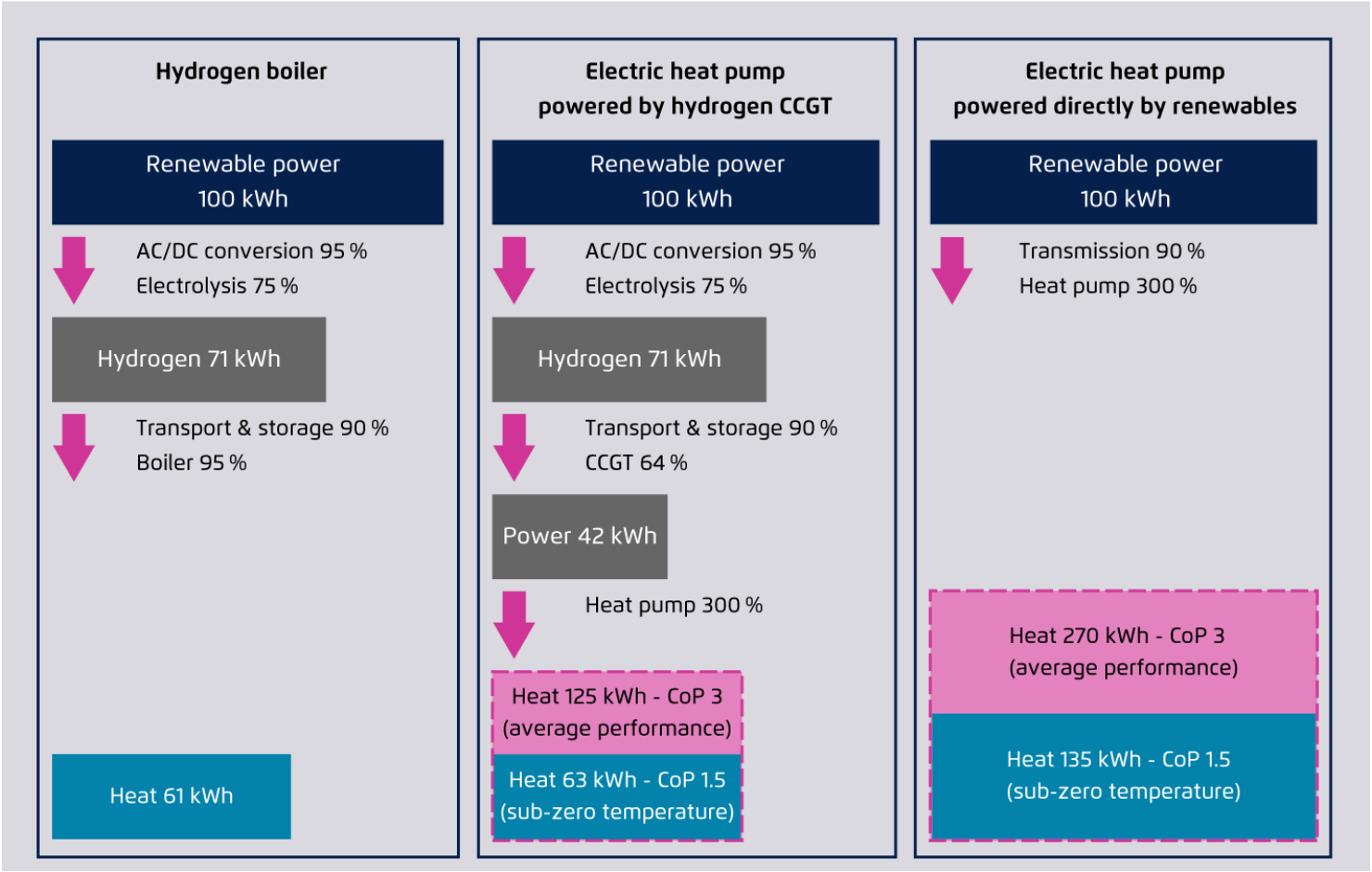
IRENA (2021b) Note: This assumes a fossil gas price of 20 EUR/MWh (= 5.6 EUR/GJ) and a hydrogen price of 3.7 EUR/kg taken from Figure 2.

