

Presentation of the Clean Hydrogen Monitor 2022

European Hydrogen Week

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Clean Hydrogen Monitor 2022

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Agenda

Clean Hydrogen Monitor 2022

Levelized cost of hydrogen

Current market

Future production

Future consumption

Scaling-up the hydrogen industry: Electrolyser manufacturing capacity and critical raw materials

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Q&A



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Levelized cost of hydrogen

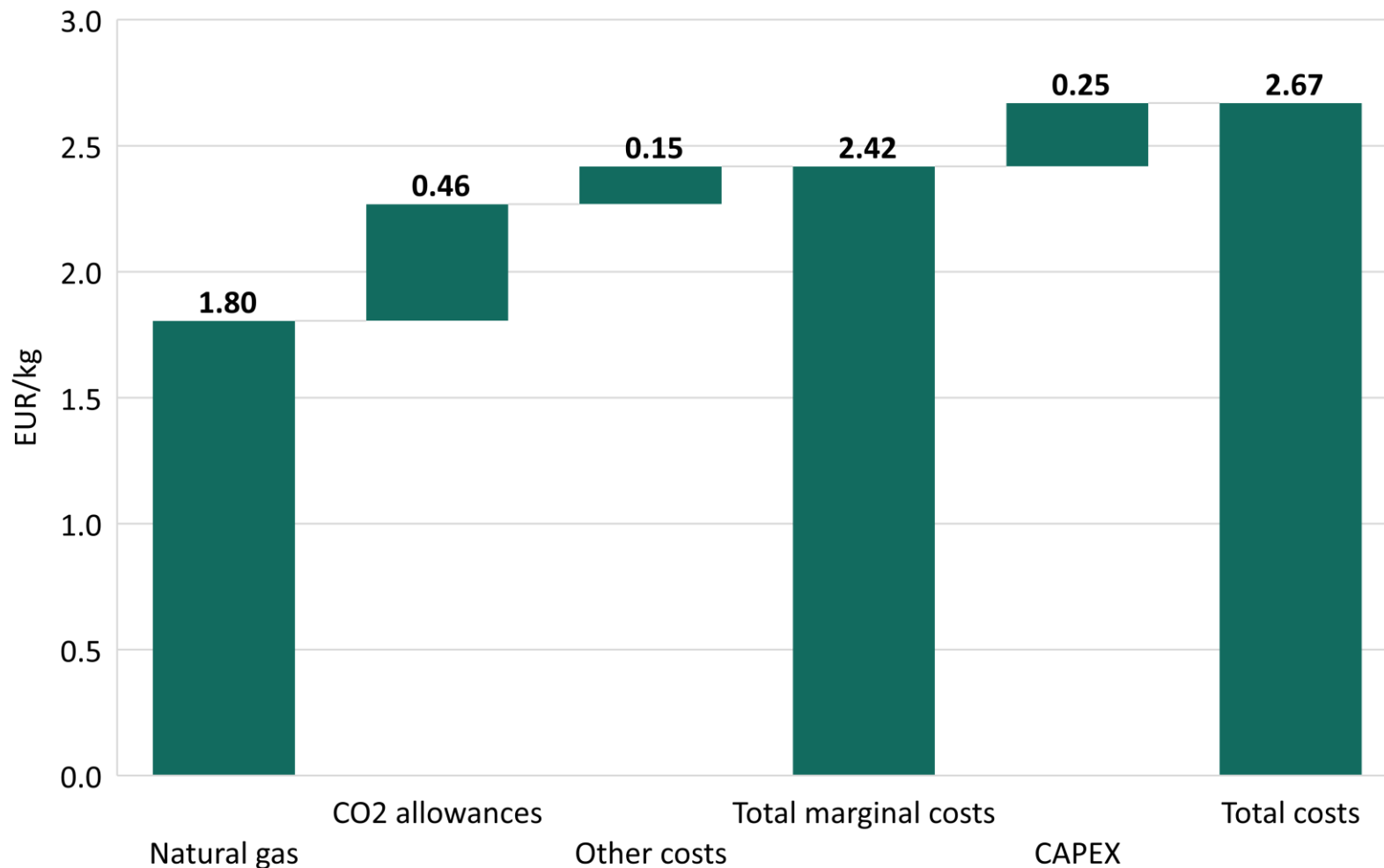
Grzegorz Pawelec

- Fossil fuel benchmark
- Grid connected electrolysis
- Direct connection to renewables

Cost of conventional hydrogen production

Marginal costs represent 90% of the total cost for steam methane reforming

Hydrogen production costs via SMR in EU27 in 2021 (in EUR/kg)

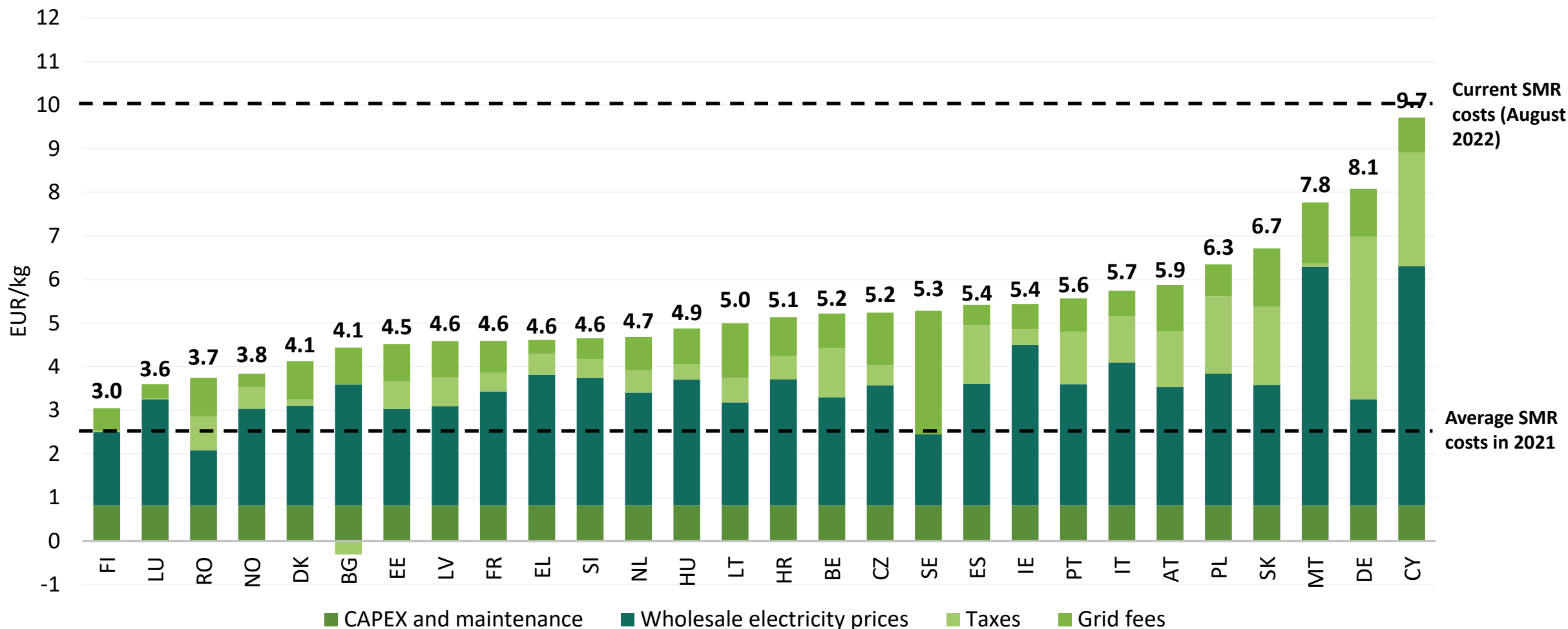


- Average estimated costs of „grey hydrogen” production in the EU in 2021 was around **2.67 EUR/kg**
- Long-term average of the last 5 years is **1.5 – 2 EUR/kg**
- Average estimated costs of „grey Hydrogen” production in the EU in 2022 is around **10 EUR/kg**
- Grey hydrogen carbon footprint is on average around **9-10 t CO2 per t H2**

Costs of grid connected electrolytic hydrogen

Grid connected electrolytic hydrogen inching towards 2021 SMR production costs in some countries

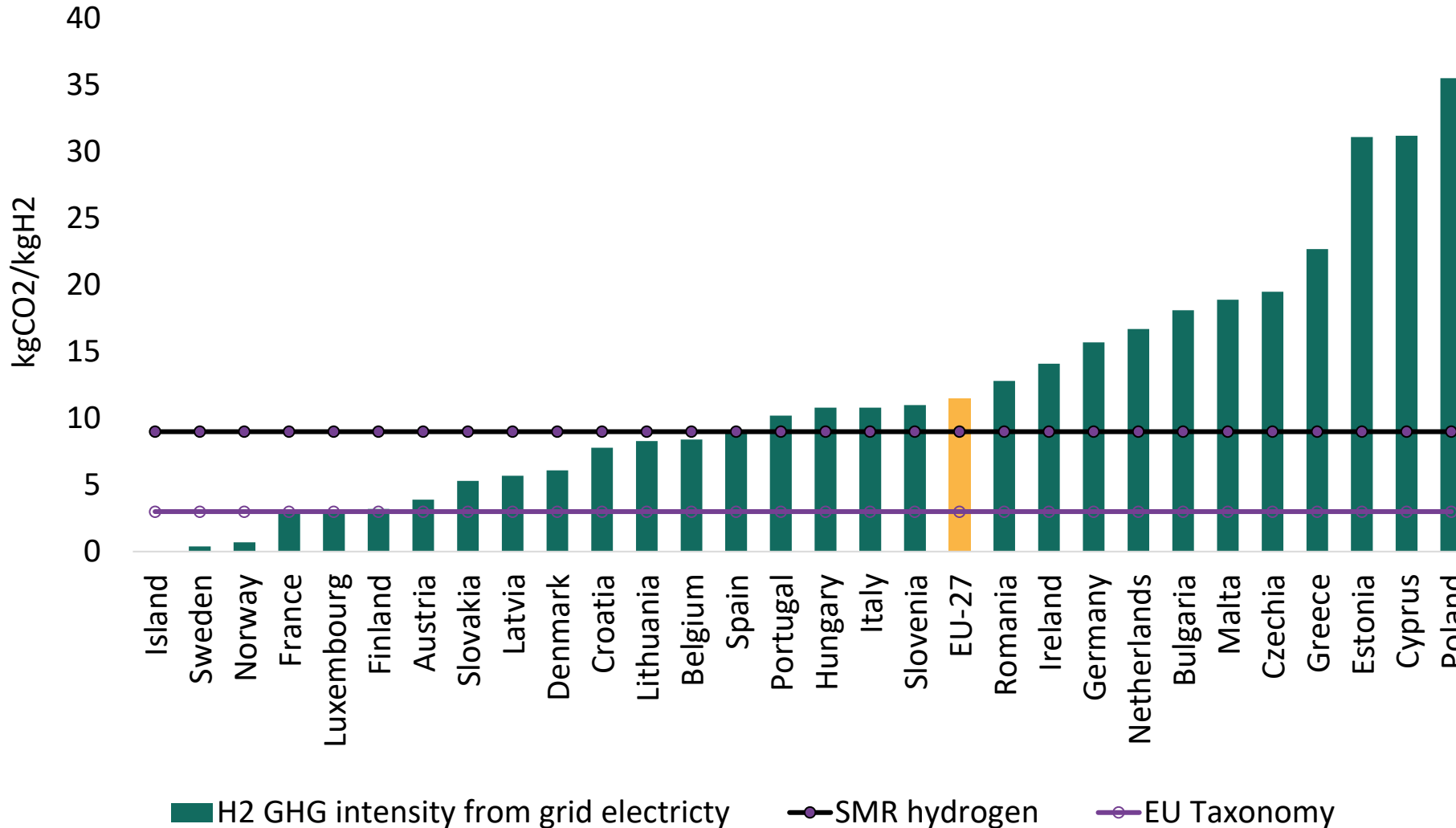
Grid-connected electrolysis hydrogen production costs in the EU in 2021 (in EUR/kg)



Notes: The above calculations were based on the assumption that the electrolyser would run, on average, around 4,000 hours per year in off-peak hours, when the wholesale electricity prices are lowest.
Source: Hydrogen Europe

GHG emissions from grid connected electrolytic hydrogen

Even though average emissions keep falling down – the emissions are on average still higher than from natural gas

