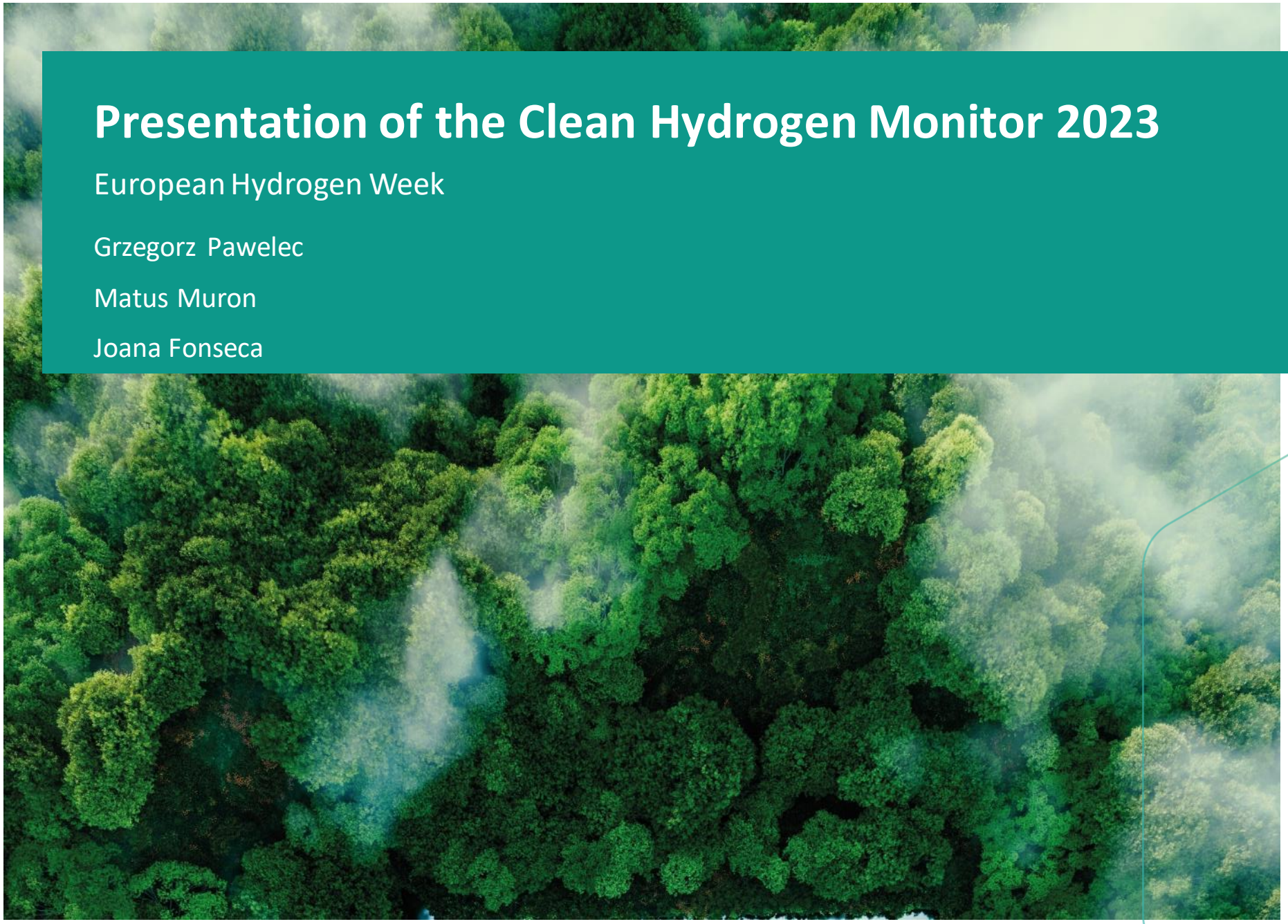


Presentation of the Clean Hydrogen Monitor 2023

European Hydrogen Week

Grzegorz Pawelec

Matus Muron

Joana Fonseca

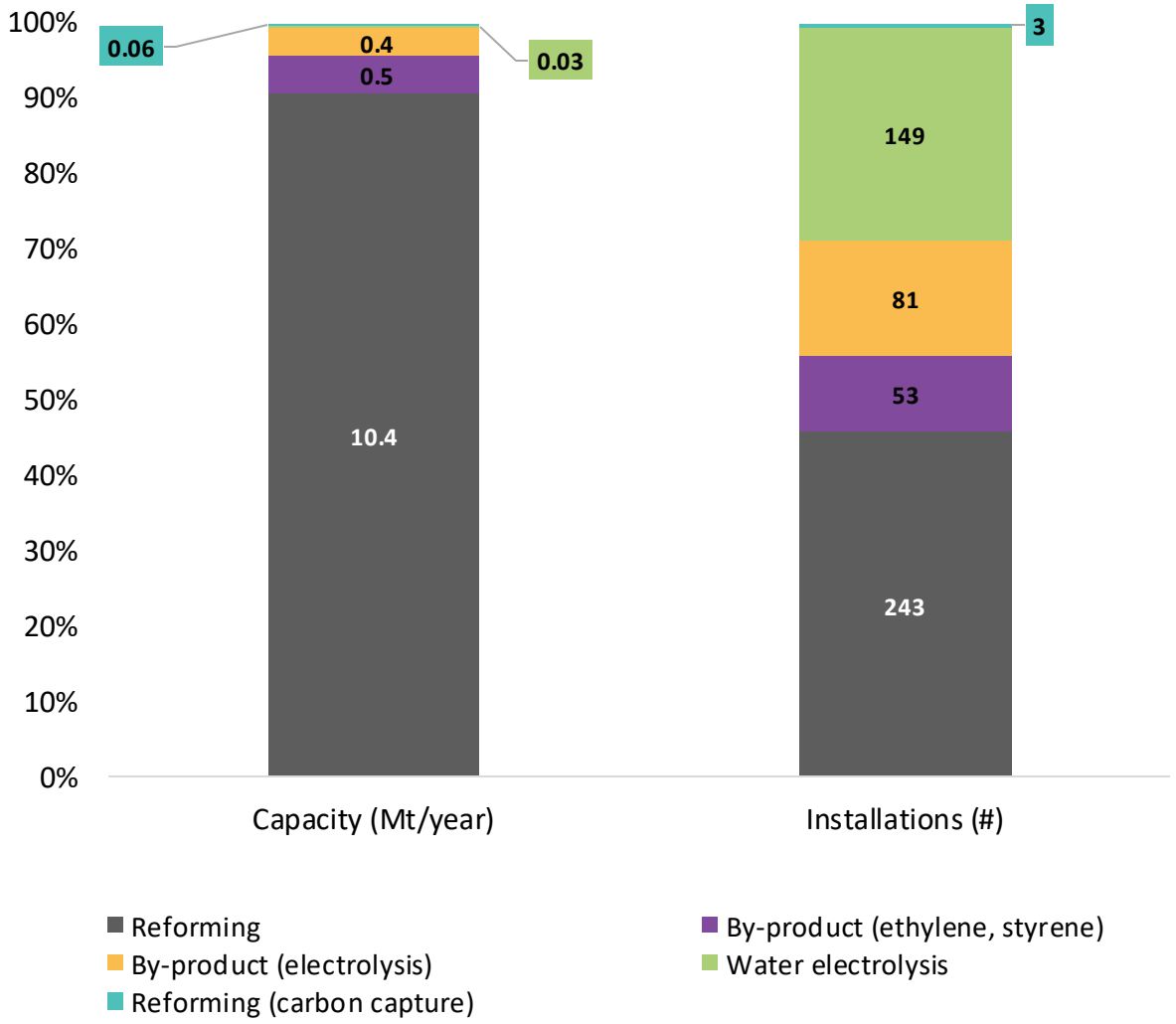
Hydrogen Europe

Clean Hydrogen Monitor 2023

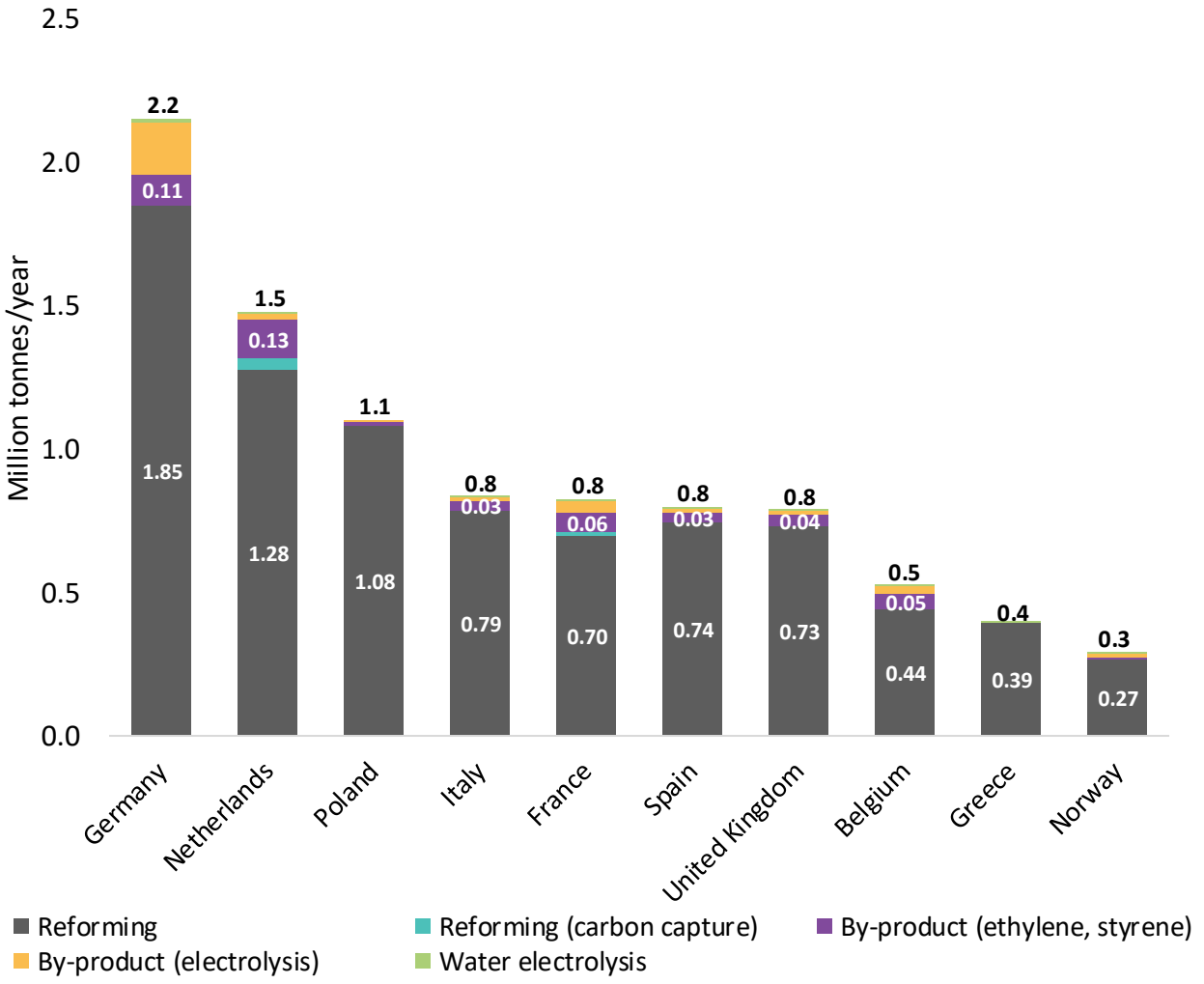
Table of contents

Water electrolysis nearly doubled in three years but represents 0.3% of the total capacity of 11.4 Mt