6. Gas distribution grids need to prepare for a disruptive end of their business model



Efficiency comparison of different heating systems starting from renewable electricity

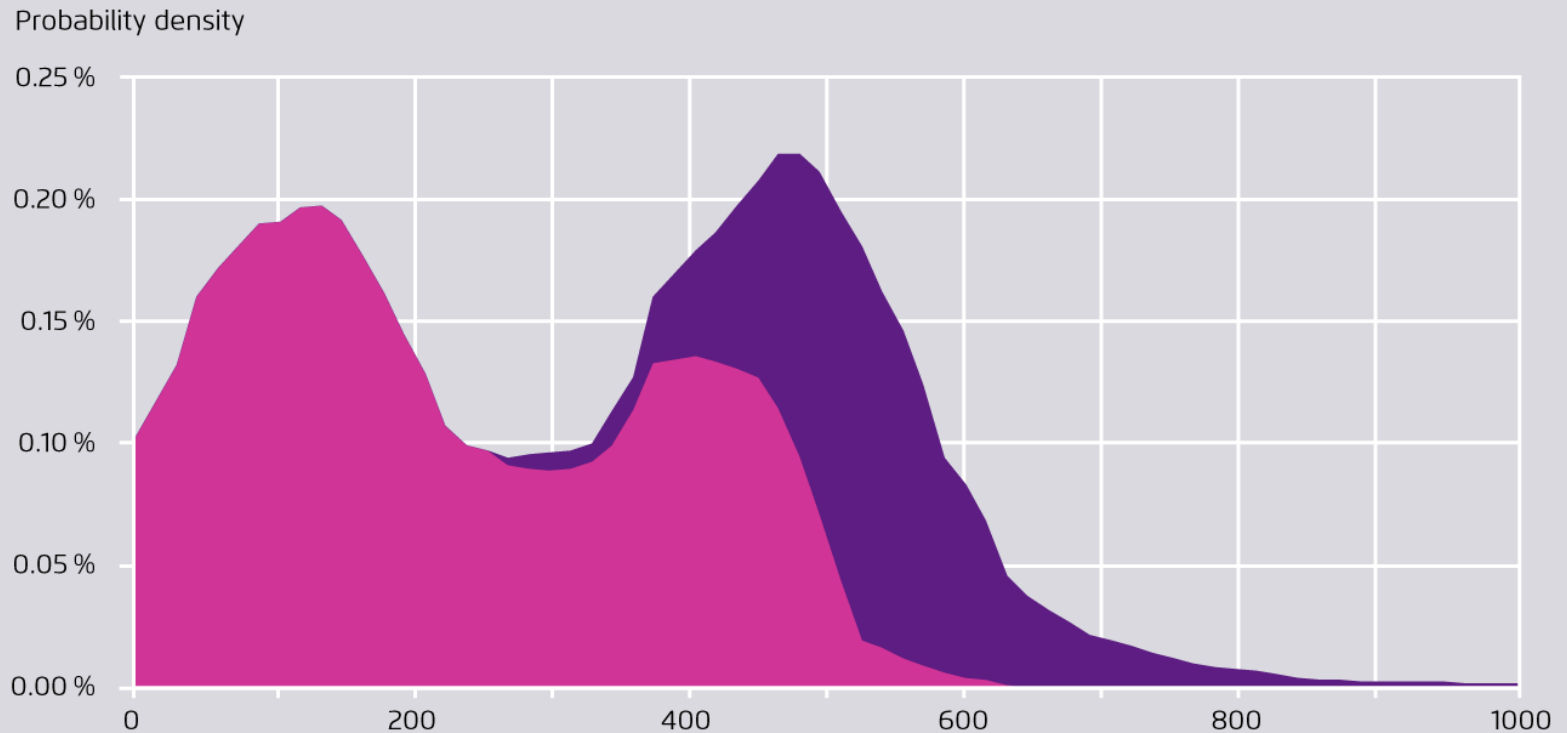
Efficiency comparison of different heating systems starting from renewable electricity Figure 16



Own calculations based on LETI (2021) and Fraunhofer ISE (2011) Note: Heat pump performance varies based on external temperature. Heat pump coe cient of performance (CoP) were chosen based on average seasonal performance (CoP = 3) and performance under sub-zero temperatures typical of winter months (CoP = 1.5)