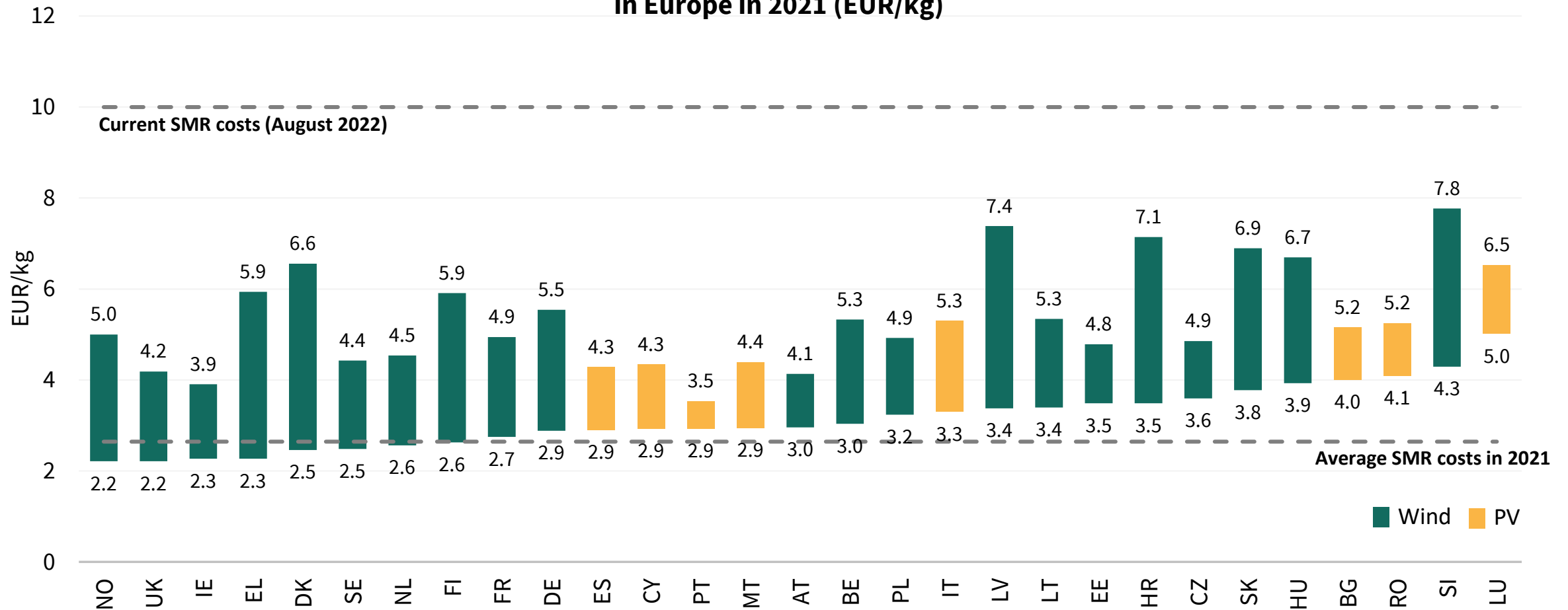


Production of hydrogen using the EU-27 average electricity mix in 2021 would have resulted in emissions of **11.5 kgCO₂/kgH₂** (vs **12.8 kgCO₂/kgH₂** in 2020)

Levelized cost of electrolytic hydrogen directly connected to RES

Electrolytic hydrogen directly connected to RES started becoming competitive in 2021

Levelized cost of electrolytic hydrogen directly connected to RES in Europe in 2021 (EUR/kg)

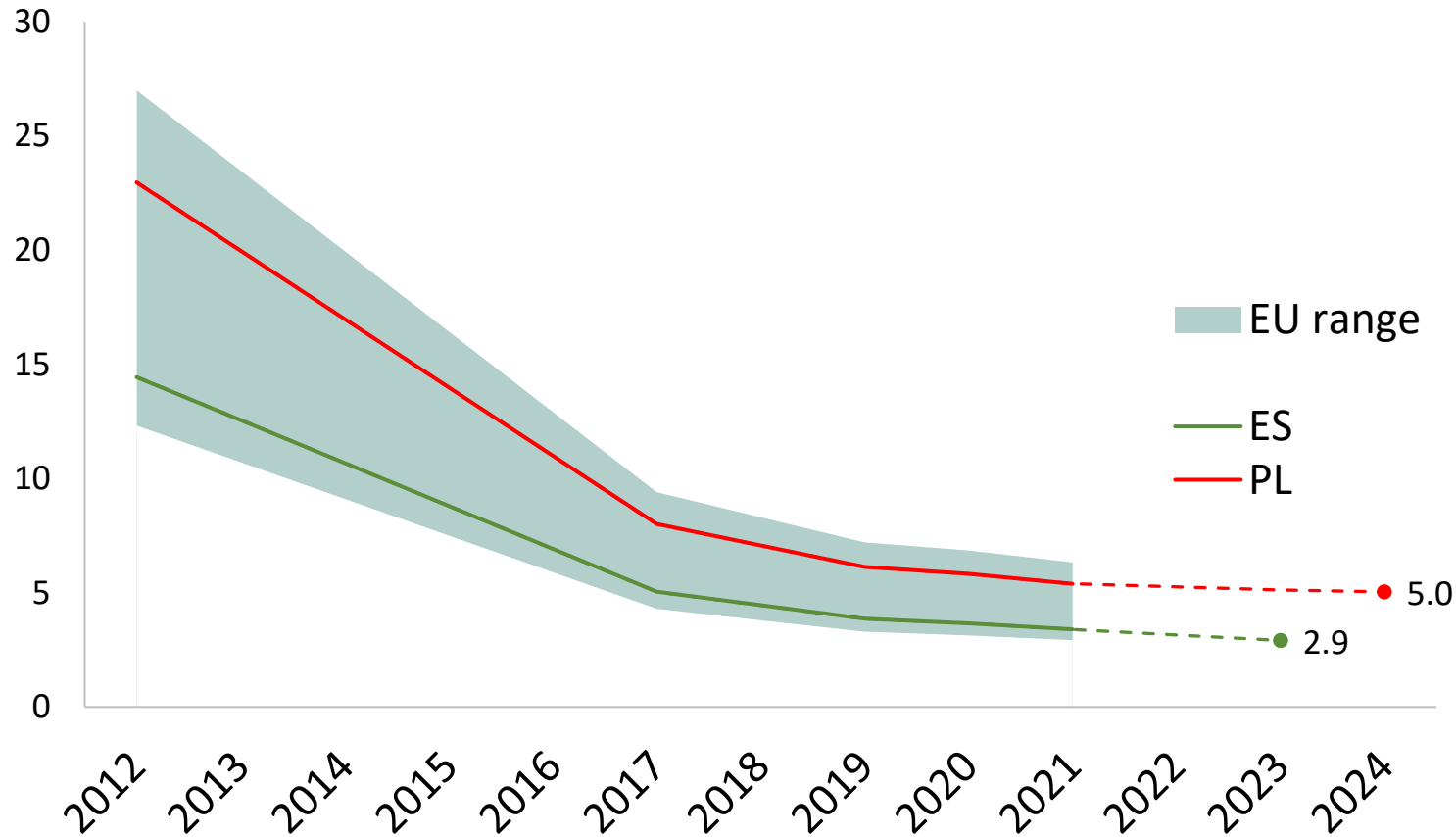


Notes: Costs refer to calculated costs based on electrolyser CAPEX and OPEX, cost of renewables, etc.
Source: Hydrogen Europe

Lowering RES and ELY costs and thus LCOH costs in the future

Decreasing costs of renewables and electrolysis will drive down renewable LCOH

Renewable hydrogen production costs (in EUR/kg) via water electrolysis with solar PV over the 2012-2021 period and expected developments in selected countries based on 2021 RES auction results



- In 2021 the median for EU countries is around **6.5 EUR/kg**, which means a change of...
 - **-76%** since 2012 (27 EUR/kg)
 - **-7%** since 2020 (6.8 EUR/kg)

Current hydrogen market

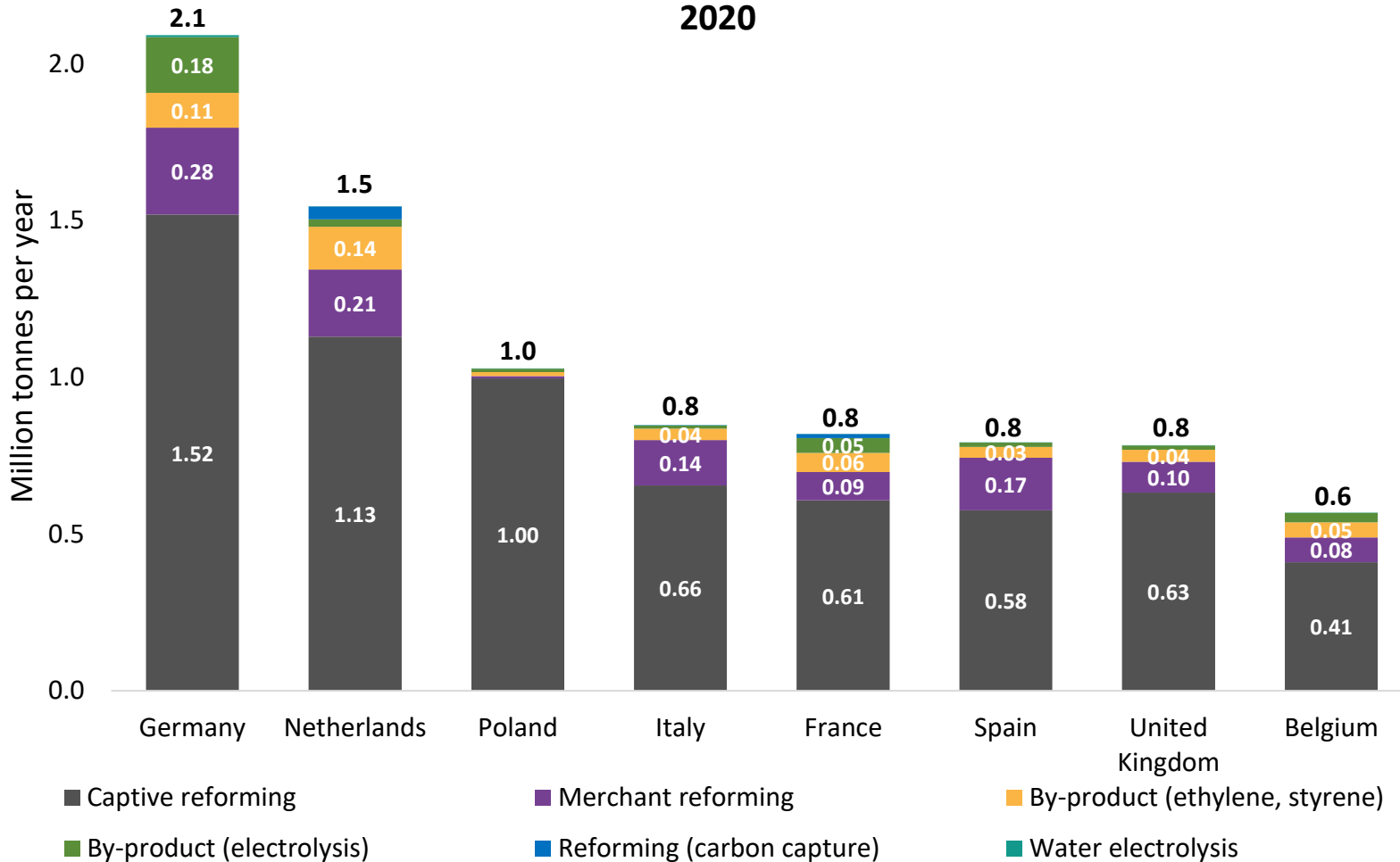
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- Hydrogen production capacity
 - Conventional
 - Reforming with carbon capture
 - Power-to-hydrogen
- Hydrogen demand