European hydrogen production capacity in 2022 by production process (% of total volume and # of installations)

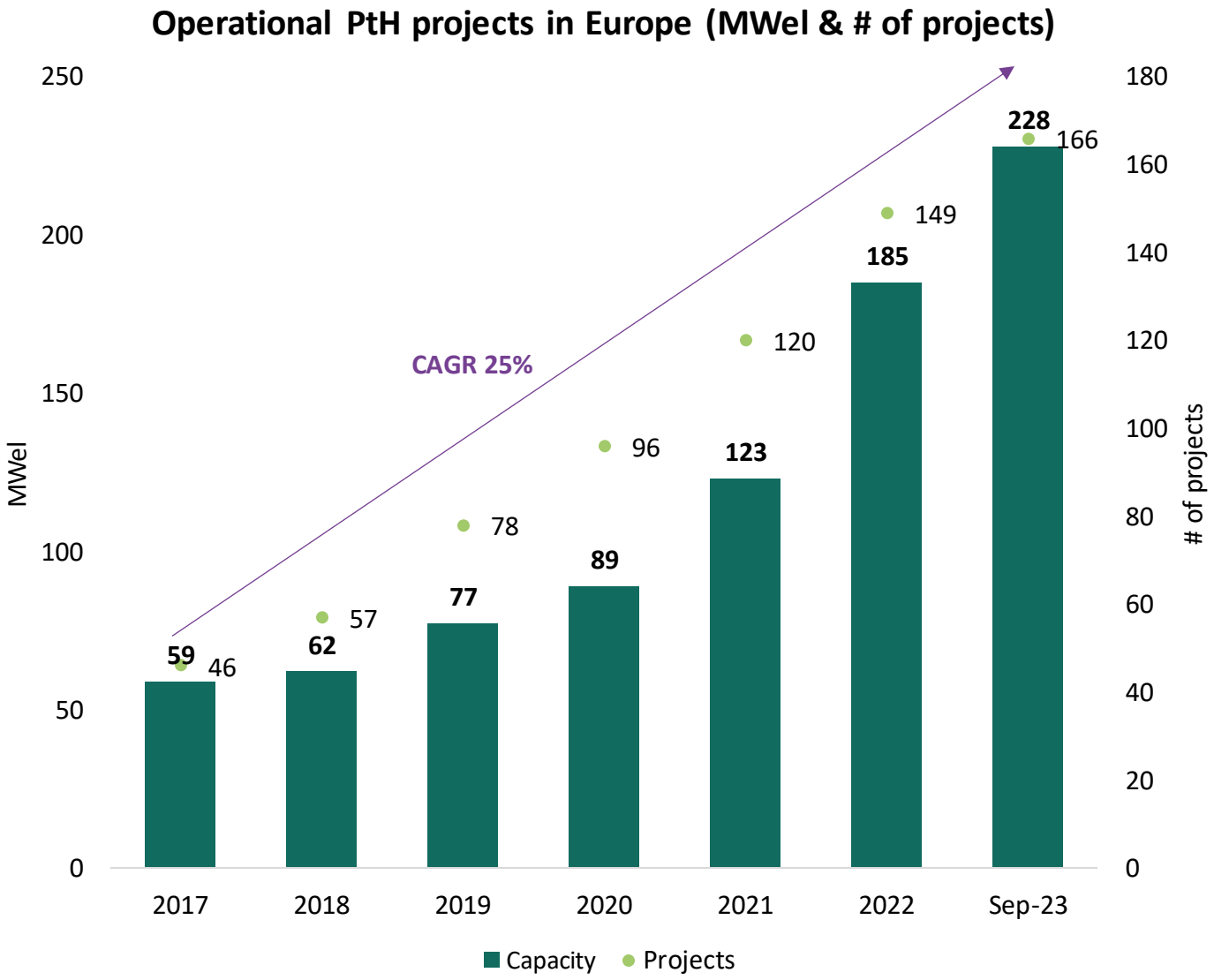


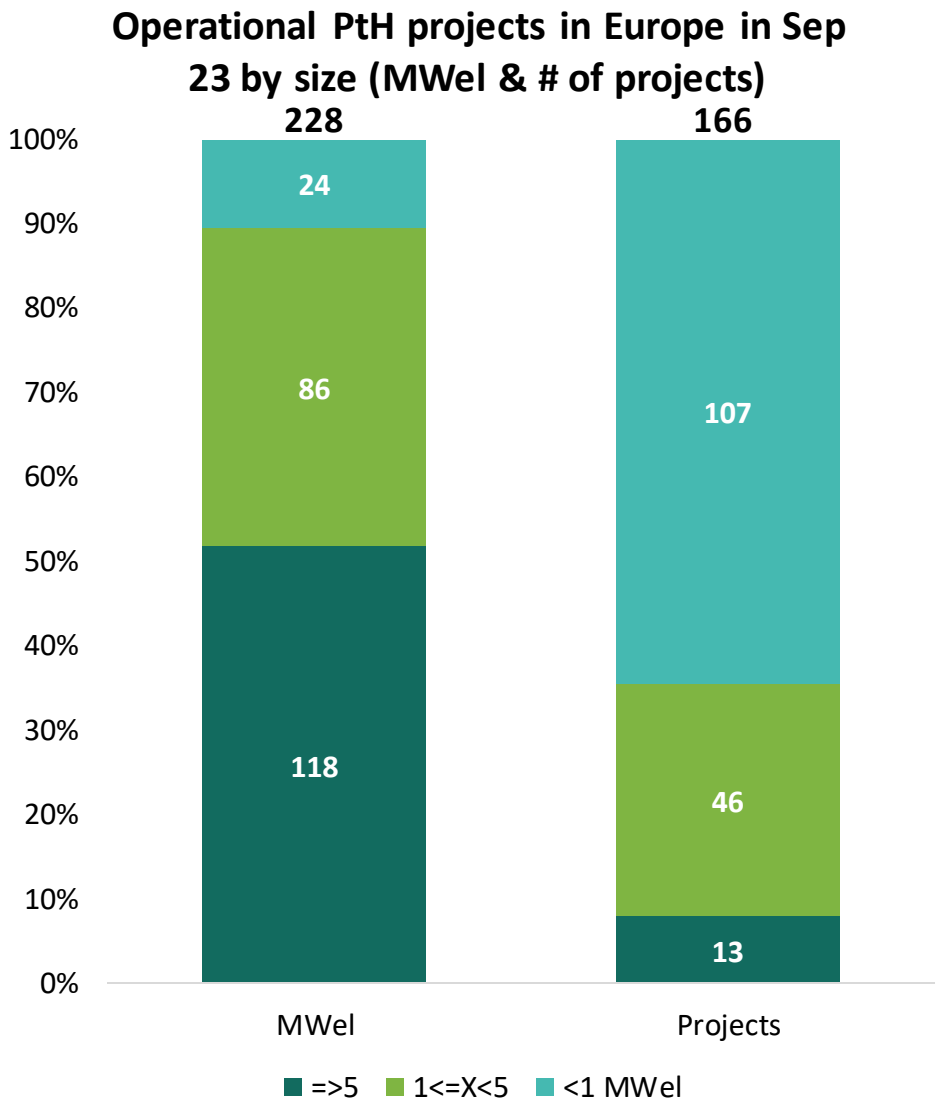
10 countries with the largest hydrogen production capacity in Europe in 2022 (Mt/year)



Notes: Explanations of the used terminology can be found in the methodological note of the report.
Source: Hydrogen Europe