7. The potential future market for hydrogen vehicles is shrinking daily

Distribution of heavy trucks by daily driving distance, 2050 Figure 18

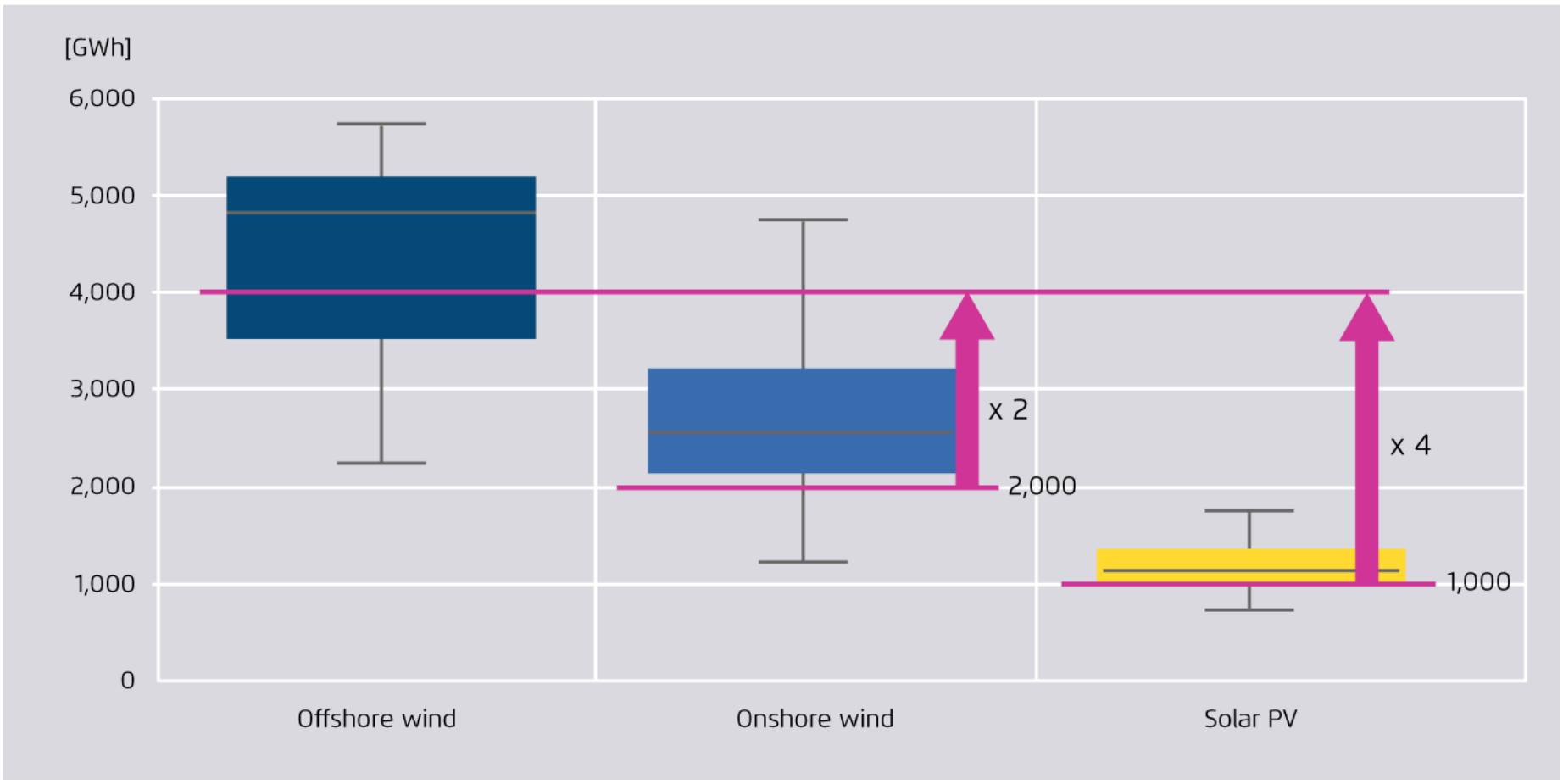


IEA (2021a)