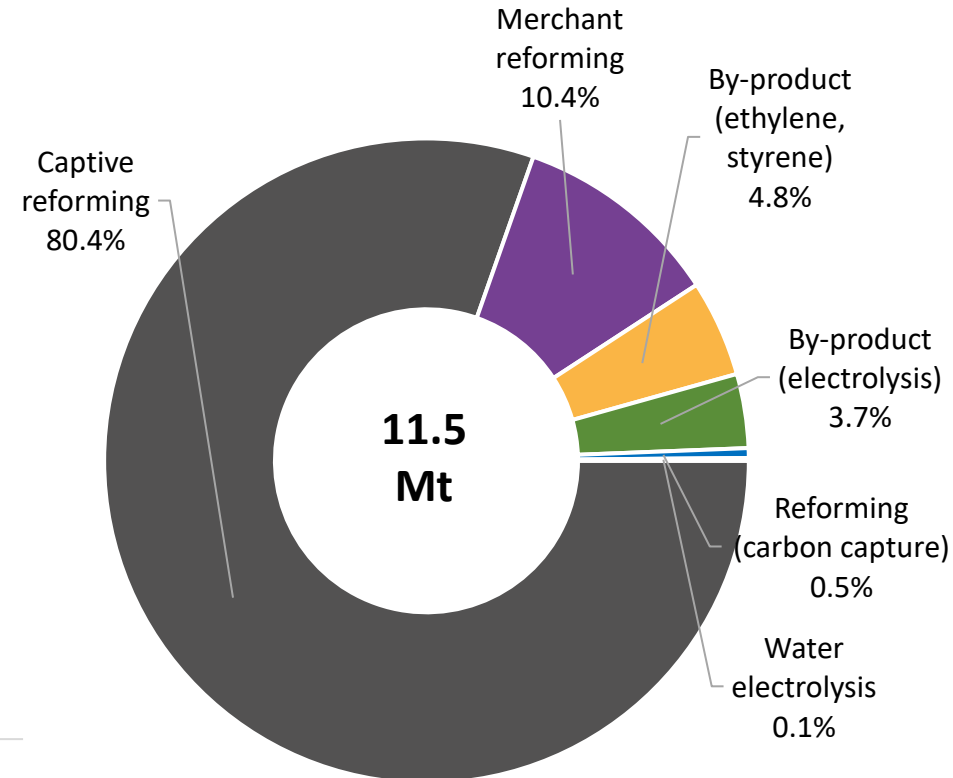
Current hydrogen production capacity

90% of 11.5 Mt of hydrogen production capacity in Europe is from reforming¹

Production capacity of the eight largest hydrogen producers in Europe in 2020



Production capacity by process in 2020



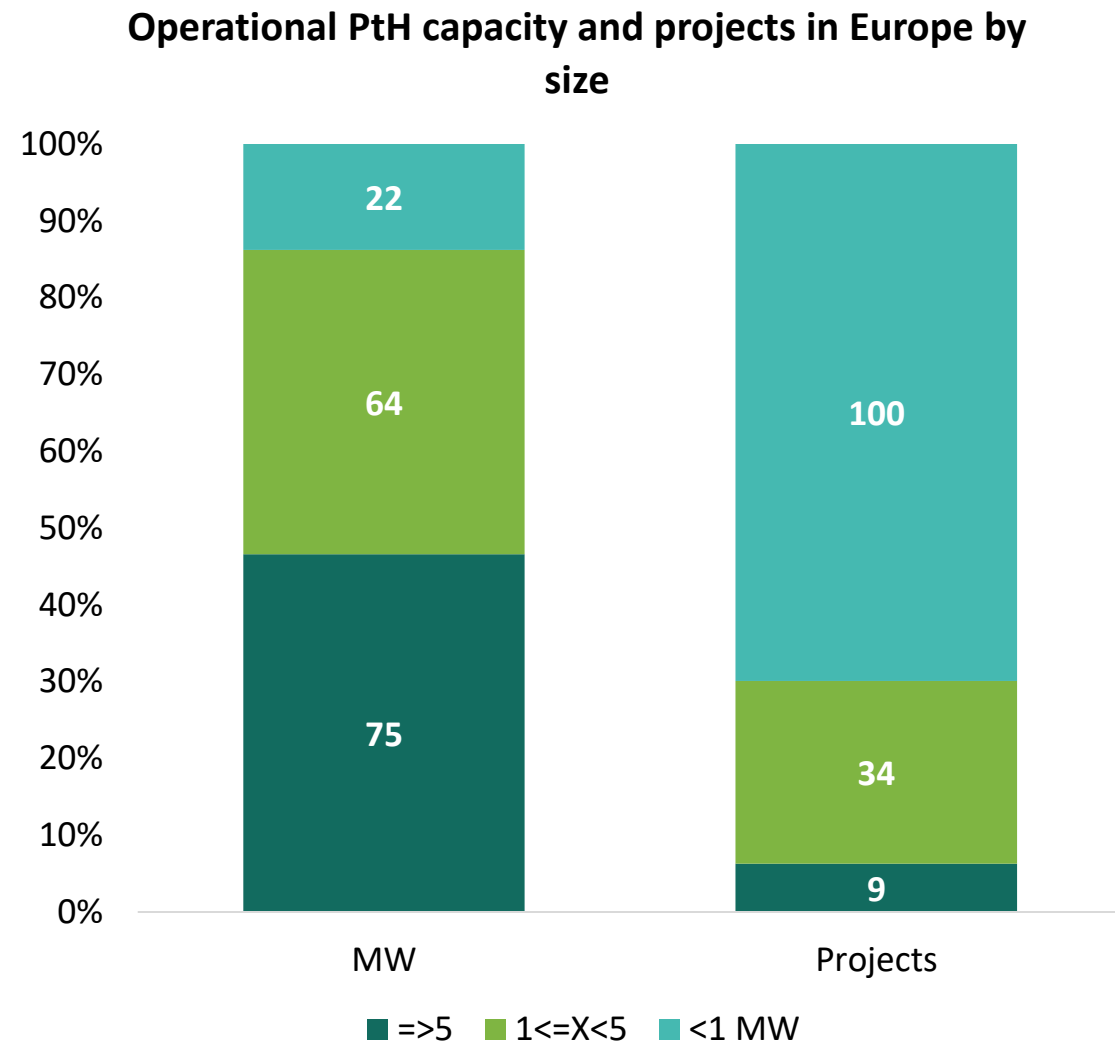
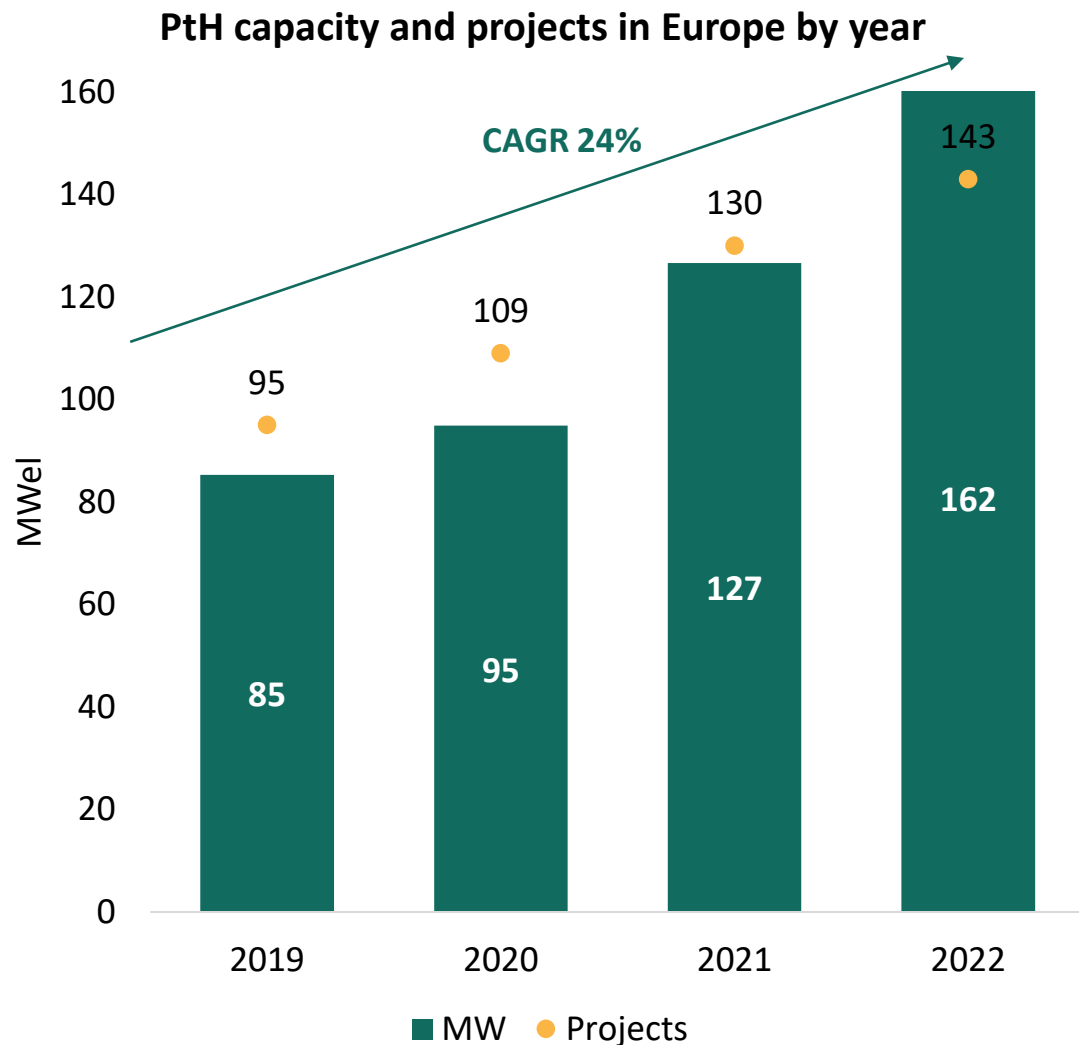
1. Reforming category includes SMR, ATR, partial oxidation, refining off gases.

Source: Hydrogen Europe based on work for Fuel Cells and Hydrogen Observatory

Operational PtH capacity in Europe

Total operational PtH capacity in Europe is only slightly larger than the largest operational installation