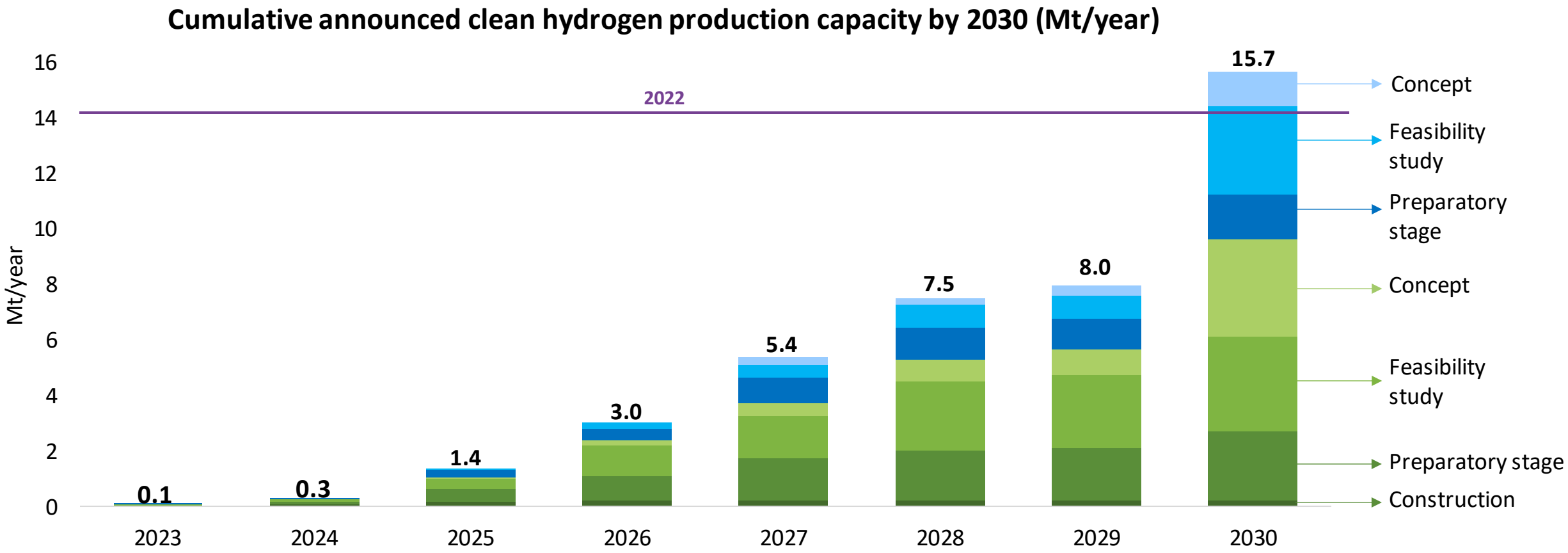
Three-year power-to-hydrogen (PtH) CAGR is 37% but needs to be 138% to achieve ~ 100 GWel by 2030





Notes: For clarifications regarding terminology and methodology, please consult the methodological note at the end of the chapter and terminology at the end of the report.
Sources: Hydrogen Europe

Total announced clean hydrogen production capacity increased to 15.7 Mt/y, but only 4.4 Mt/y is in an advanced stage with only 0.2 Mt/y in construction



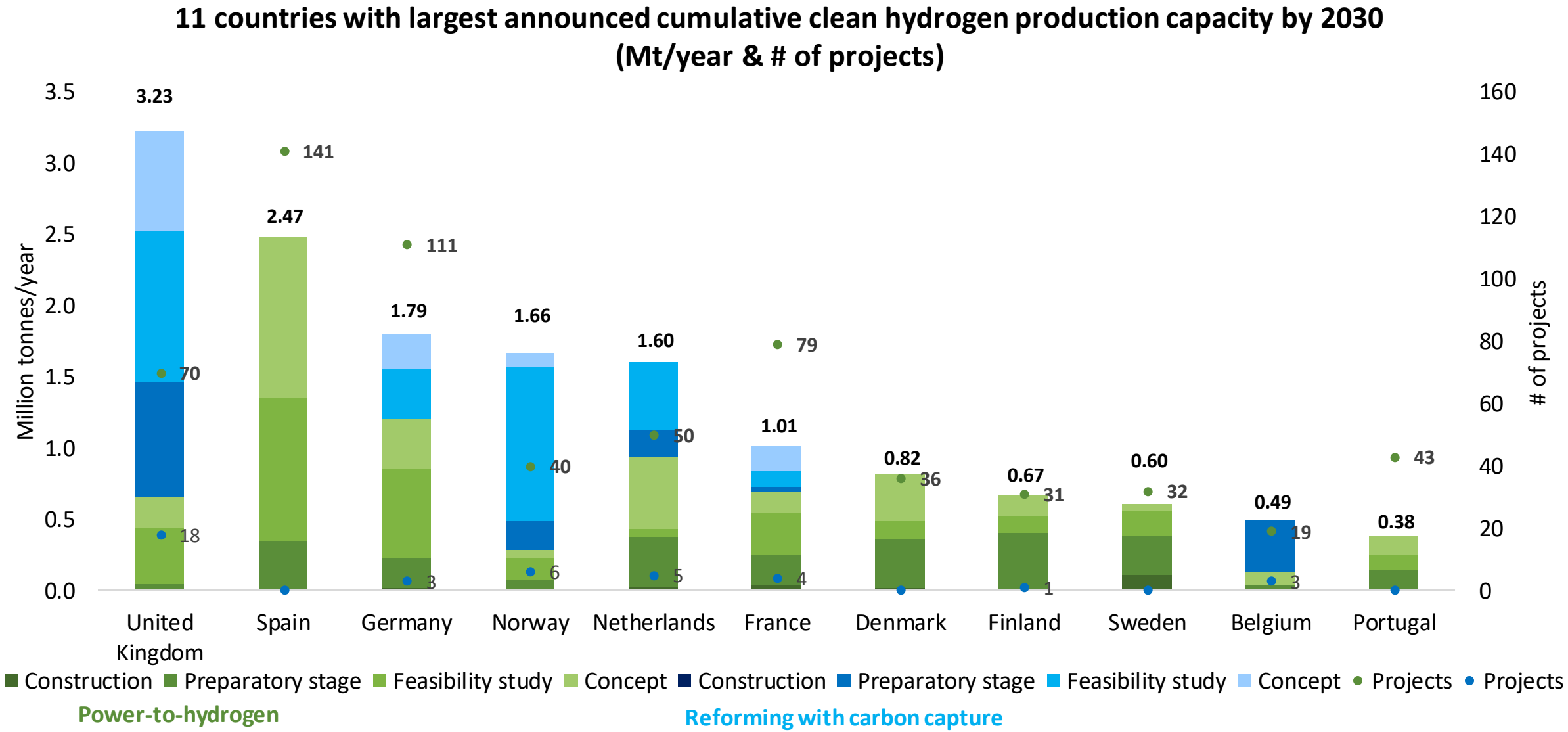
+30%
projects compared to last year

+1.7 Mt/year
Capacity increase after adjusting for a single large cancelled project

-0.4 Mt/year
Decrease in PtH projects planned for 2024

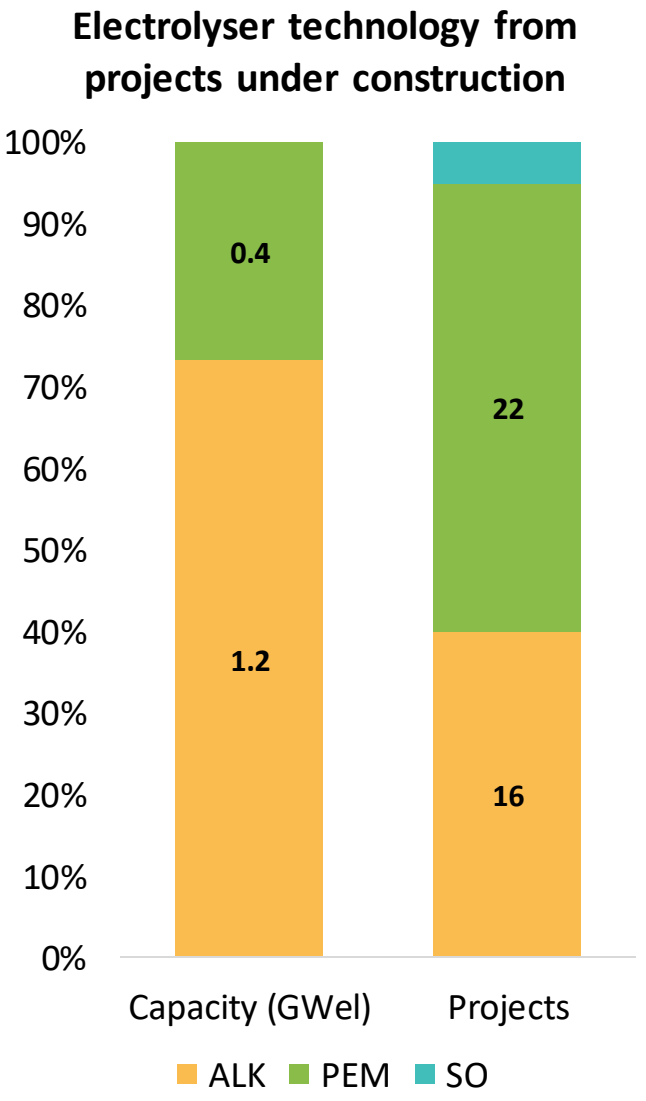
Notes: Data does not represent a forecast but announced production project pipeline; For clarifications regarding terminology and methodology, please consult the methodological note at the end of the chapter and terminology at the end of the report.
Sources: Hydrogen Europe

The clean hydrogen project pipeline is dominated by Nordic, Iberian, and Western European countries