8. Each GW electrolysis must come with 1–4 GW of additional renewables

GWh electricity produced by 1 GW of renewable technology per year

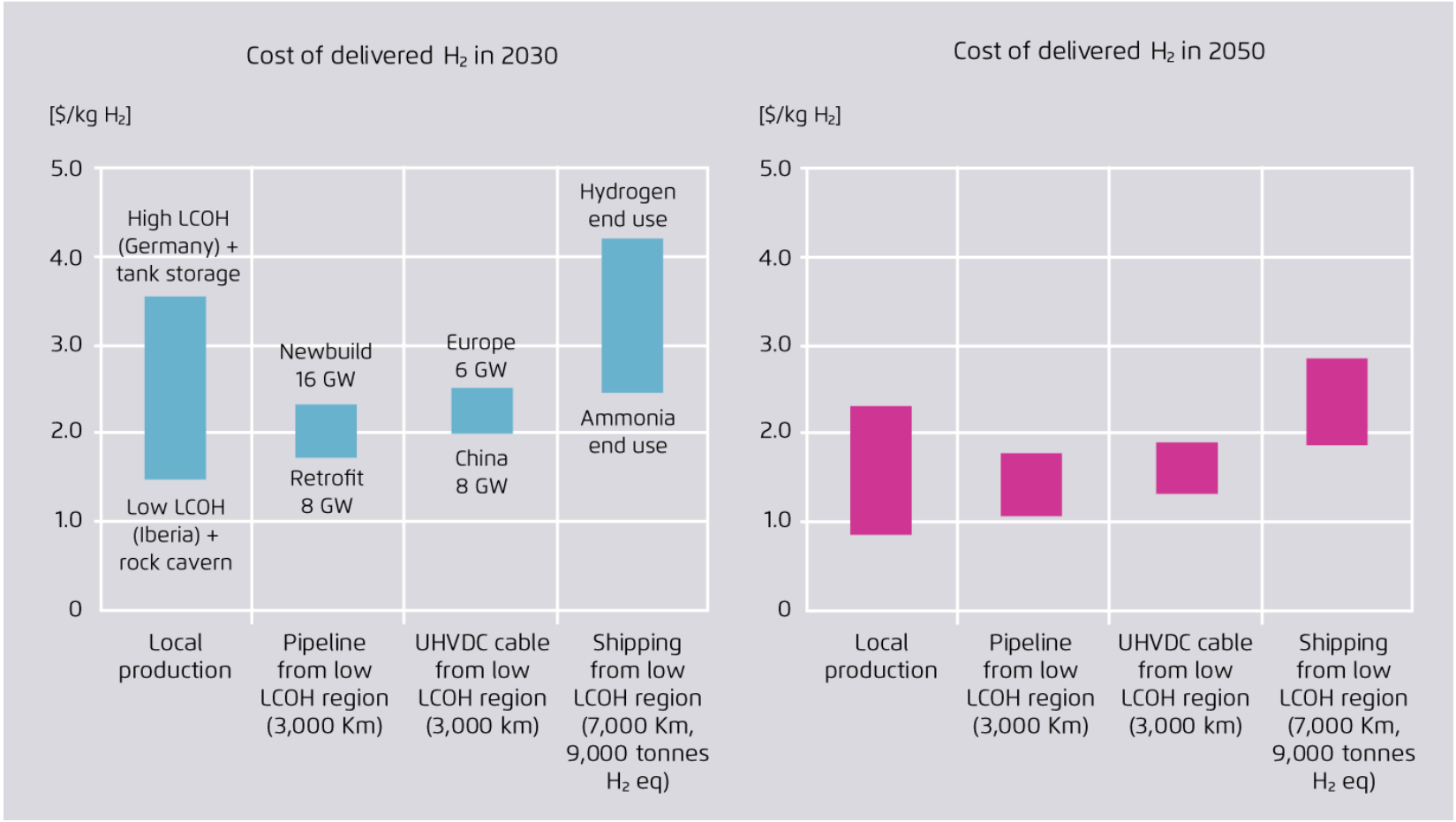
Figure 19



Agora Energiewende based on AFRY Management Consulting (2021) Note: The underlying box plots represent key statistics of average full-load hours, multiplied by 1 GW at the level of hexagons in Europe with an approximate size of 50,000km². They do not represent the total potential volume of renewable electricity that can be generated.