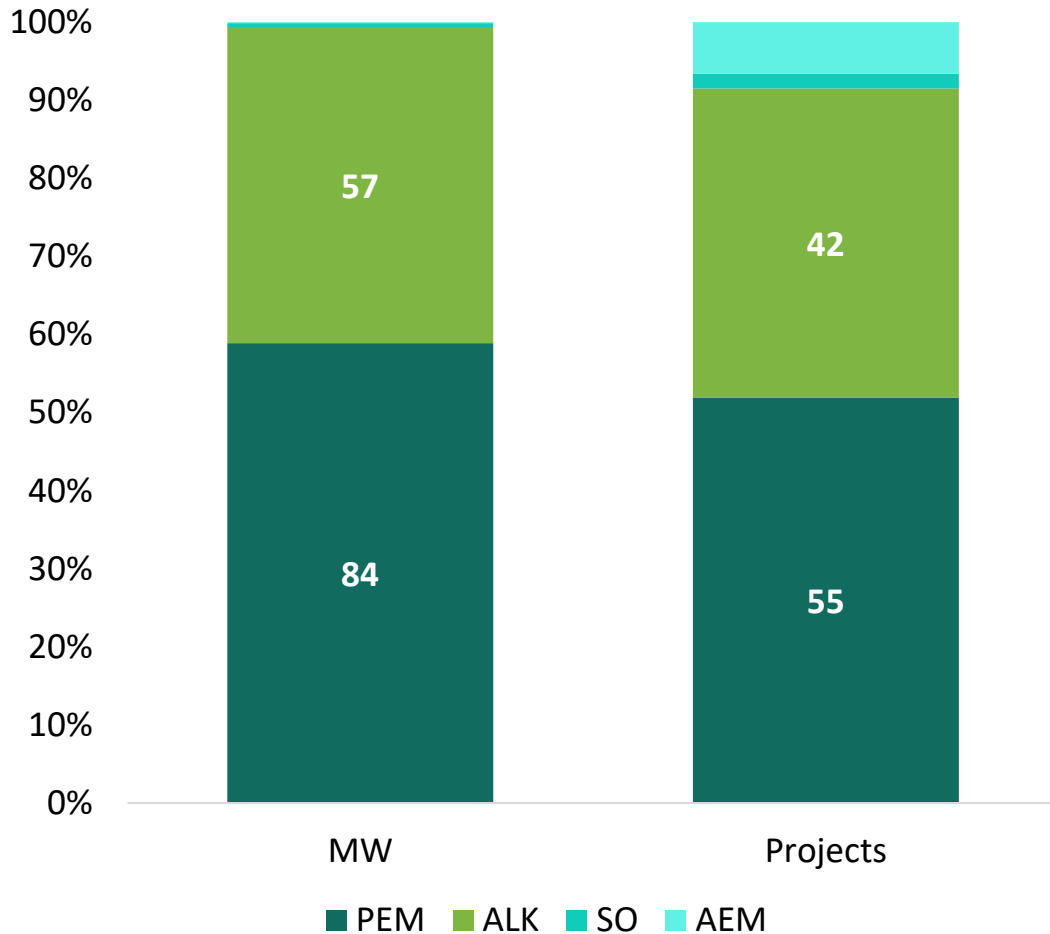
Last update: 31/08/2022



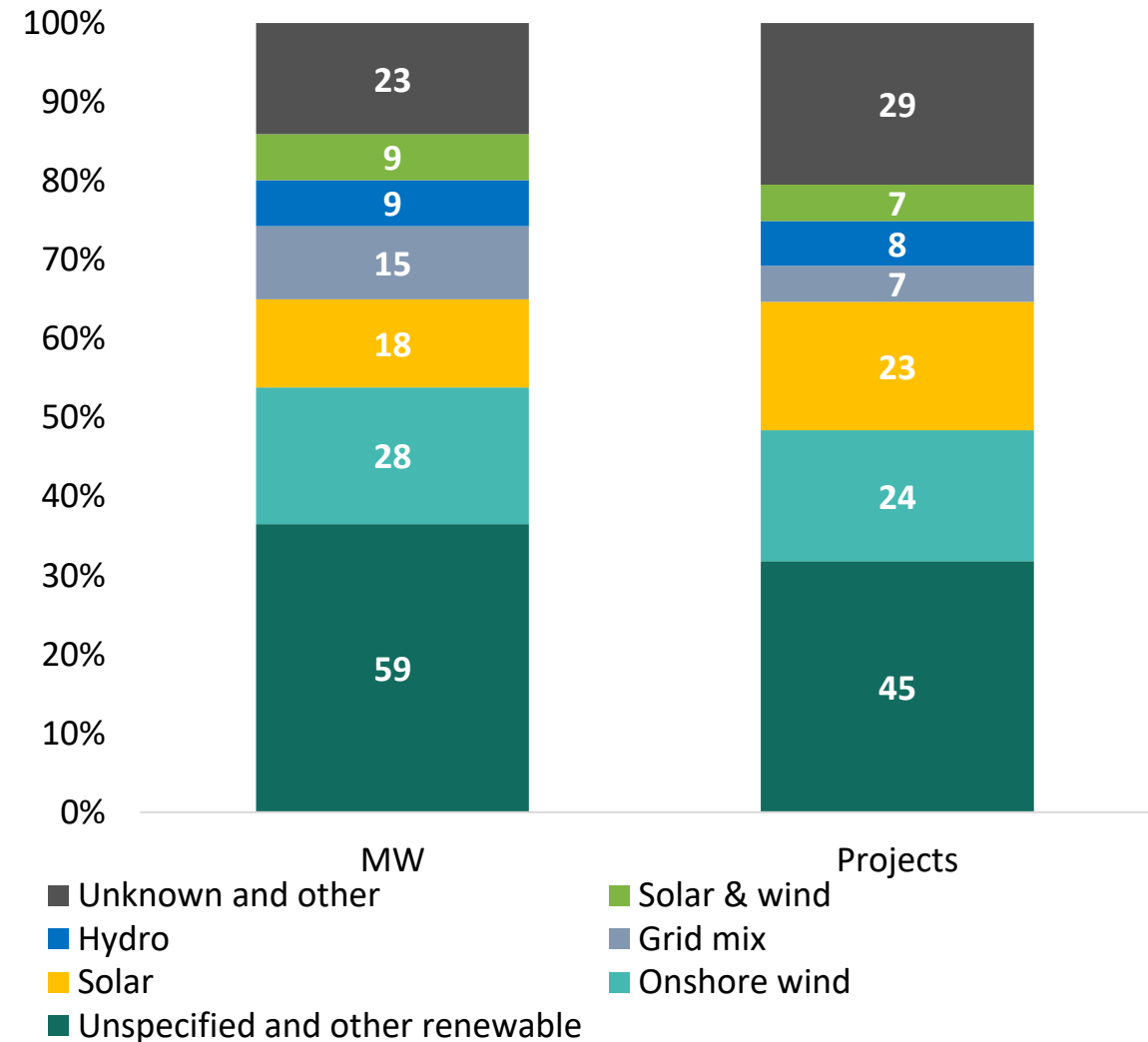
Operational electrolysers in Europe

A single 20 MW PEM deployment in 2022 pushed PEM to 60% of operational PtH in Europe

Current PtH capacity in Europe by technology



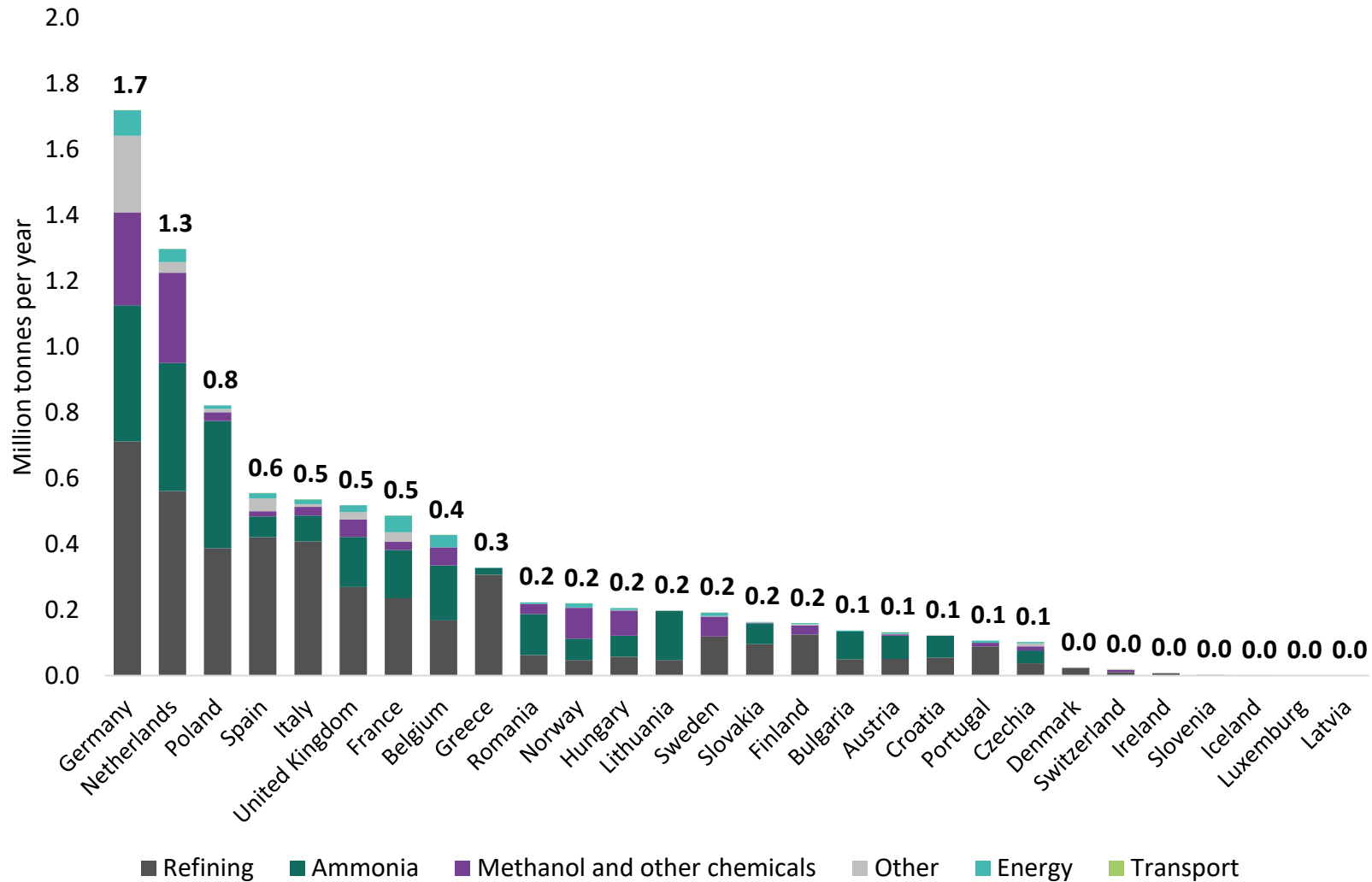
Current PtH capacity in Europe by electricity source



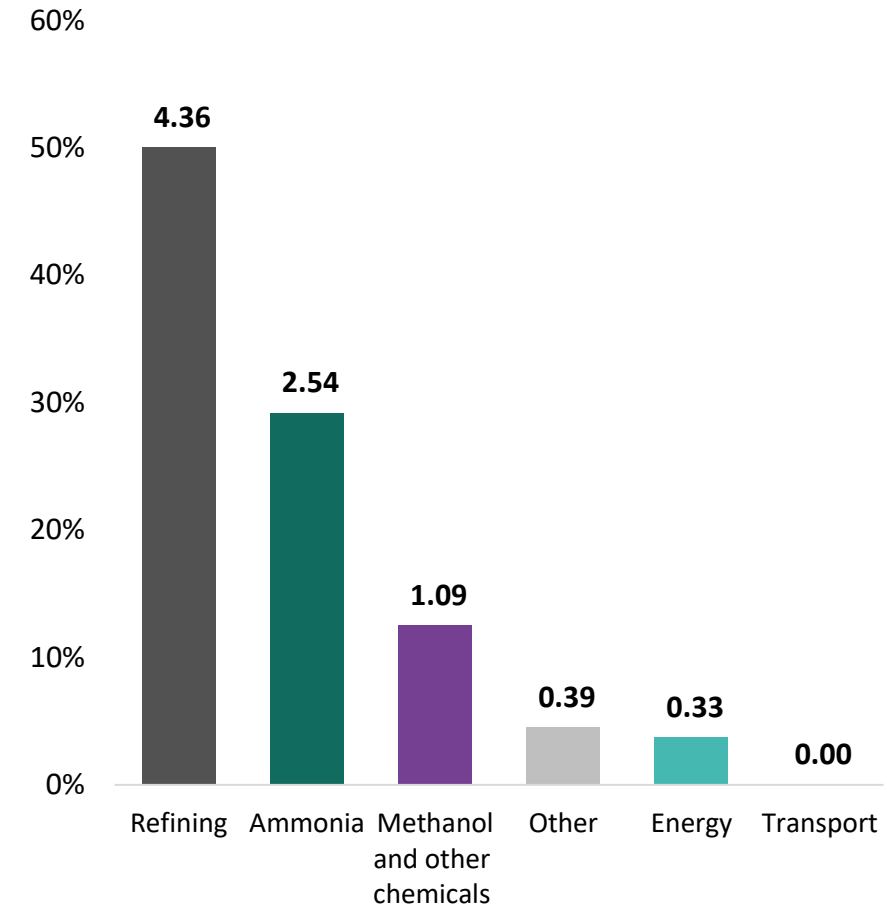
Current hydrogen demand

50% of 2020 European hydrogen demand, 8.7 Mt, was in the refining sector

Hydrogen demand by country in Europe in 2020 (Mt)



Hydrogen demand by end-use in Europe in 2020 (% and Mt)



Notes: All displayed countries have at least some hydrogen consumption. 0.0 refer to value below 50,000 tonnes per year
 Source: Hydrogen Europe based on work for Fuel Cells and Hydrogen Observatory

Planned hydrogen production

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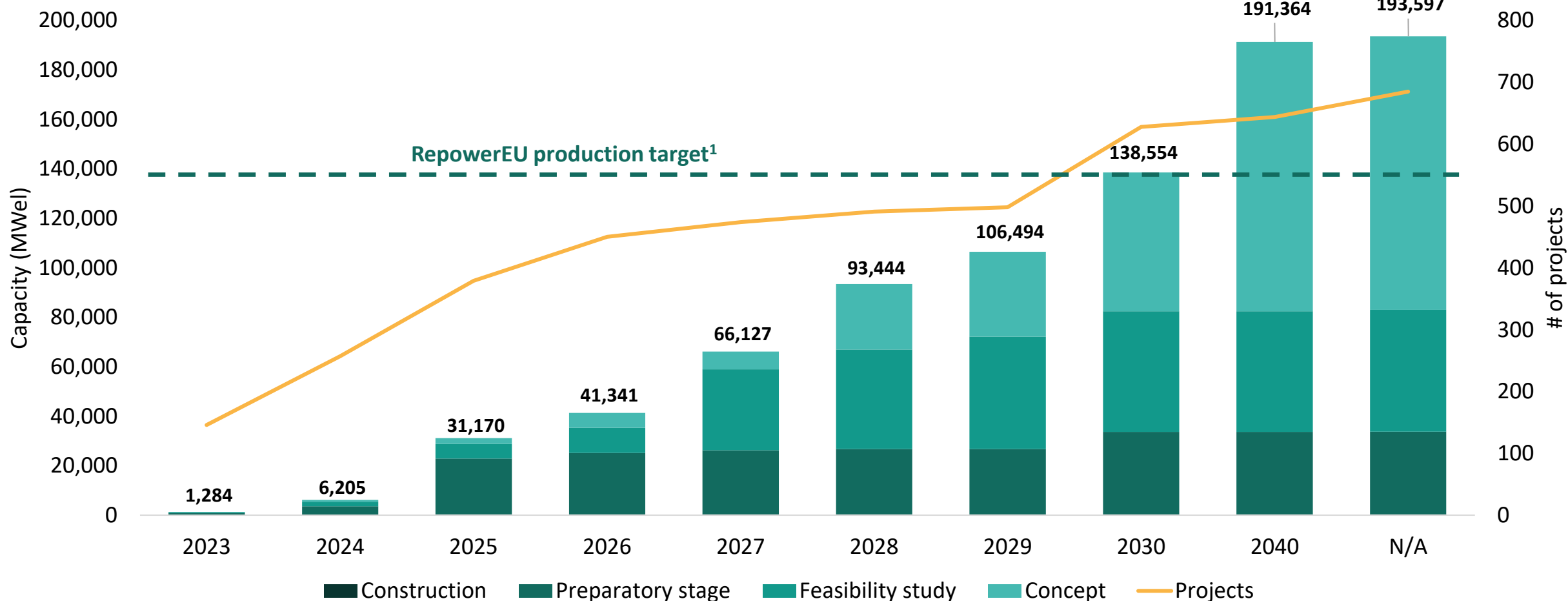
- Planned power-to-hydrogen production
- Planned reforming with carbon capture production