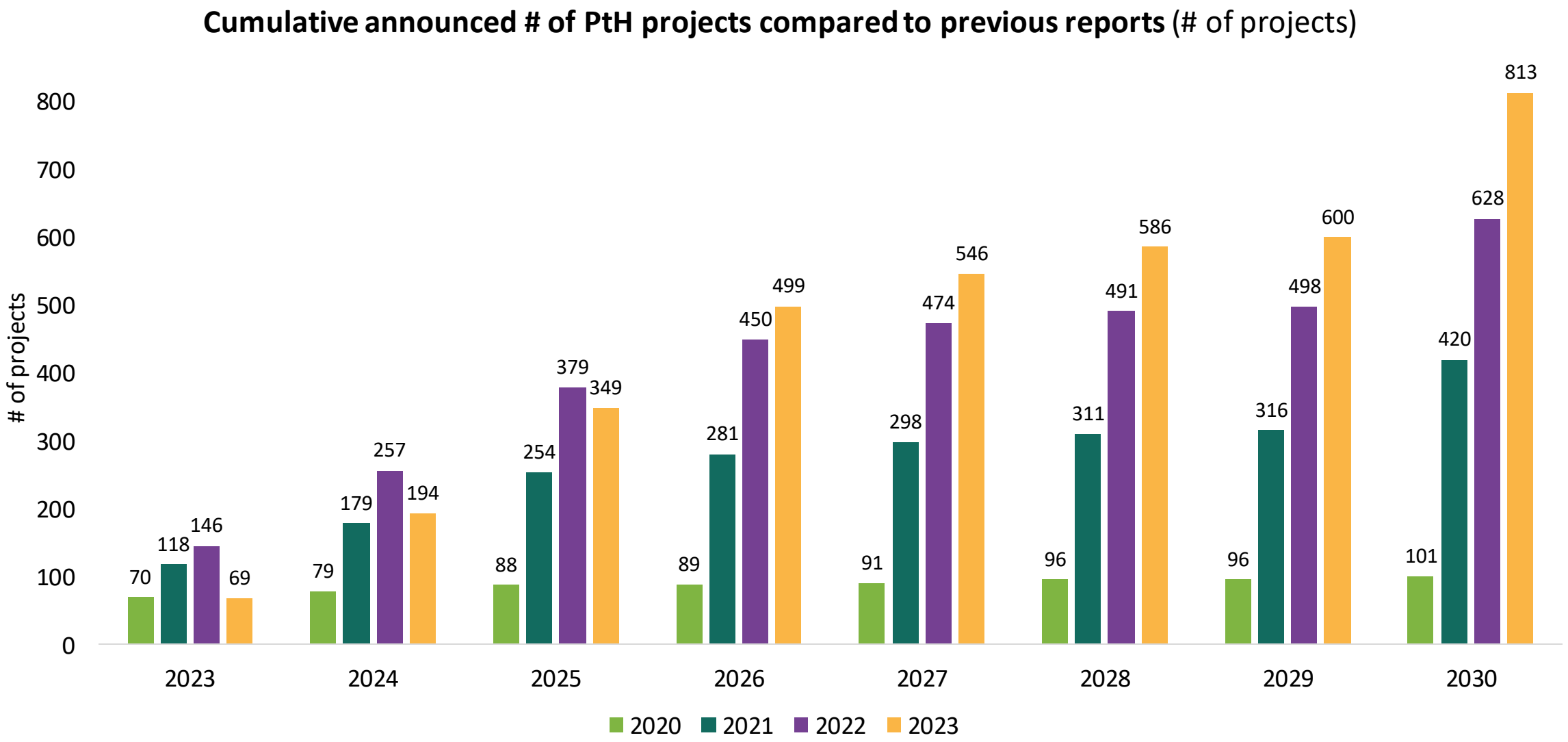
Notes: Data does not represent a forecast, but announced production project pipeline; For clarifications regarding terminology and methodology, please consult the methodological note at the end of the chapter and terminology at the end of the report.
Sources: Hydrogen Europe

73% of the capacity in projects under construction now is alkaline while that number decreases to 48% for all announced projects by 2030



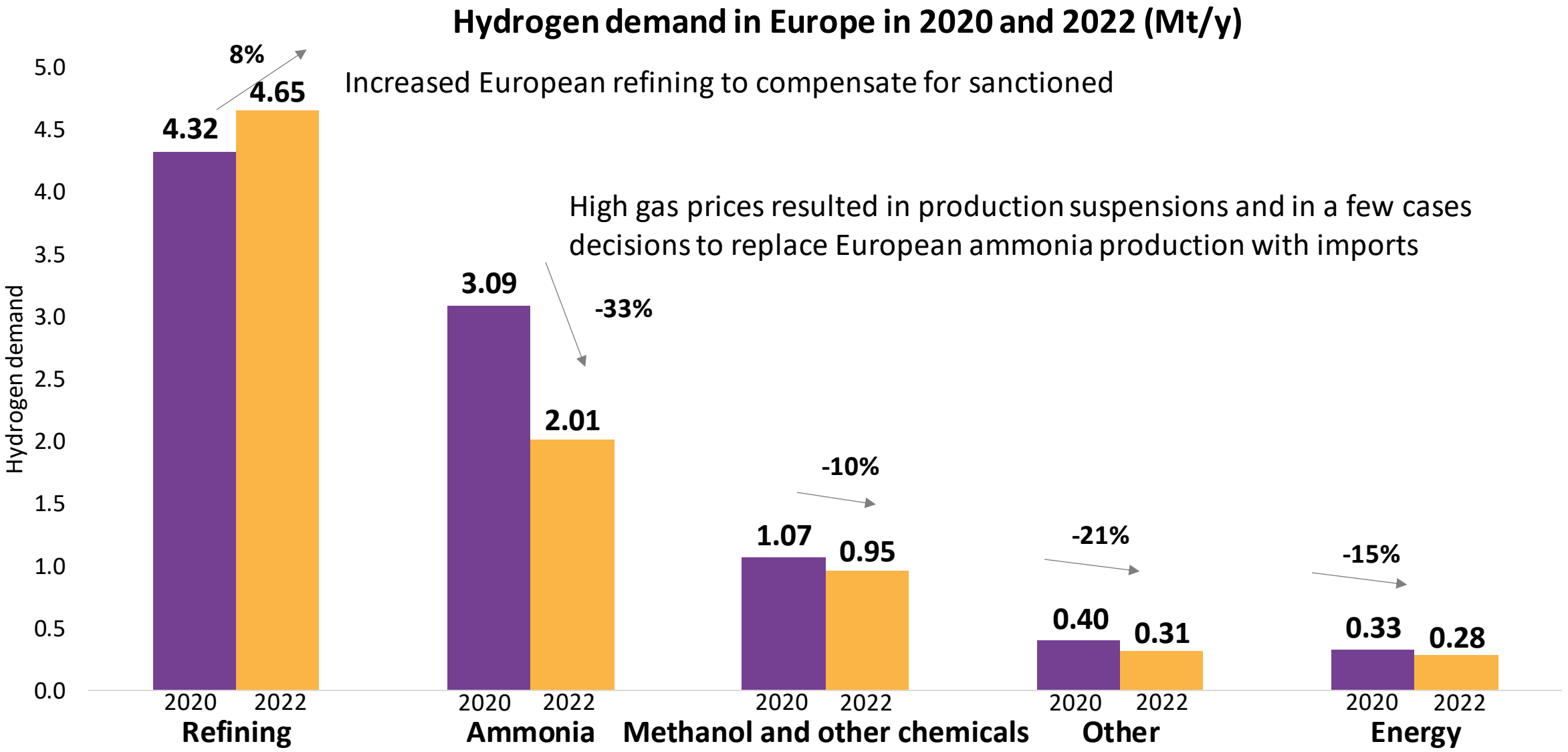
Notes: Data does not represent a forecast, but announced production project pipeline; For clarifications regarding terminology and methodology, please consult the methodological note at the end of the chapter and terminology at the end of the report.
Sources: Hydrogen Europe

PtH developers experience delays in short and medium term, but pipeline of announced PtH projects to be online by 2030 grew by 30% compared to 2022



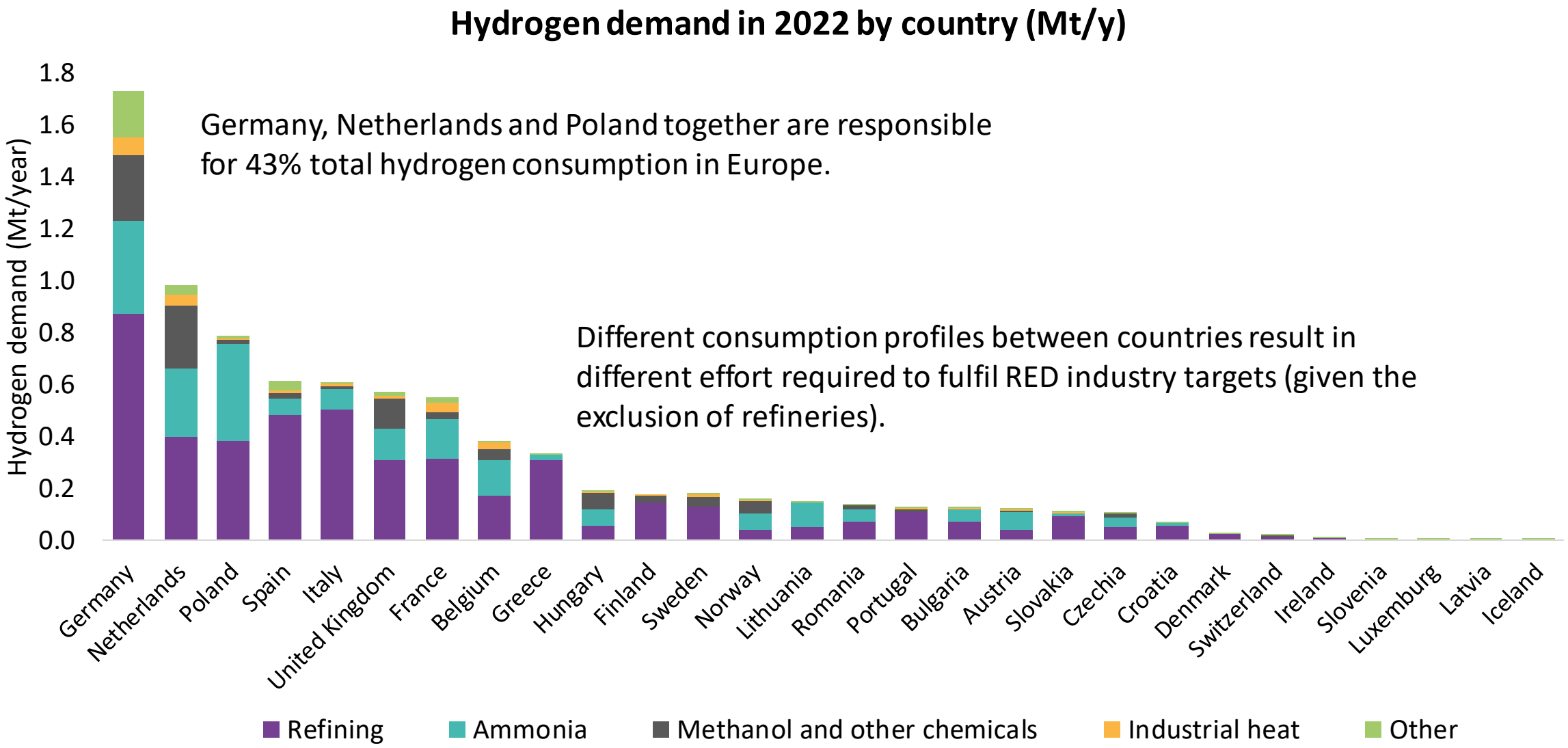
Notes: Data does not represent a forecast, but announced production project pipeline; For clarifications regarding terminology and methodology, please consult the methodological note at the end of the chapter and terminology at the end of the report.
Sources: Hydrogen Europe