9. Hydrogen trade will be regional: shipping hydrogen is more expensive than pipes or cables

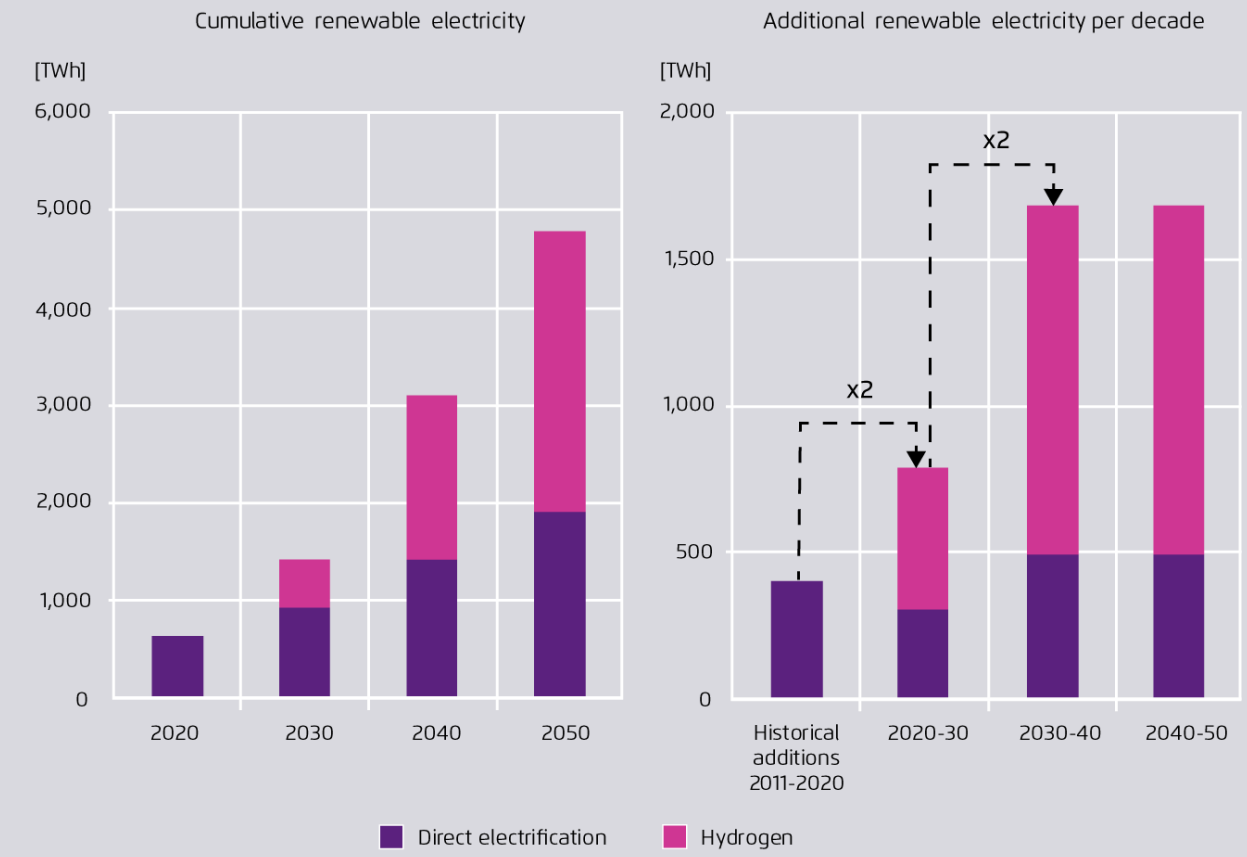
Economics of delivered hydrogen — Figure 20



ETC (2021), Guidehouse (2021a), BloombergNEF (2020) Notes: Green hydrogen production takes into account storage costs of 50 % annual demand. This is the lowest-cost retrofitted gas pipeline according to the European Hydrogen backbone report.