Planned power-to-hydrogen project pipeline

Industry plans match EU ambition on the production side

Last update: 31/08/2022

Cumulative planned PtH pipeline in Europe by year 2023 - 2040 in MW and # of projects



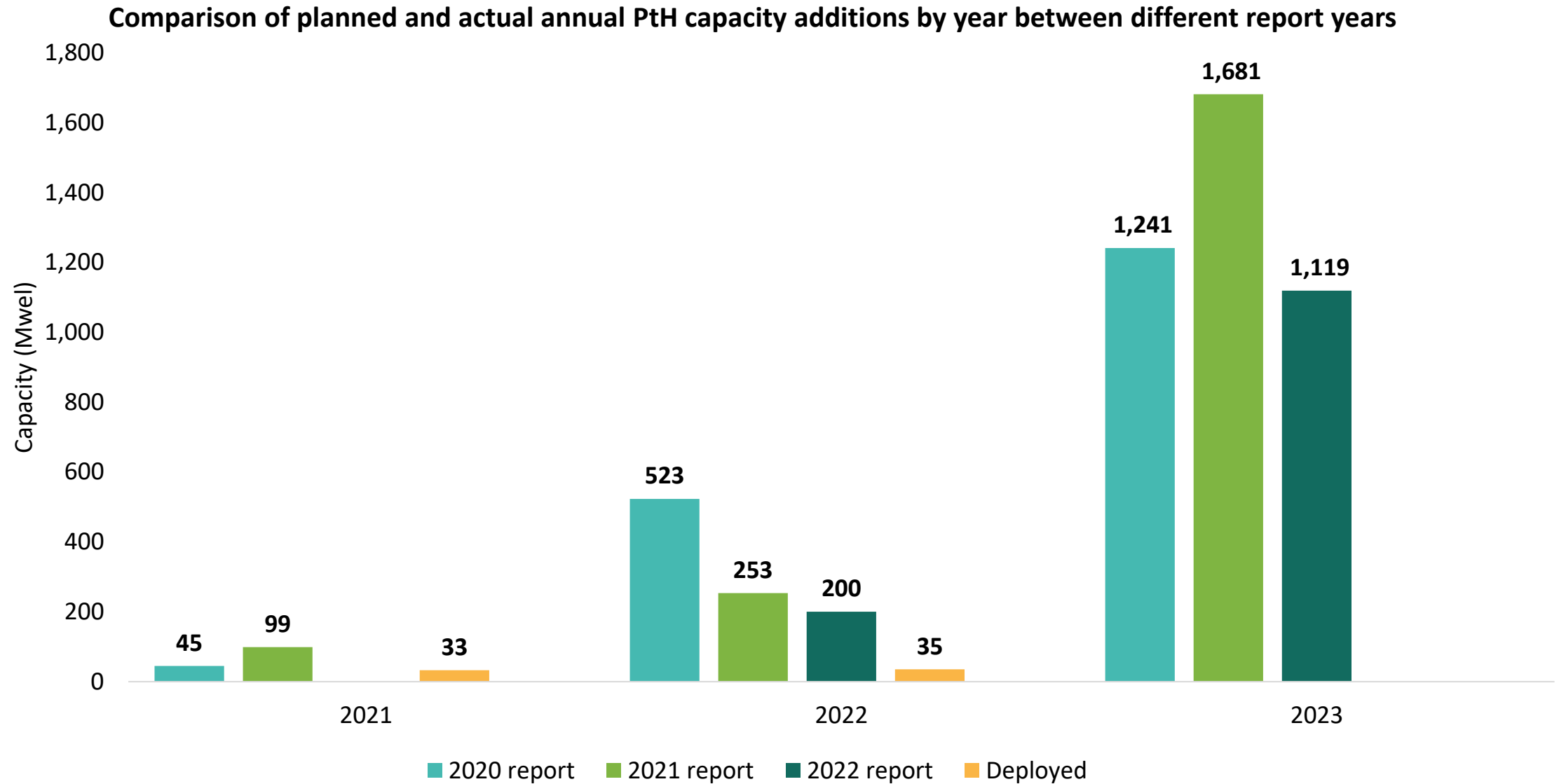
Notes: Individual phases with separate FIDs are counted as separate projects

1. Translating 10 Mt of European renewable hydrogen production into installed electrolysis capacity depends on utilization and efficiency assumptions. For PtH projects connected to the electricity grid, an electrolyser capacity factor of 68% was assumed. Country-specific utilisation factors for different electricity sources have been used to calculate expected production for directly connected projects. The values can be underestimated as they do not consider increasing electrolysis efficiency up to 2030, increasing renewable generation utilisation up to 2030, and oversizing renewables directly connected to electrolysers, which are expected to constitute almost 62% of the current planned capacity by 2030.

Source: Hydrogen Europe

PtH ambitions and deployed capacity

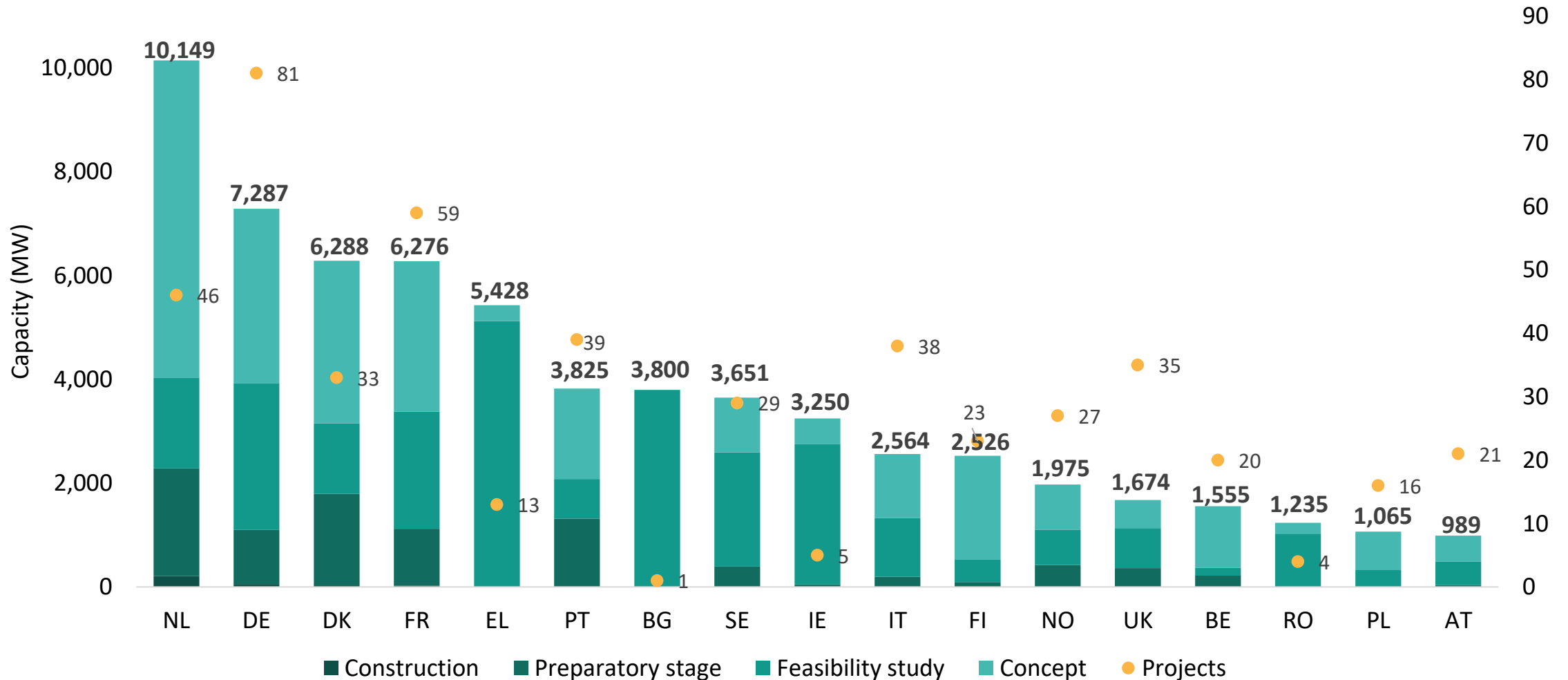
Industry PtH ambition for 2022 decreased by 61% within two years



Maturity comparison of different national markets

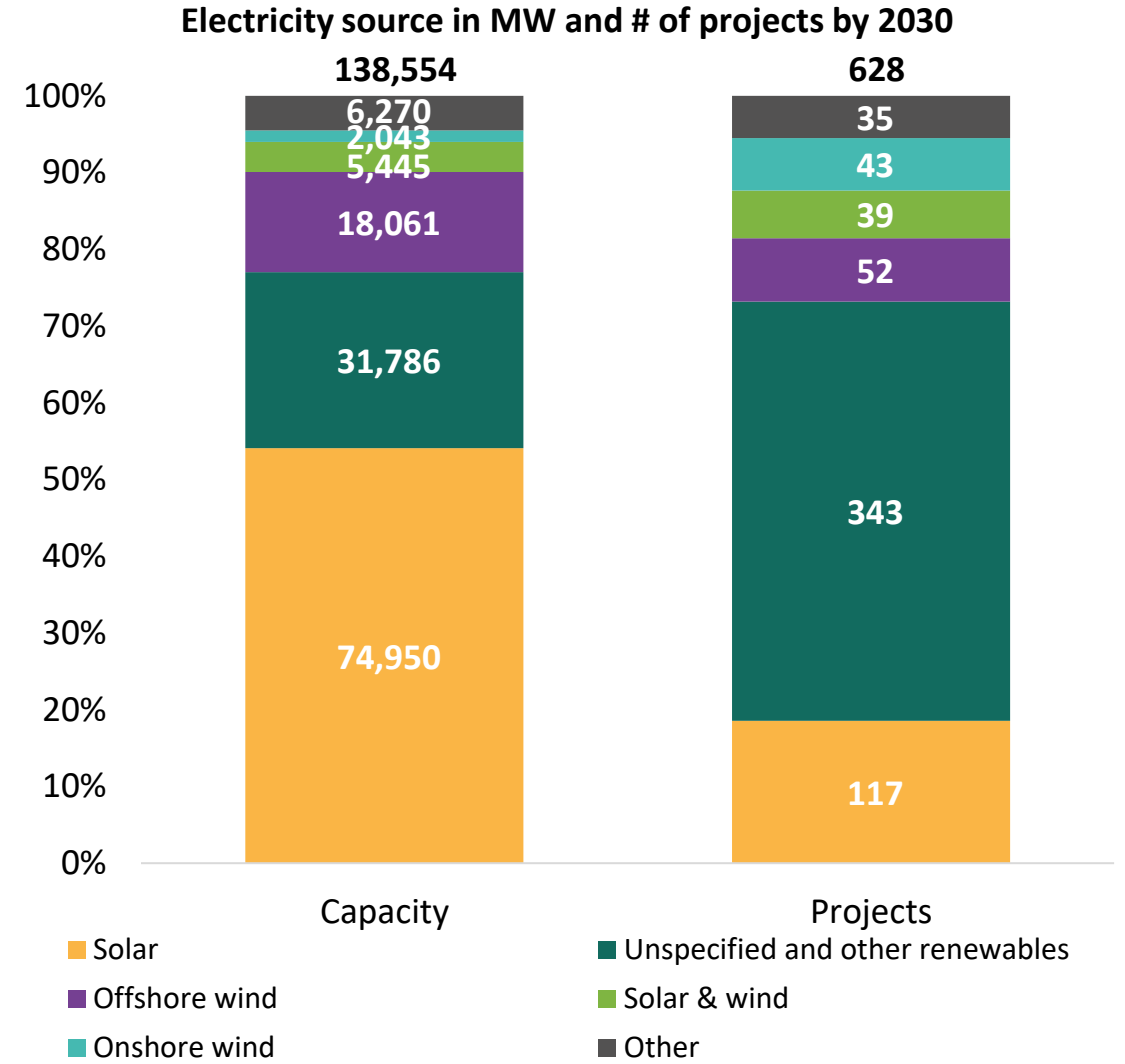
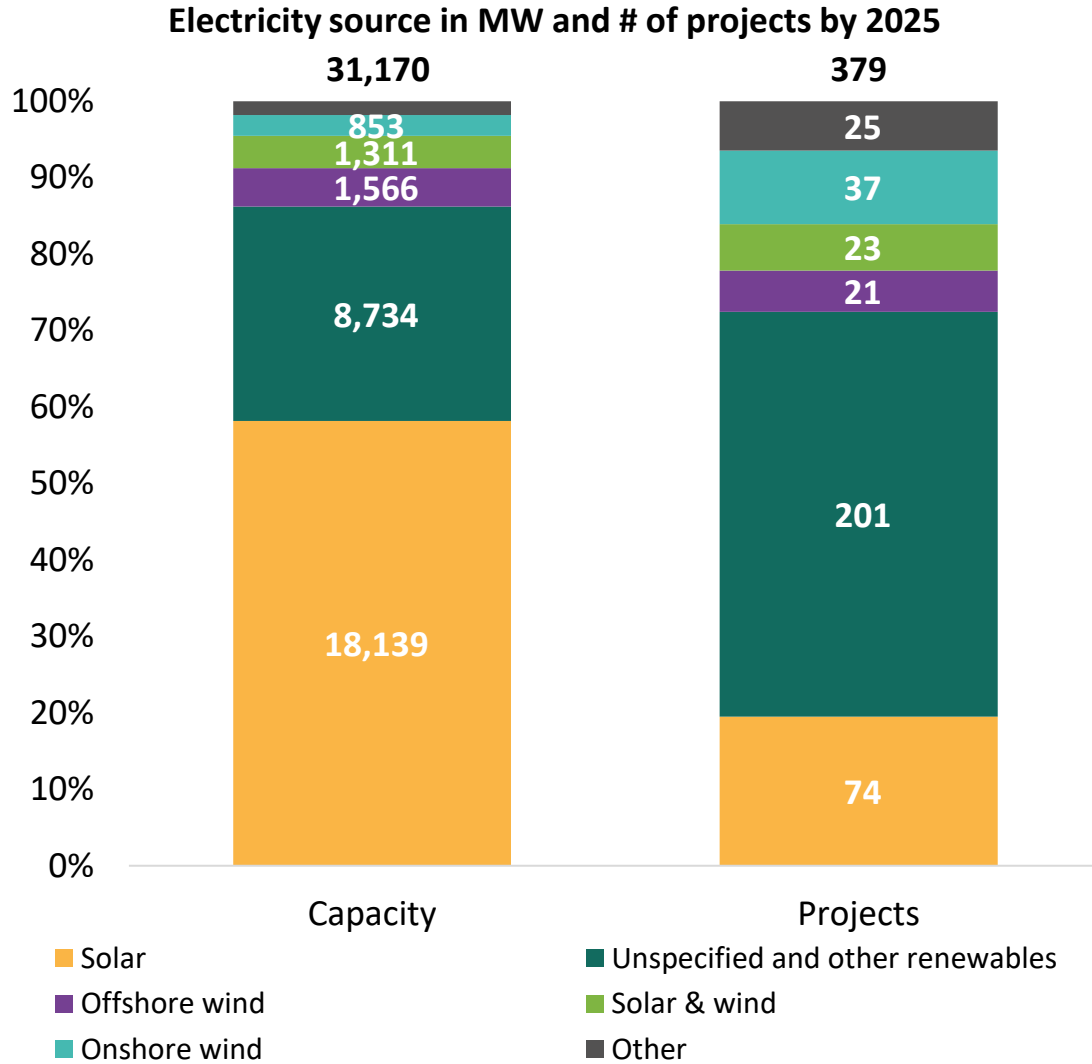
3.8 GW of planned PtH capacity in Portugal is different than 3.8 GW in Bulgaria