H2 demand decreased by 9% from over 9 Mt in 2020 to 8.2 Mt in 2022

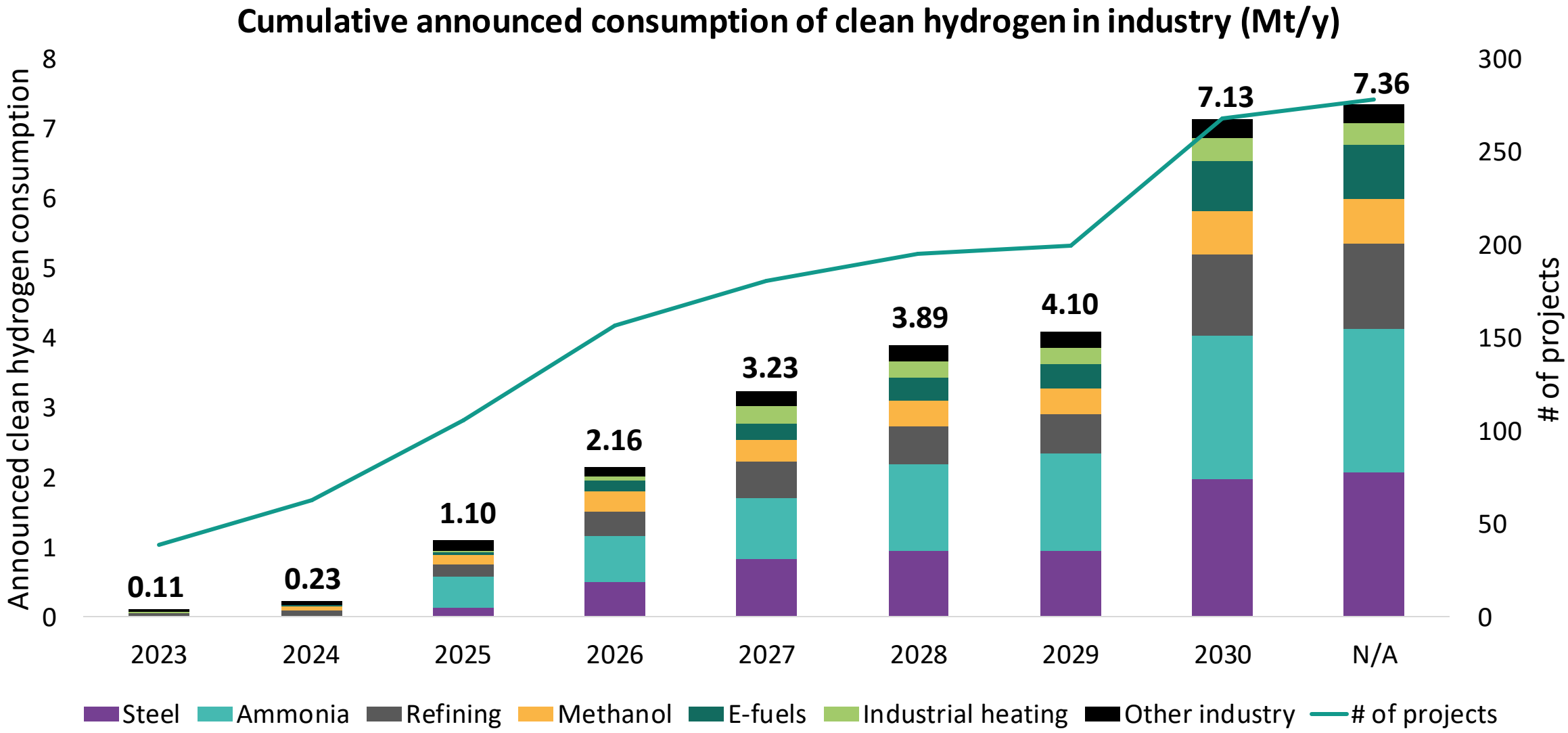


Source: Hydrogen Europe

Biggest consumers are also those with limited access to cheap renewable energy

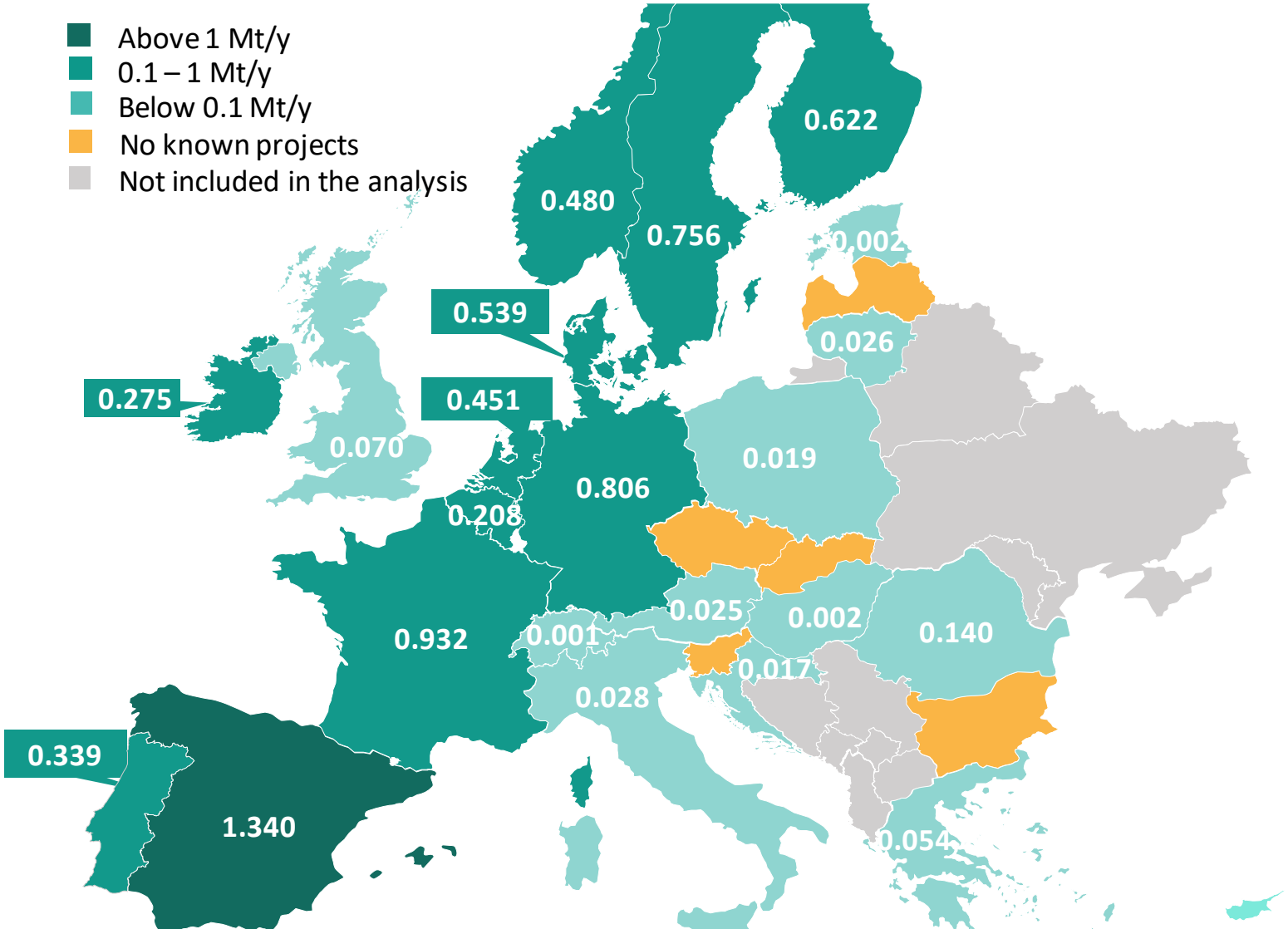


Industrial off-takers have announced 7.1 Mt of clean H2 consumption by 2030



Spain, France and Germany have announced the highest volumes

Announced consumption of clean hydrogen in industry by 2030 (Mt/y)