10. Actively securing public acceptance is crucial for Europe to reach its full hydrogen potential

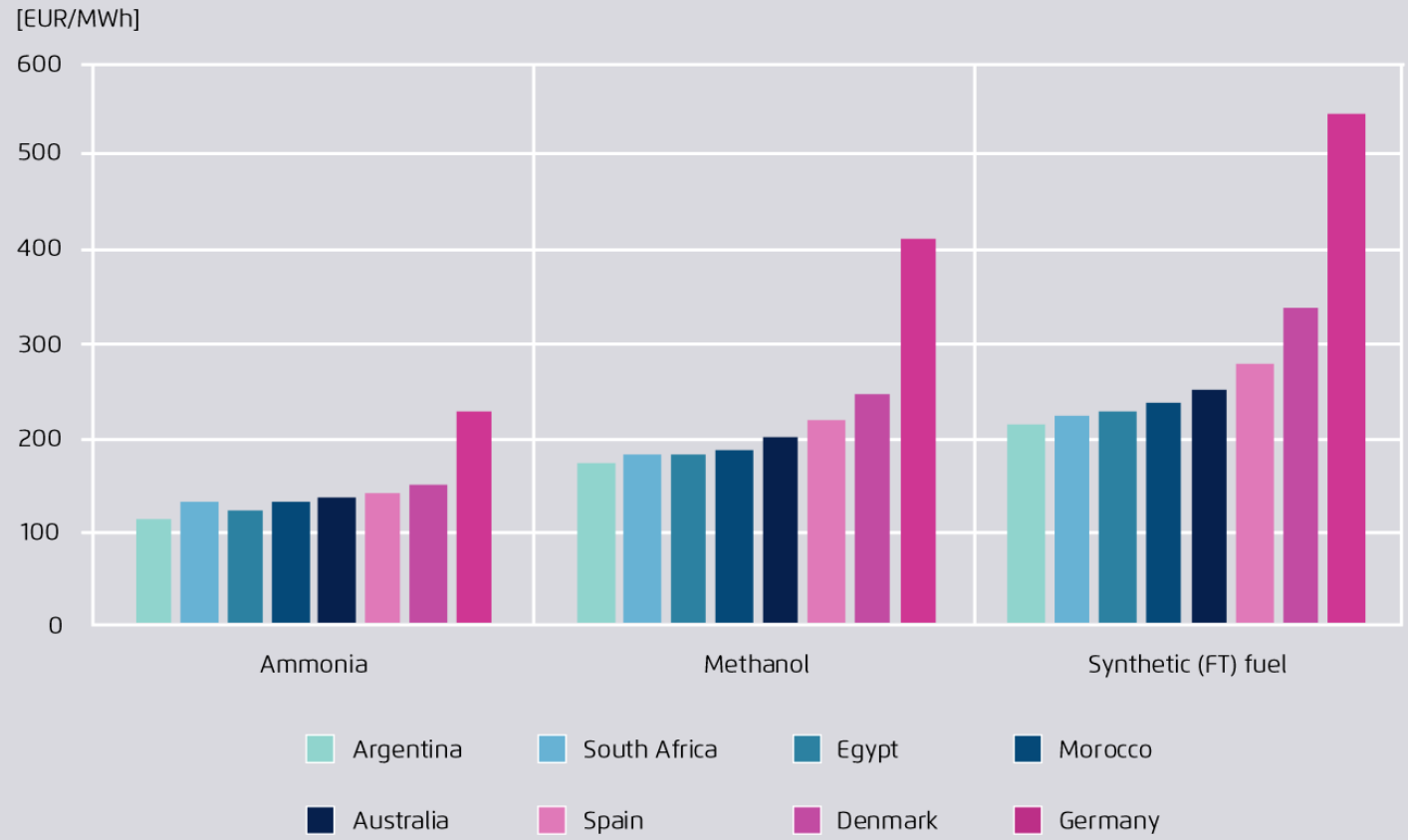
Electricity requirements to meet European hydrogen demand projections and renewable supply gap. Figure 22



Guidehouse (2021a), COM (2020) and Agora Energiewende & Ember (2021) Note: Assumed electrolyser efficiency of 70 % for 2020–2030 and 80 % for period 2030–2050.

11. To keep its industry competitive EU should access cheap H_2 from neighbours while importing synfuels from global market