Planned PtH project pipelines of selected countries by 2030 in MW and # of projects



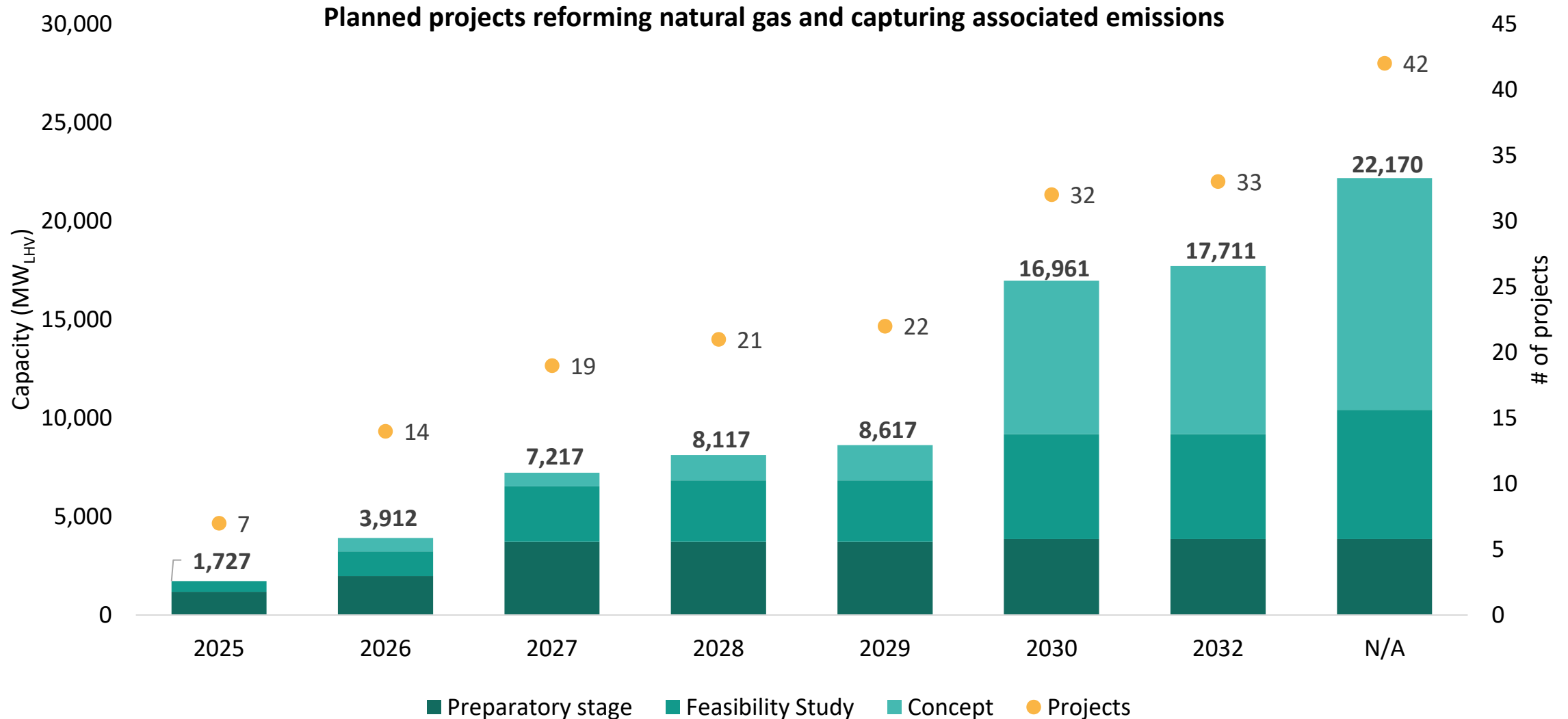
Electricity source of PtH project pipeline

Solar dominates the capacity but 55% of projects by 2030 refer to unspecified renewables



Status of the reforming with carbon capture pipeline

17 GW of low-carbon hydrogen capacity by 2030 could deliver 4 Mt by 2030



Planned consumption in industry

Joana Fonseca

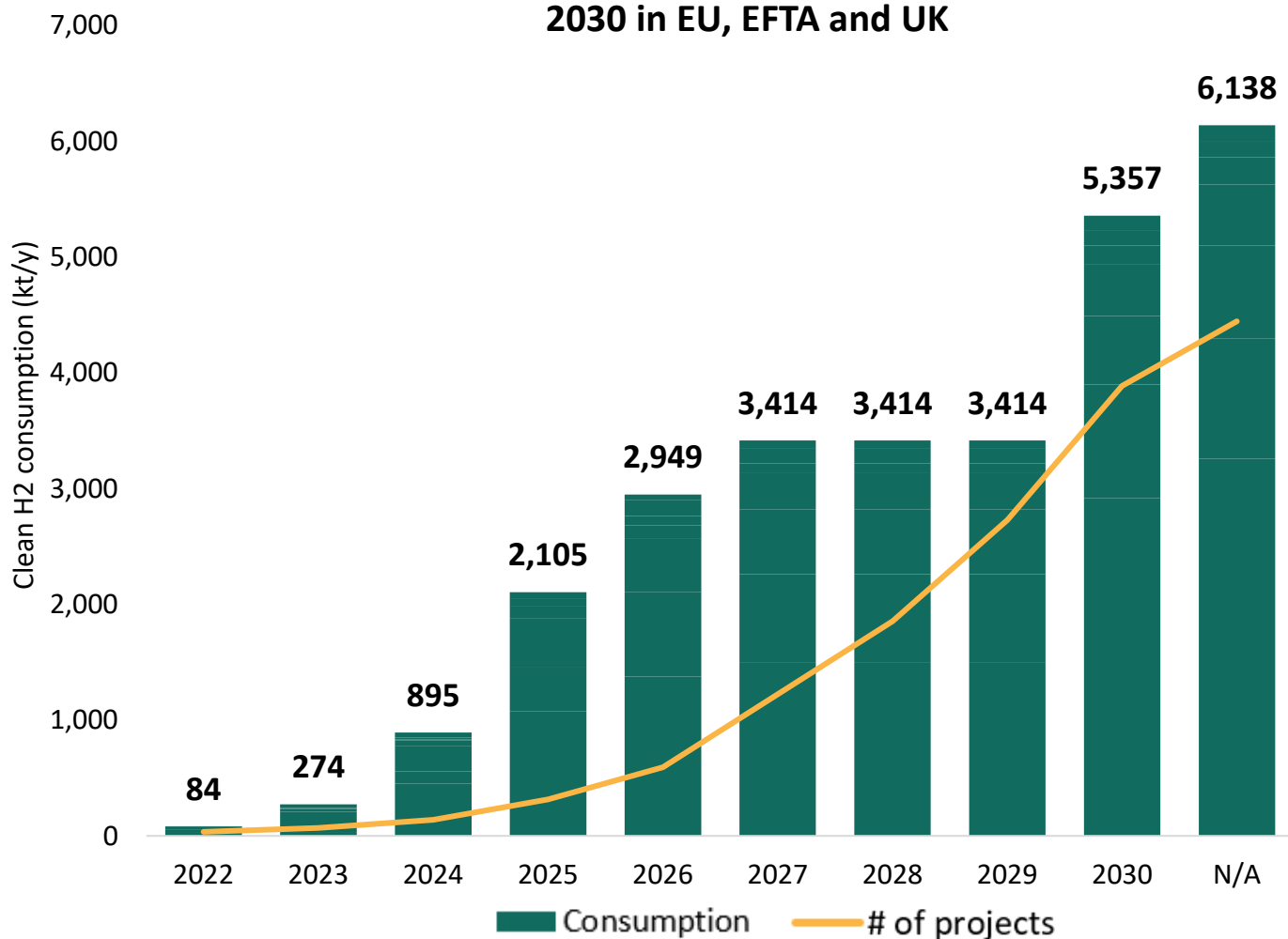
- Clean hydrogen consumption in industry
- Consumption in steel
- Consumption in ammonia
- Consumption in refining

Project pipeline for clean hydrogen consumption in industry

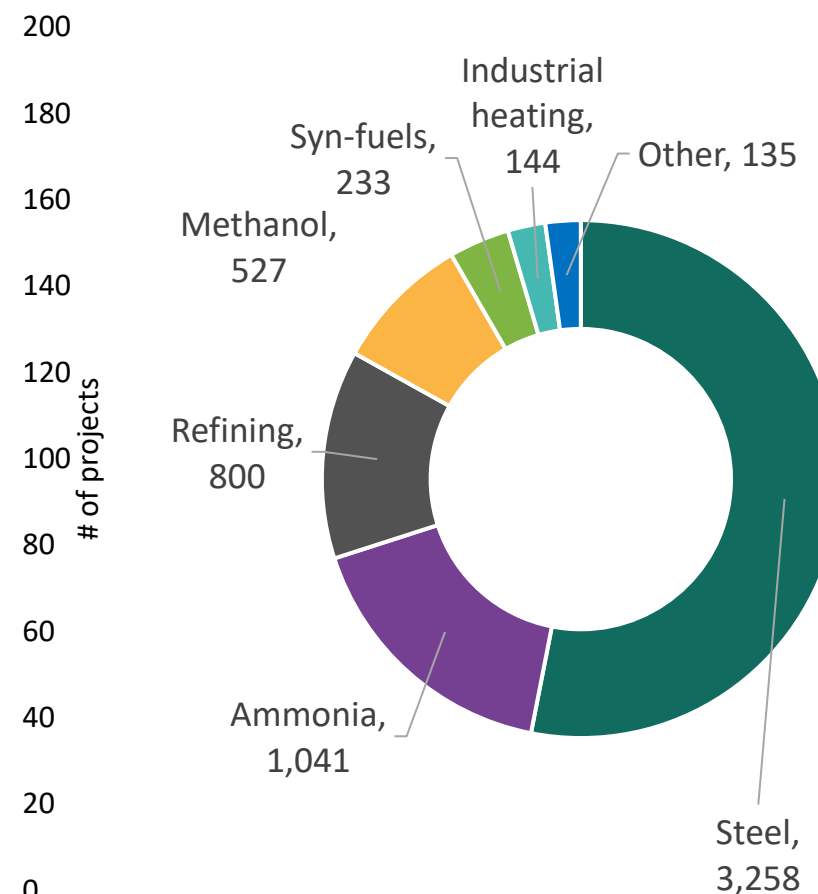
6.1 Mt of annual clean H₂ consumption are already in the project pipeline