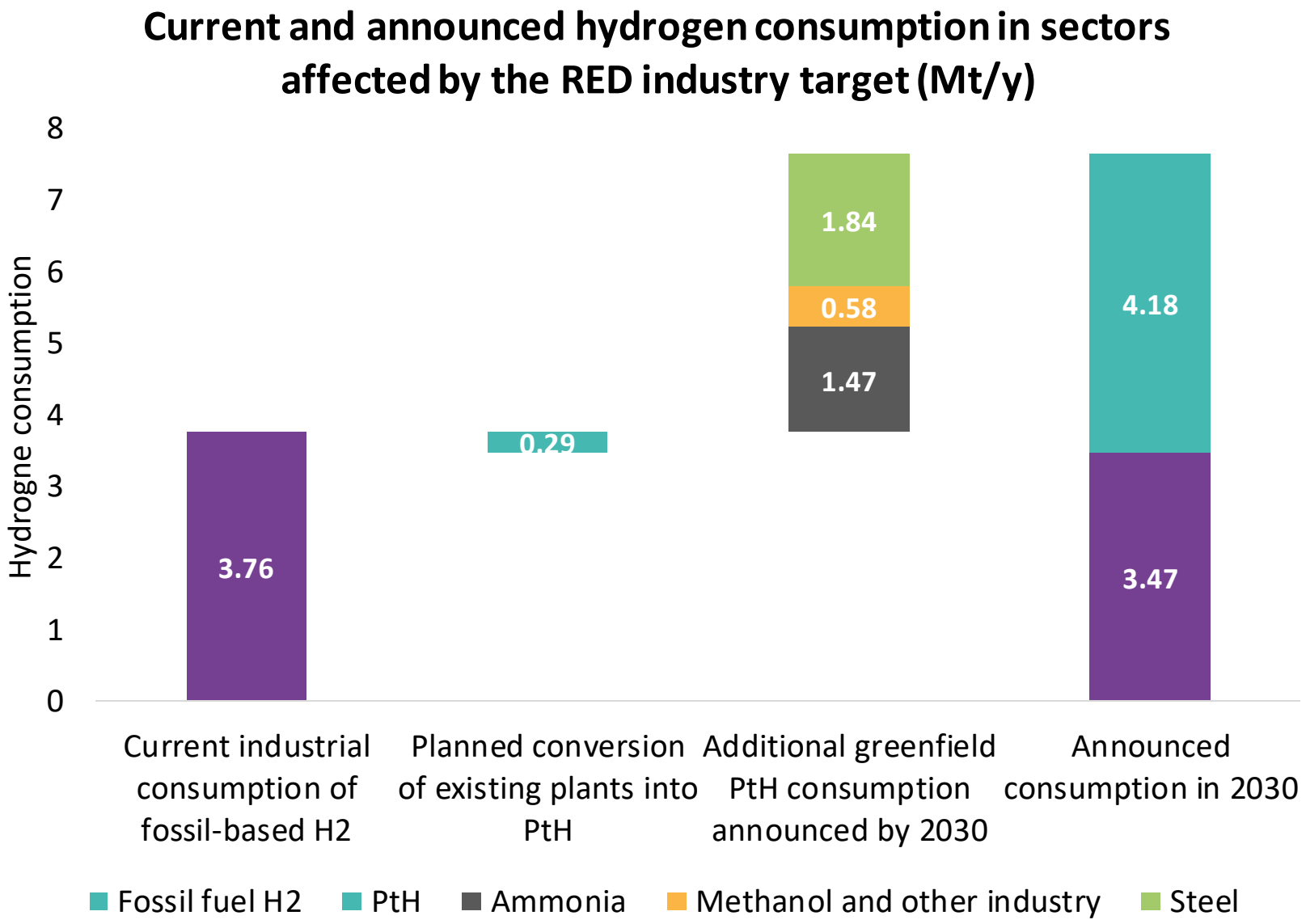


Highest volumes have been announced in countries with:

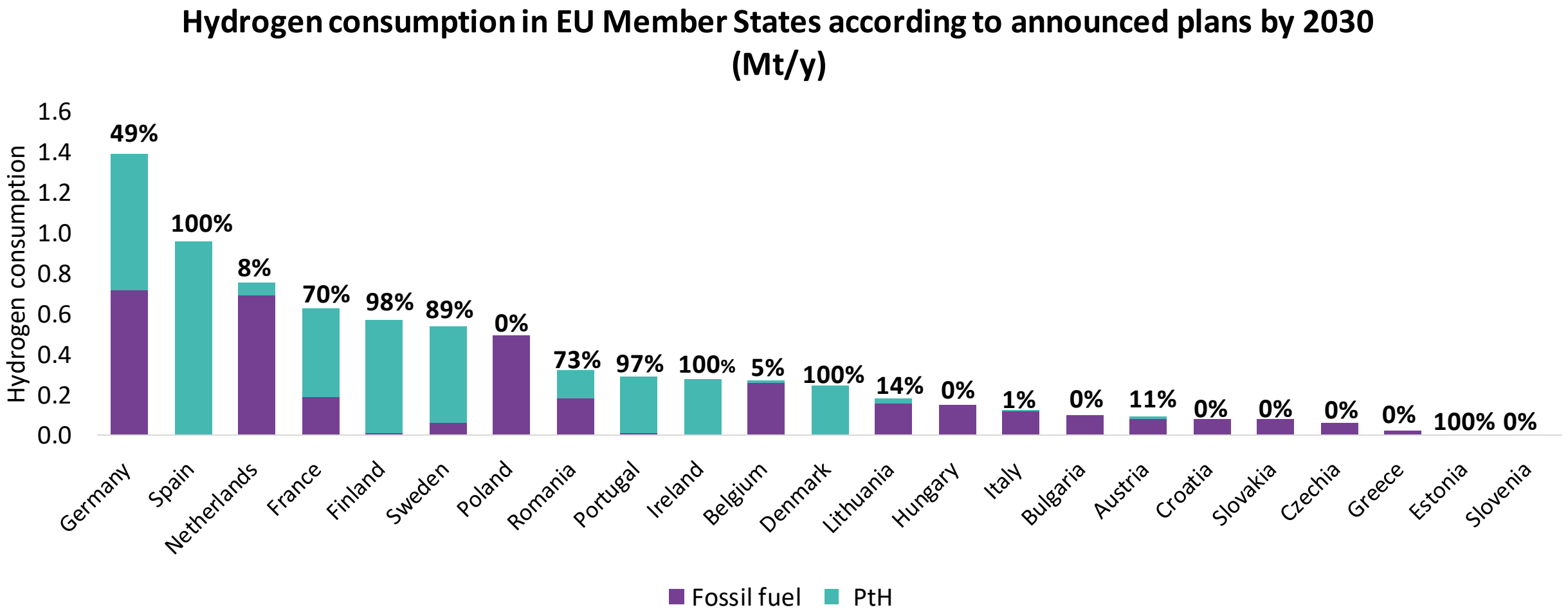
- Large demand for fossil-fuel hydrogen today
- Favourable renewable energy potential or access to a low GHG-intense grid
- Availability of subsidies

Announced PtH projects in RED industry sectors cover 55% of consumption in 2030

- REDIII imposes a target of 42% consumption of RFNBO in industry (excluding refineries)
- Provided that all announced PtH consumption is RFNBO and follows the planned timeline, the EU could reach 55% of RFNBO consumption in industry by 2030.
- However, the target must be met on a Member State level



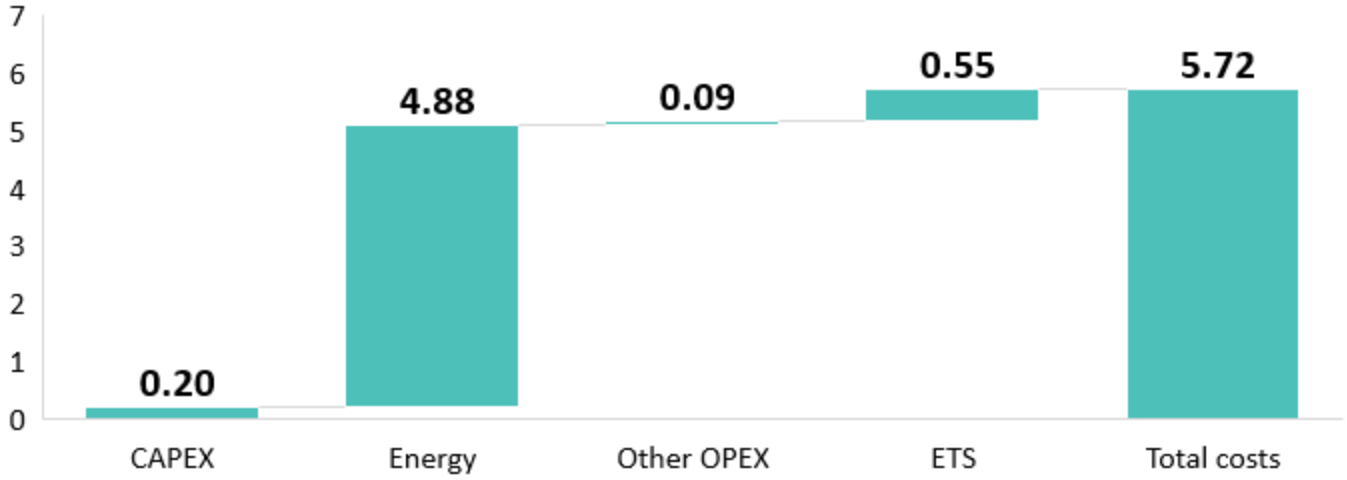
Not all MS have announced PtH consumption to meet the targets