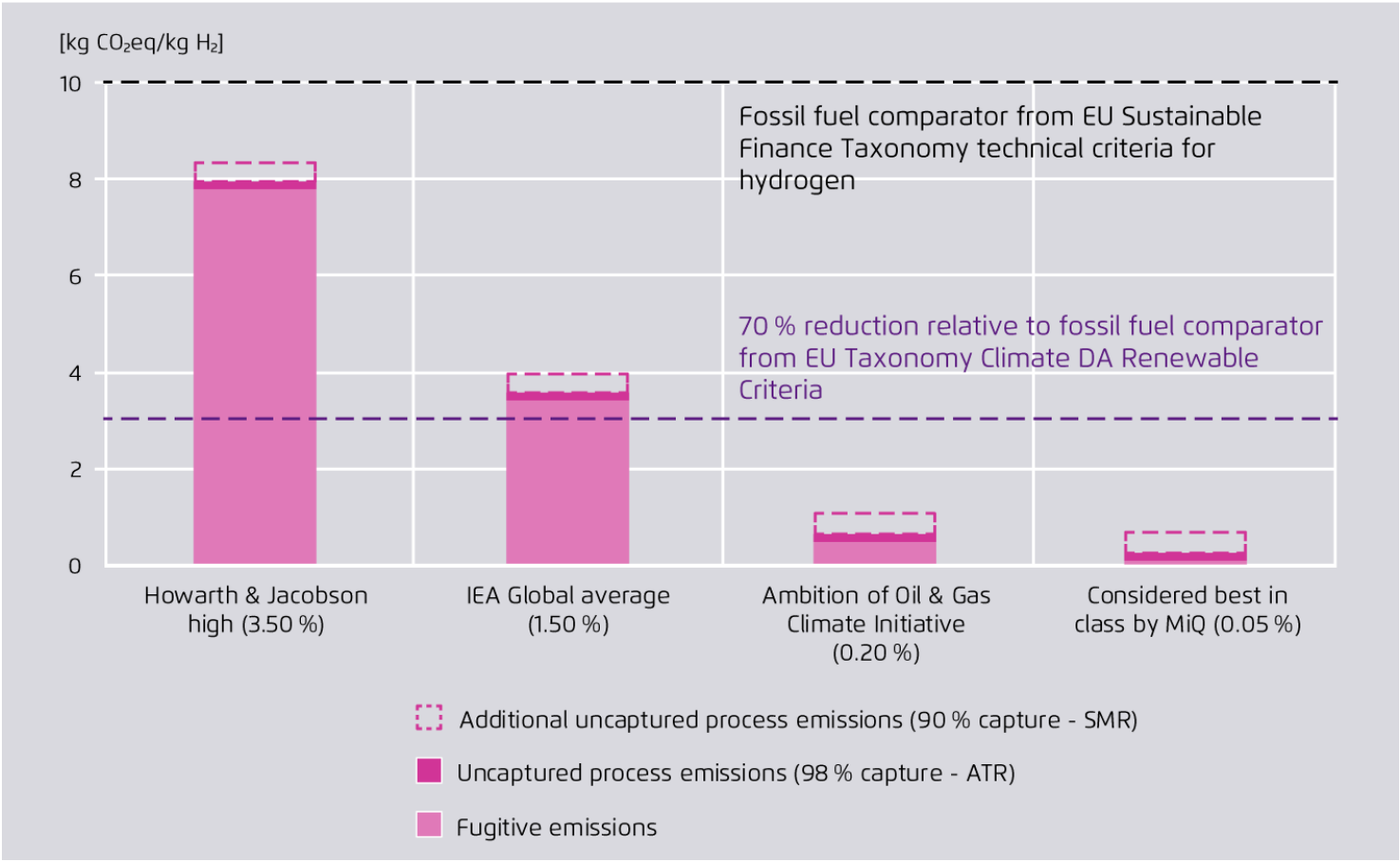
Cost of energy delivered through hydrogen-based products to Germany, 2030 Figure 25



J. Hampp et. al (2021) Note: 10 % Weighted average cost of capital

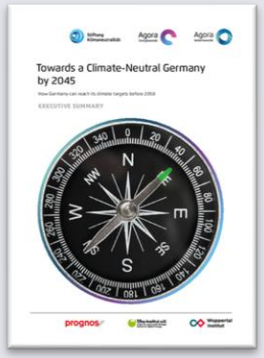
12. We should remain open to the idea of H_2 from processes involving carbon capture, but combine it with strict safeguards

Total GHG emissions on a GWP 20 basis from fossil-based hydrogen with CCS (methane leakage as percentage of consumed gas in brackets) Figure 27



ETC (2021), IPCC (2021), Robert W. Howarth, Mark Z. Jacobson (2021) Note: The figure assumes GHG emissions factor of 82.5 used to reflect the global warming potential of methane over 20 years based on IPCC AR6. Note that the most commonly used GWP is GWP100. With GWP100, the GHG effect of fugitive emissions would be considerably smaller. OGCI = Oil and Gas Climate Initiative; DA = Delegated Act.

Publications on climate-neutrality, hydrogen and industry

12 Insights on Hydrogen	Making renewable hydrogen cost-competitive	No-regret hydrogen: Charting early steps for H_2 infrastructure in Europe	Towards a climate-neutral Germany by 2045	Breakthrough Strategies for Climate-Neutral Industry in Europe
				
> impulse	> main study > legal analysis	> full study	> summary (EN) > full study (DE)	> summary > full study
	> slide deck > webinar	> data appendix > webinar	> data appendix (DE)	> webinars

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