Last update: 31/08/2022

Cumulative planned consumption of clean H₂ in industry 2022-2030 in EU, EFTA and UK



Planned consumption by country

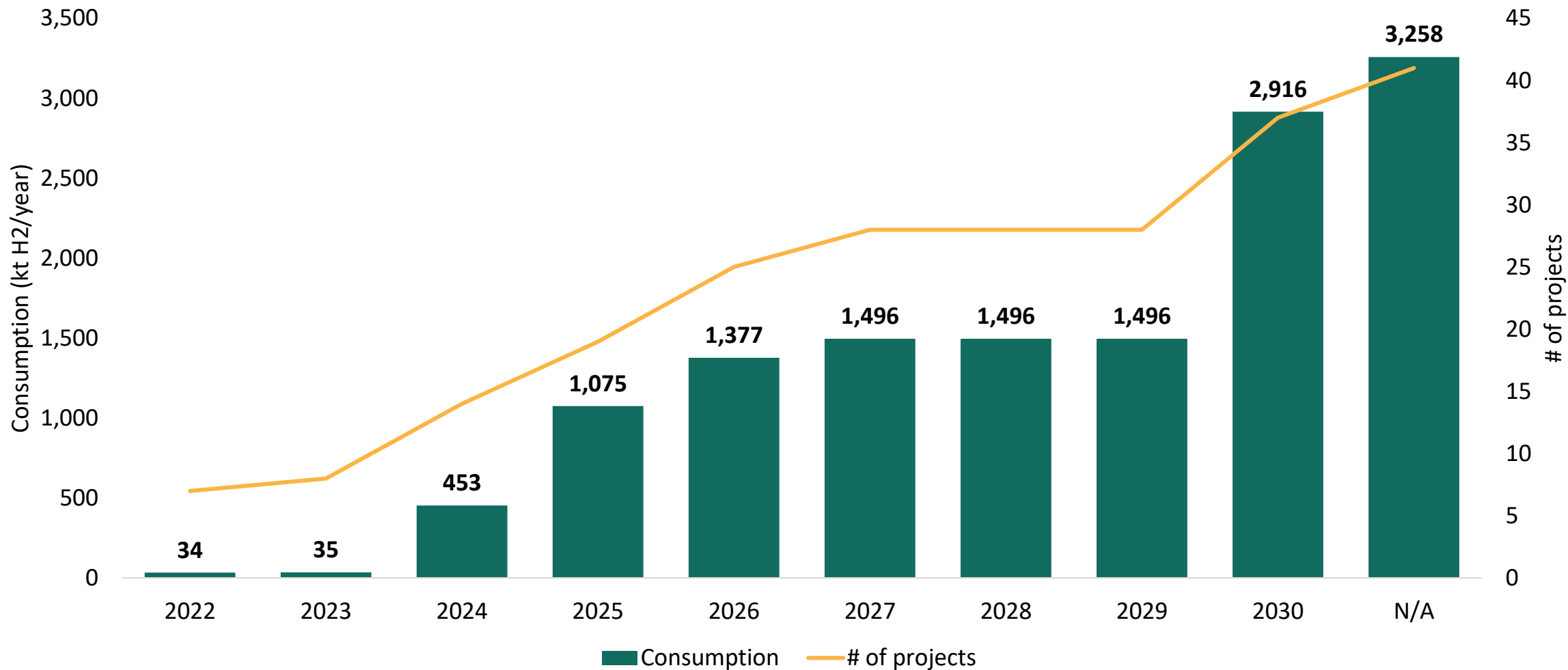


Planned consumption of clean hydrogen in steel

63 882 Mt of green steel are already in the project pipeline, 58% of current primary production in the region

Last update: 31/08/2022

Cumulative planned consumption of clean H2 in steel 2022-2030 in the EU, EFTA and UK



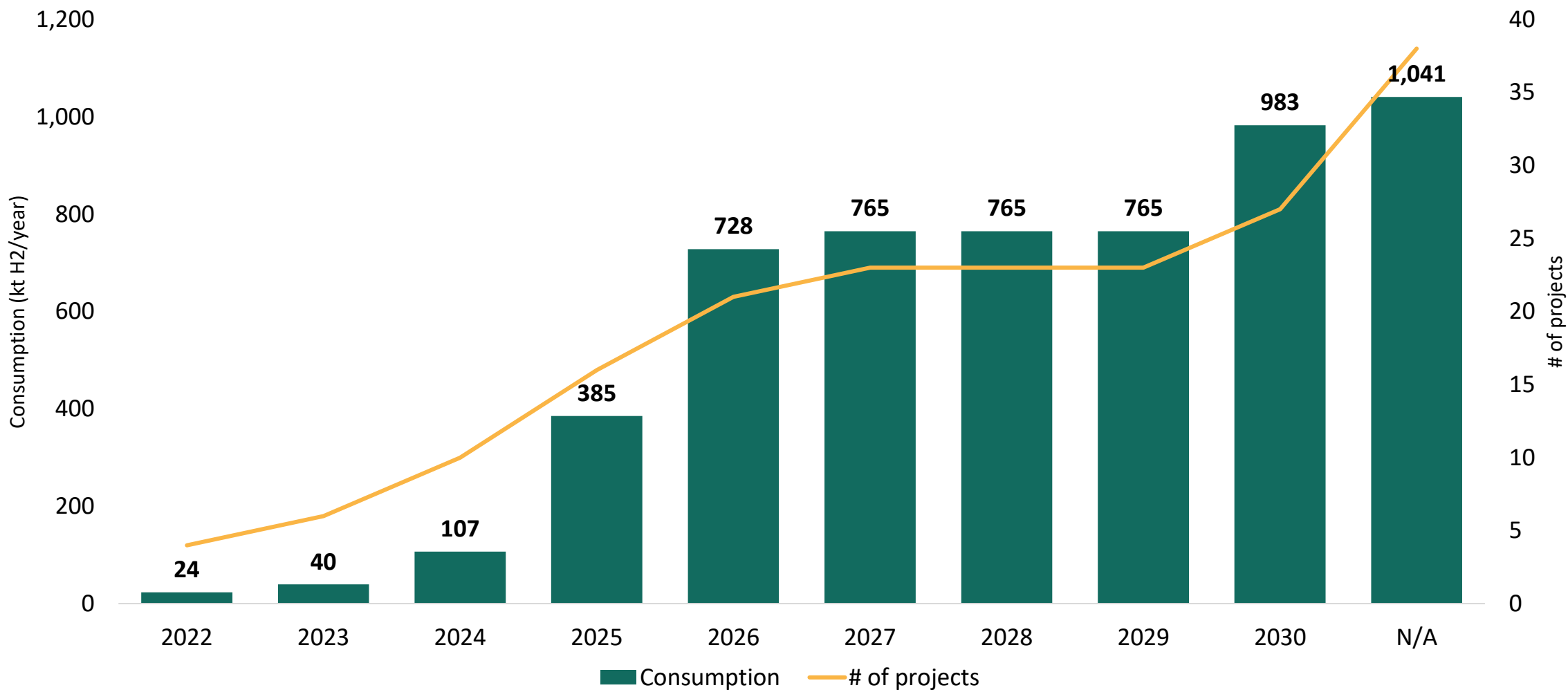
Notes: Individual phases with separate FIDs are counted as separate projects
Source: Hydrogen Europe

Planned consumption of clean hydrogen in ammonia

1 Mt of clean H₂ consumption already planned for green ammonia production

Last update: 31/08/2022

Cumulative planned consumption of clean H₂ in ammonia 2022-2030 in the EU, EFTA and UK



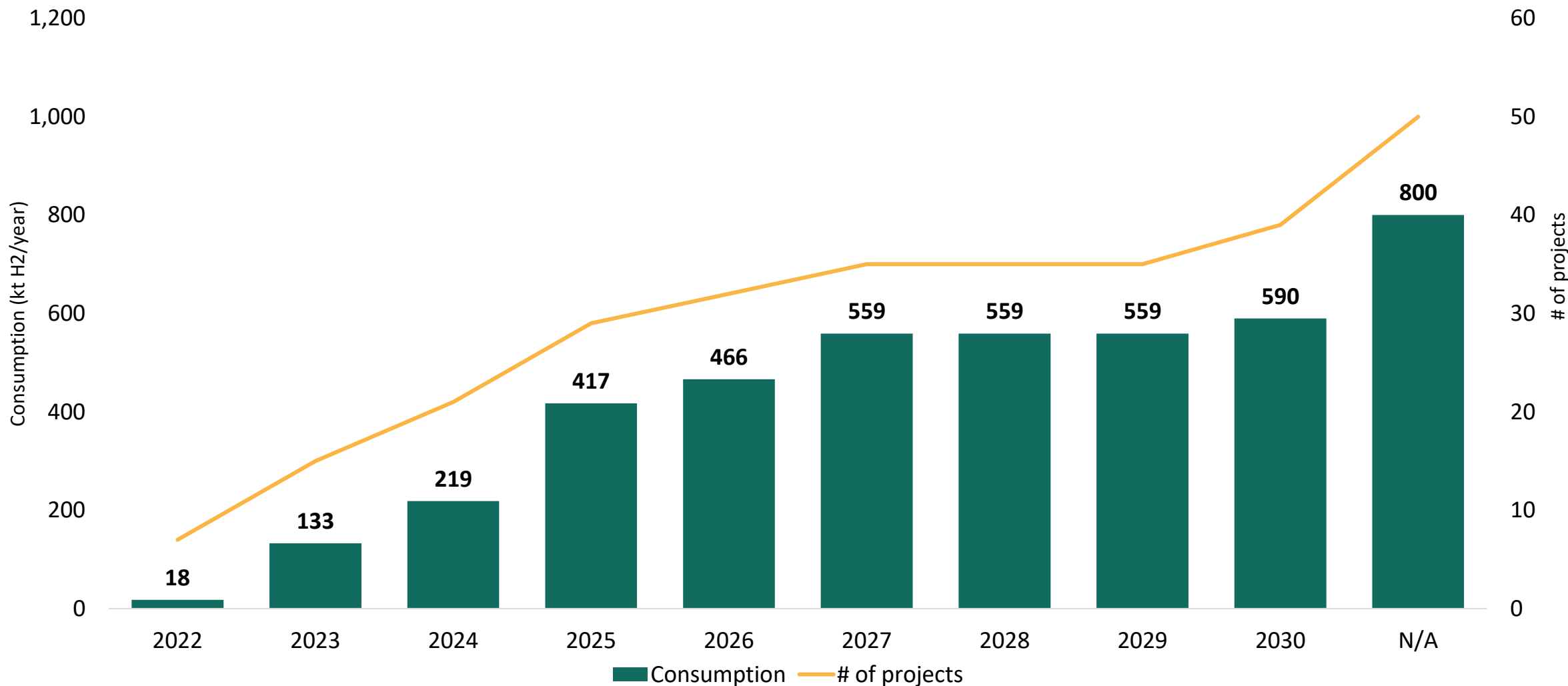
Notes: Individual phases with separate FIDs are counted as separate projects
Source: Hydrogen Europe

Planned consumption of clean hydrogen in refining

800 kt/y of clean H₂ consumption is already planned in the refining sector

Last update: 31/08/2022

Cumulative planned consumption of clean H₂ in refining 2022-2030 in the EU, EFTA and UK



Notes: Individual phases with separate FIDs are counted as separate projects
Source: Hydrogen Europe