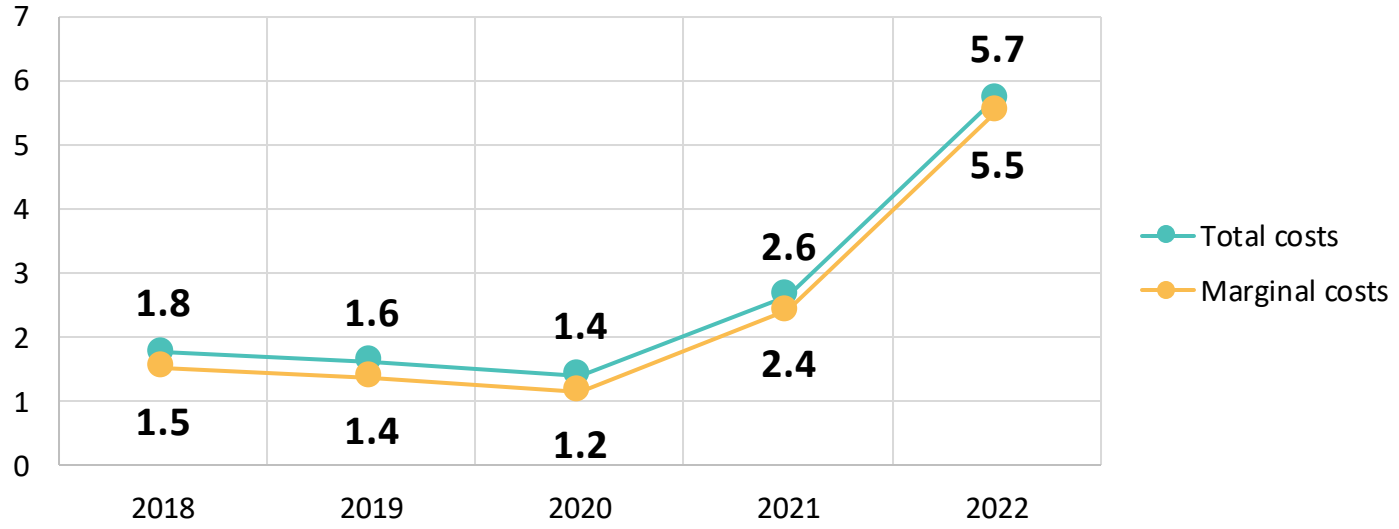
Record high fossil hydrogen production costs in 2022 due to natural gas prices

- Costs of grey hydrogen in 2022 were extraordinarily high
- High prices were the reason ammonia production in the EU suffered a signifcant downturn
- SMR without CCS results in emissions of around 9 tCO2/tH2 (or 11 when including indirect emissions)
- Natural gas prices have fallen back since to a considerable degree. Current grey hydrogen production costs are close to those from 2021 level (below 3 EUR/kg)

Breakdown of the EU-27 average levelized costs of hydrogen production via SMR in 2022 (EUR/kg)



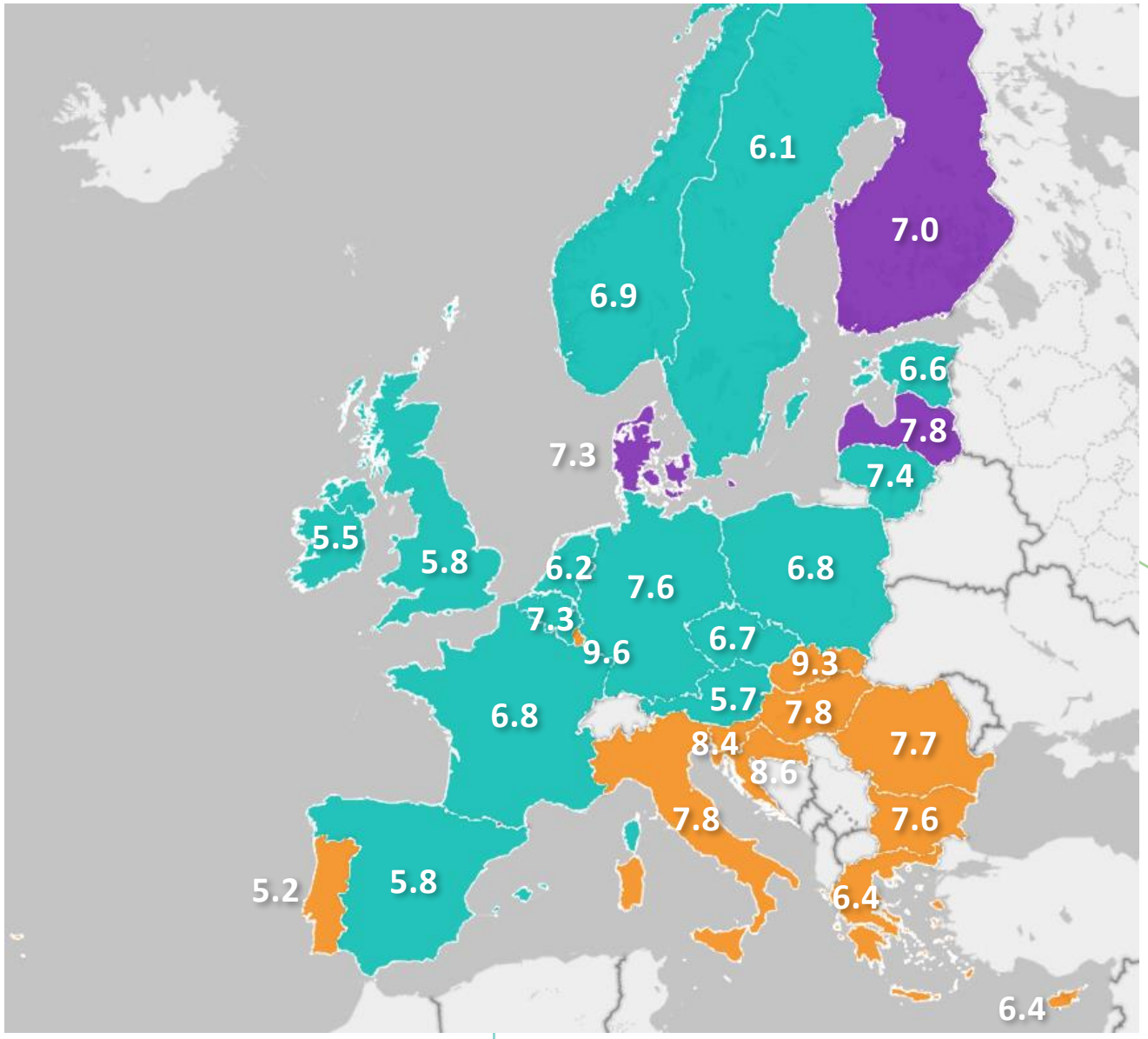
Levelized costs of hydrogen production via SMR in 2018-2022, EU-27 average (EUR/kg)



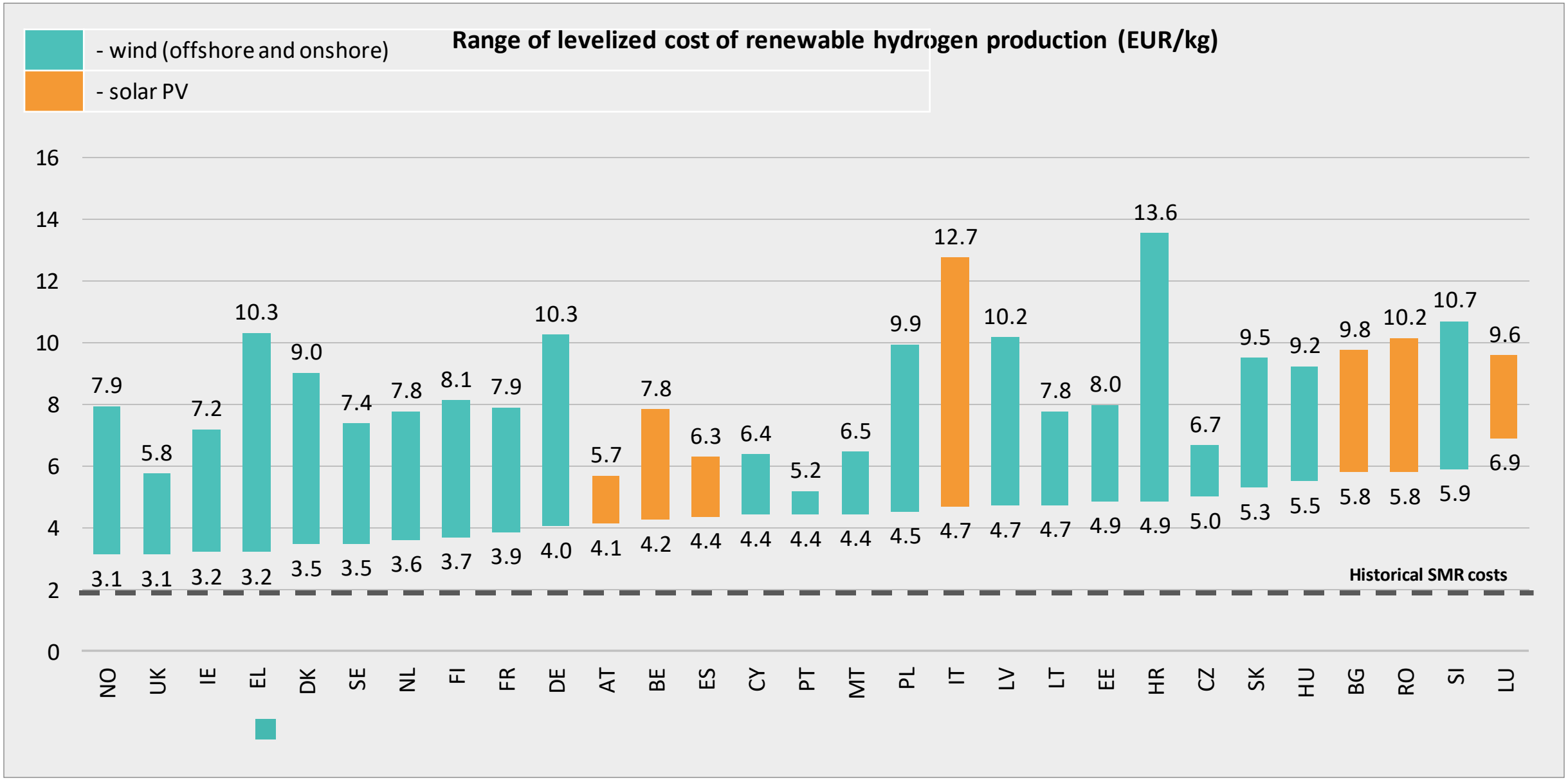
Average renewable hydrogen production costs have increased in 2022

- High inflation and a tight renewable energy supply market have lead to an increase of renewable hydrogen production costs
- Average estimated production costs have increased from 4.4 EUR/kg in 2021 to close to 7 EUR/kg in 2022
- Electricity costs are expected to drop in the short to medium term (as are natural gas prices)

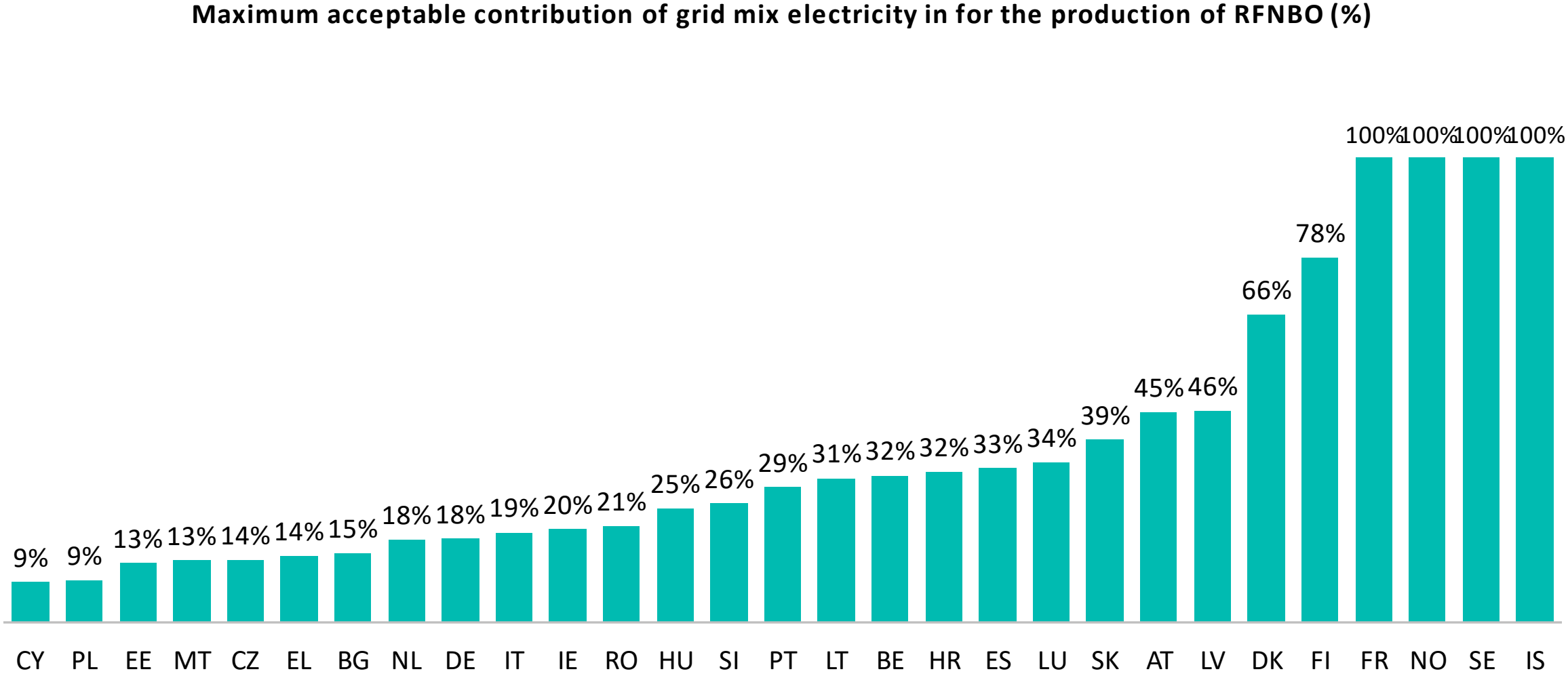
Average renewable hydrogen production costs in Europe in 2022 (in EUR/kg)



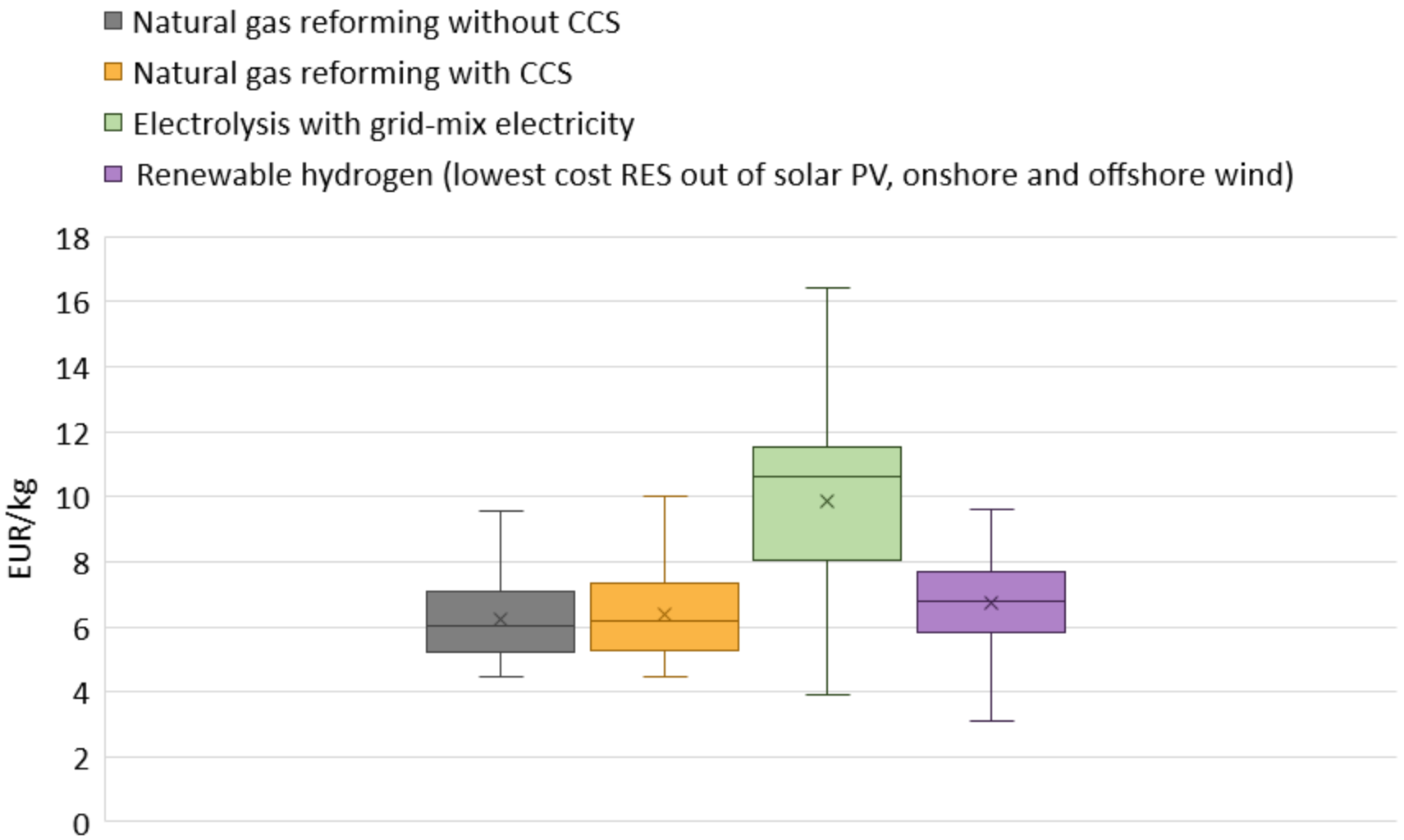
Given best available conditions, renewable hydrogen production costs could be as low as 3.1 EUR/kg

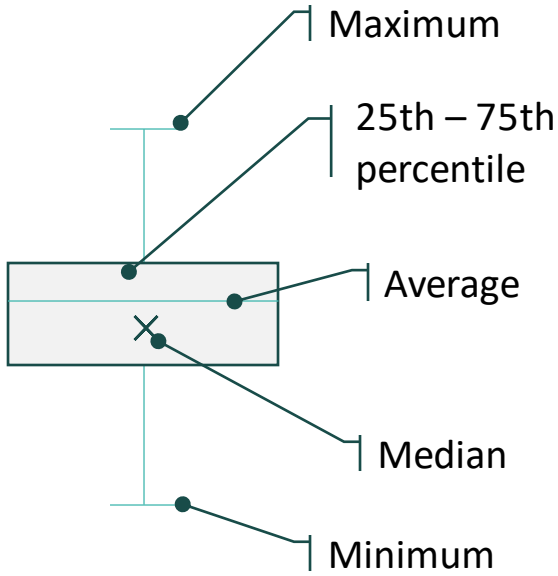


Water electrolysis using average EU-27 grid-mix electricity carbon intensity would lead to GHG emissions of 12.5 kgCO2e for each kg of hydrogen



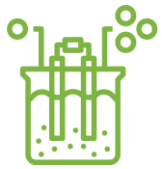
In 2022, for the first time since the inception of the Clean Hydrogen Monitor, hydrogen production costs rose across all production methods





Reflections on the state of the market

Hydrogen Europe



Pipeline of clean hydrogen production projects is growing but FIDs are being delayed due to regulatory uncertainty, slow access to or lack of funding, only recently created regulatory demand for RFNBO

Most of the planned clean hydrogen demand in industry are greenfield projects for steel, ammonia, refining

Hydrogen production costs for all production technologies increased due to high energy prices

Two years after the publication of the Fit for 55 package, some of the key policy drivers for clean hydrogen production and consumption are finally in place

Infrastructure development is critical to connect hydrogen production and demand regions with Belgium and the Netherlands being the most advanced

The clean hydrogen sector still requires significant public support and incentives to mitigate risks, attract the whole private finance value chain and unlock the sector’s economic and decarbonisation potential