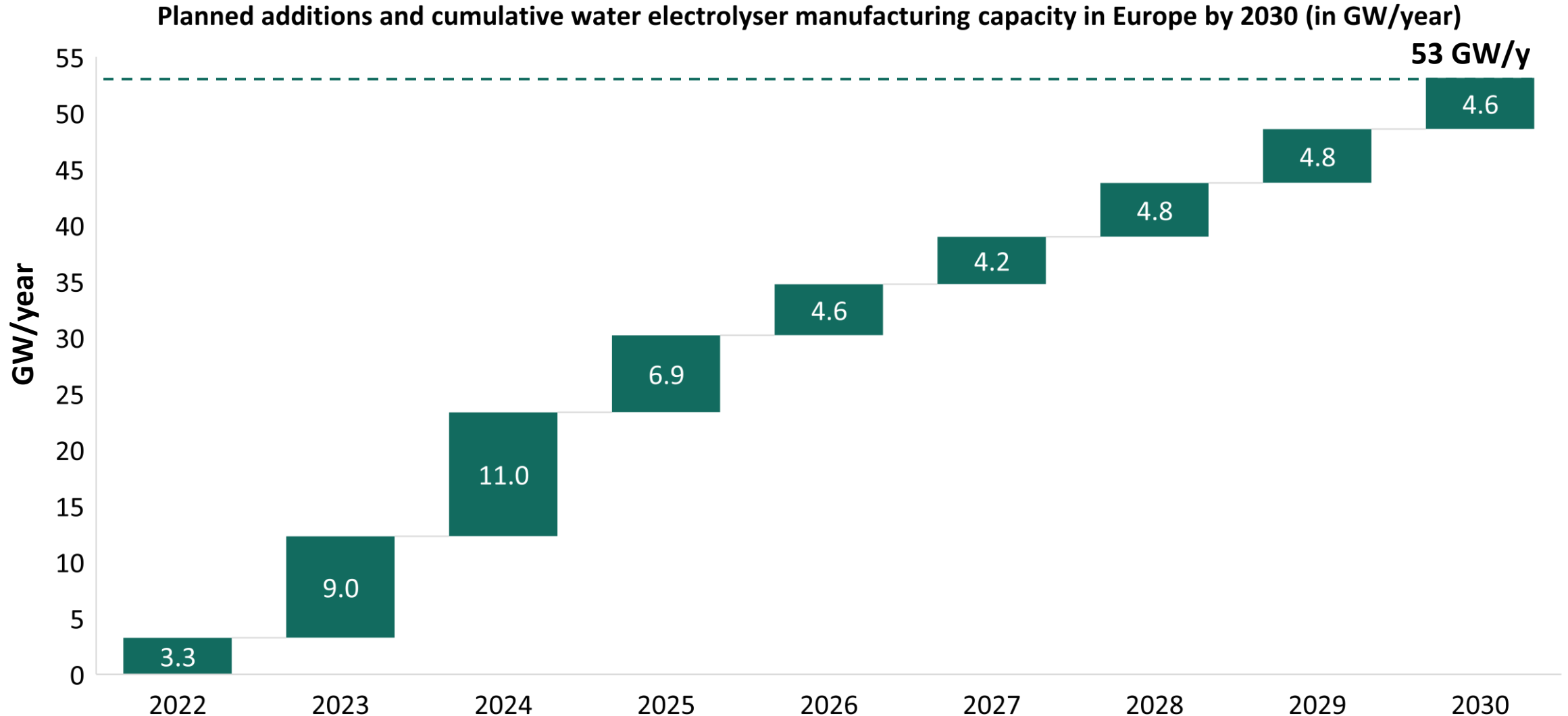
Scaling-up the hydrogen industry: Electrolyser manufacturing capacity and critical raw materials

Joana Fonseca

- Water electrolyser manufacturing capacity in Europe
- Critical Raw Materials: platinum and palladium

Planned water electrolyser manufacturing capacity additions

Electrolyser manufacturing capacity additions in Europe should add to 53 GW/year by 2030



Note: Provided that all planned manufacturing facilities become operational as planned, operate at a 100% capacity utilisation, and all electrolysers manufactured between 2022-2030 are subsequently deployed and installed in Europe. Tonnes are calculated assuming 5256 load hours (60% utilisation), and 69% efficiency using Lower Heating Value.

Source: Hydrogen Europe

Cumulative water electrolyser manufacturing capacity

79% of the electrolyser manufacturing capacity planned by 2030 in Europe is in initial planning stage

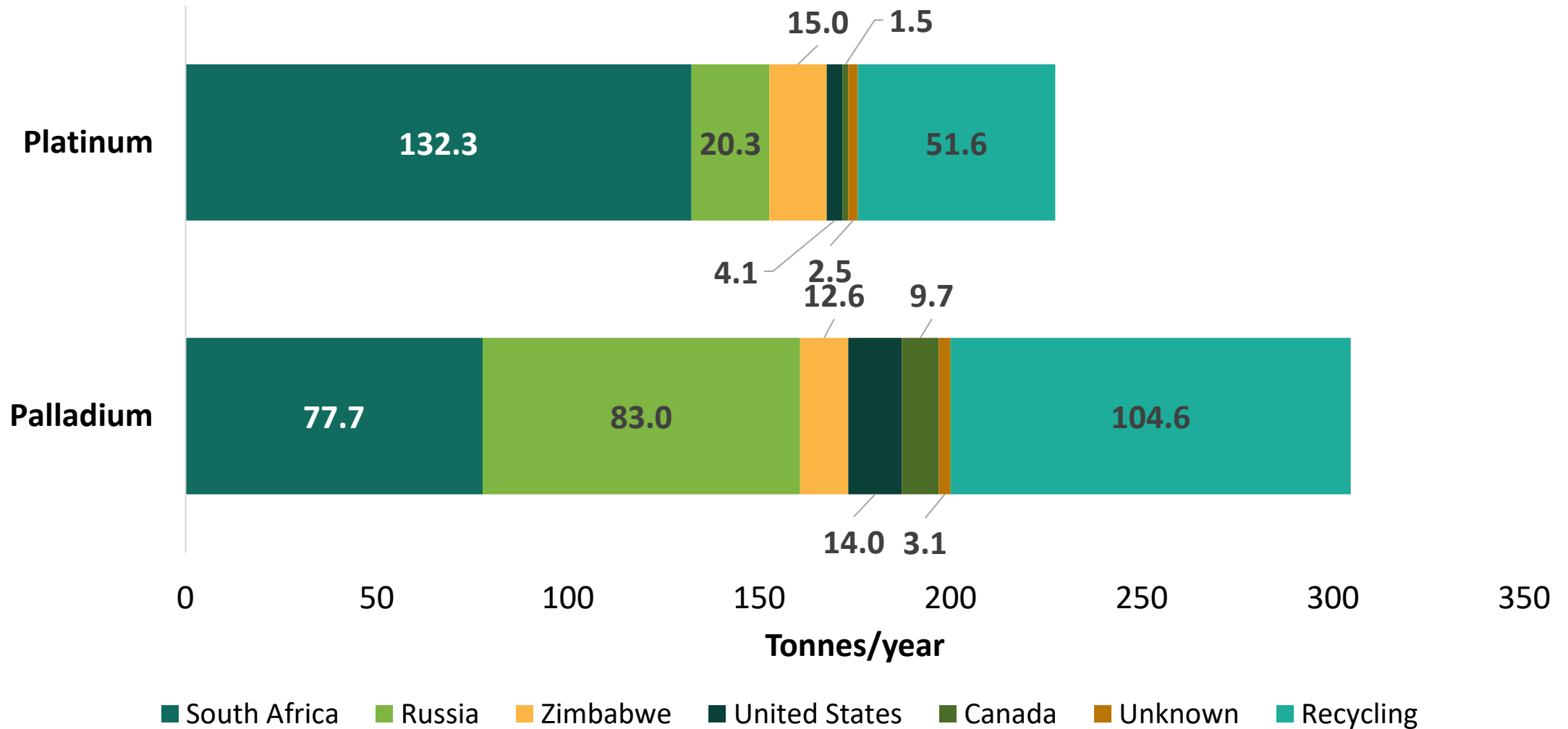
Cumulative electrolyser manufacturing capacity by stage of development in Europe by 2030 (in GW/year)



Total production capacity of platinum and palladium

Total production capacity of platinum and palladium at 227 tonnes/year and 305 tonnes/year

Distribution of platinum and palladium capacity from mining and recycling (in tonnes/year) in 2021



Note: Unknown volumes refer to metals produced as a by-product of base metals mining. These volumes are not traceable in companies' reports due to incomplete information.
Source: Hydrogen Europe based on company reports and Johnson Matthey (2022).

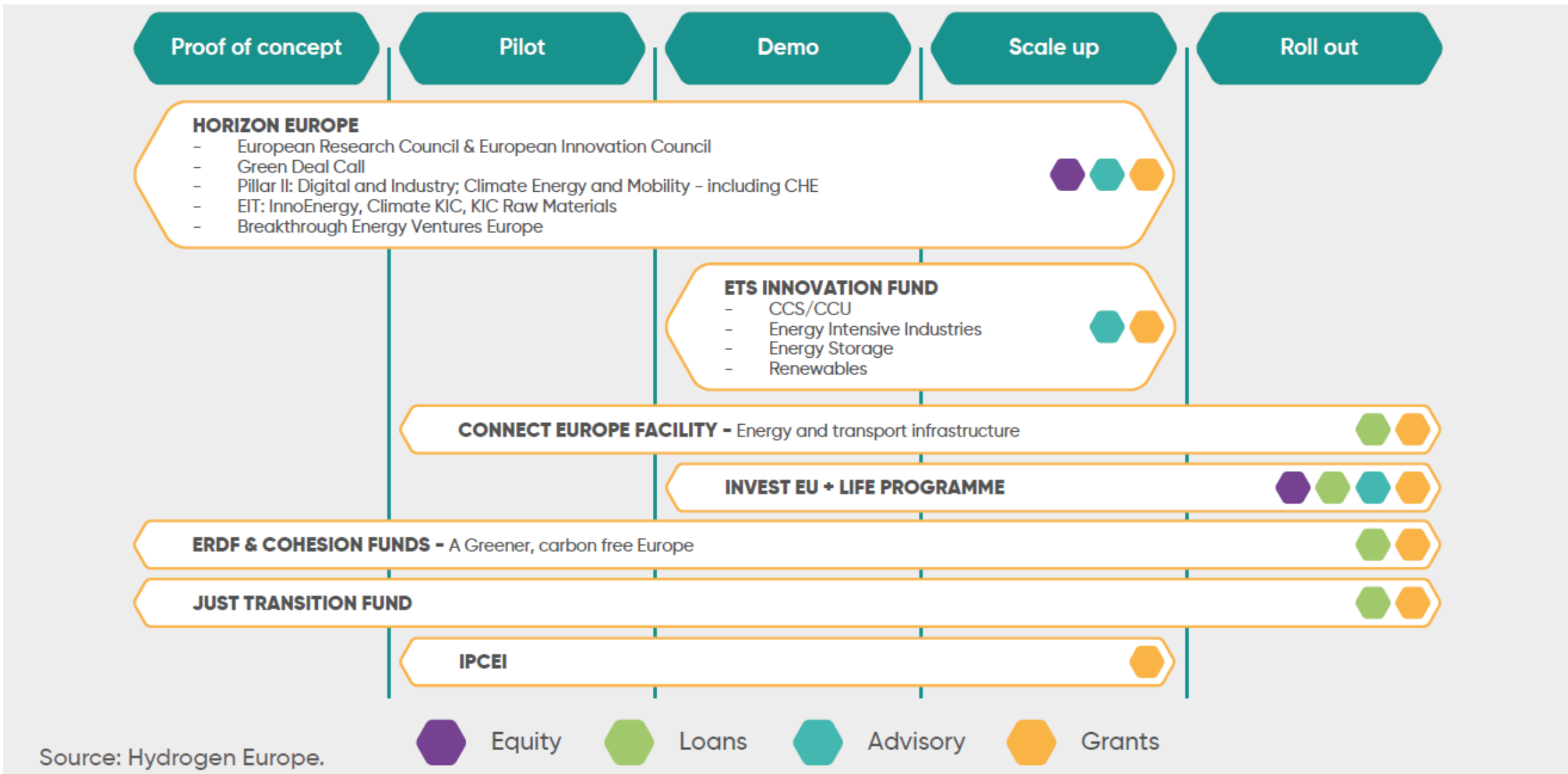
Funding & Financing

Grzegorz Pawelec

- Available EU funding opportunities
- Private financing sector

Overview of available EU Energy transition funds 2021 – 2027

Available EU funds offer support via a broad range of instruments



Private financing sector active in the hydrogen economy

Banks with an active approach to debt financing H2 projects



Equity

The max ticket size is the reference factor for each entity



Conclusion

Positive developments across Europe, but some countries are edging forward

Large ambitions on EU level for renewable hydrogen

Robust industry ambitions appropriate to deliver on EU objectives

Strong hydrogen motivation in some European capitals

Project execution being delayed due to projects waiting for funding or regulatory clarity

Risks of losing technological and deployment leadership to US and China



If you have any follow-up questions, you can contact us at:

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Thank You



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