Presentation

Hydrogen and its role in the European energy system of the future

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Catherine Robinson, Executive Director, Hydrogen and Renewable Gas
Catherine.Robinson@ihsmarkit.com, + 44 7817 617 935

Low-carbon hydrogen is becoming a core element of climate policies

- Global commitments towards **decarbonization are increasing**—Renewable gas (including hydrogen) is now recognized as a critical pillar alongside renewable power
- Policy frameworks are being put in place to drive large-scale consumption of low-carbon gas supported by a global **hydrogen market**
- **Transport** (logistics and HGV) **and industry** (steel and chemicals) are expected to be early adopters of low-carbon hydrogen
- Hydrogen for energy use is expected to be a mix of **domestically produced hydrogen** from coal/natural gas (grey/blue hydrogen), hydrogen from electrolysis (green hydrogen) and **imports**
- **Industry is responding** to the policy push: More, larger projects are being announced

Hydrogen and its role in the European energy system

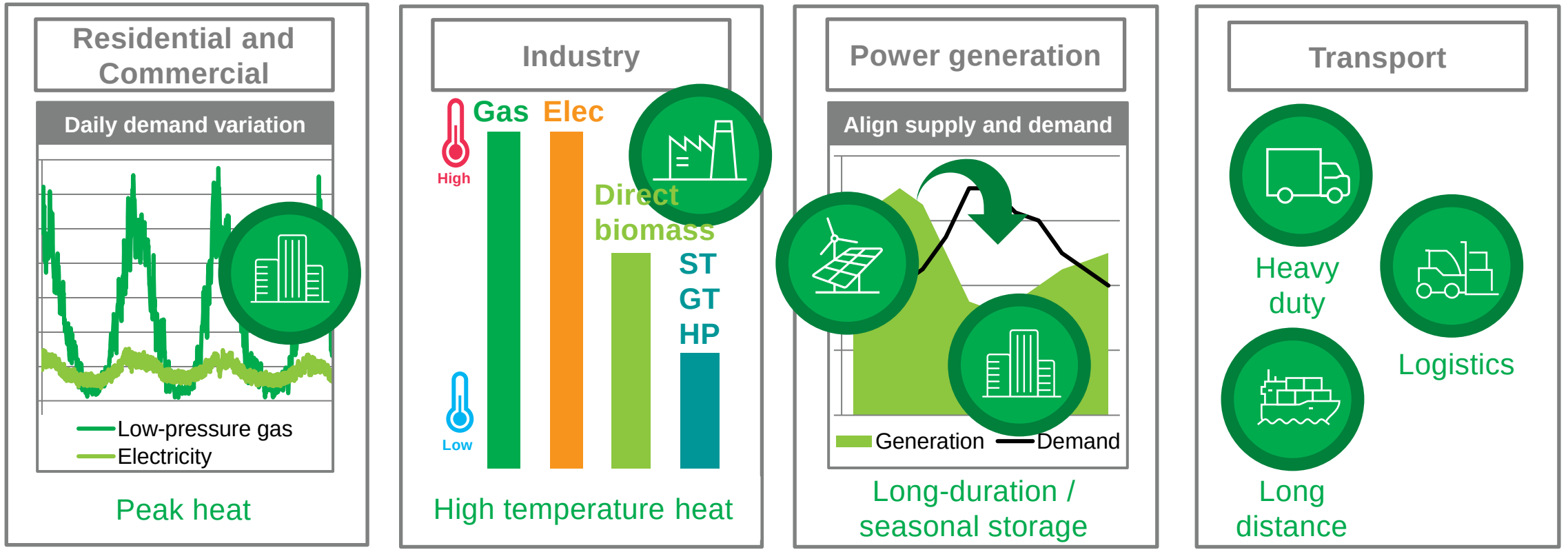
Questions to answer

- Where can hydrogen play a role in decarbonizing the European economy?
- What are Europe's hydrogen ambitions?
- What does low-carbon hydrogen cost?
- What is the status of low-carbon hydrogen today?
- What is needed to develop large-scale use of low-carbon hydrogen in Europe?

Role of low-carbon hydrogen in meeting net-zero ambitions

The role of electricity will grow, but low-carbon gas will become an important part of all sectors of a net-zero carbon economy

Roles for gas in a very low carbon energy system

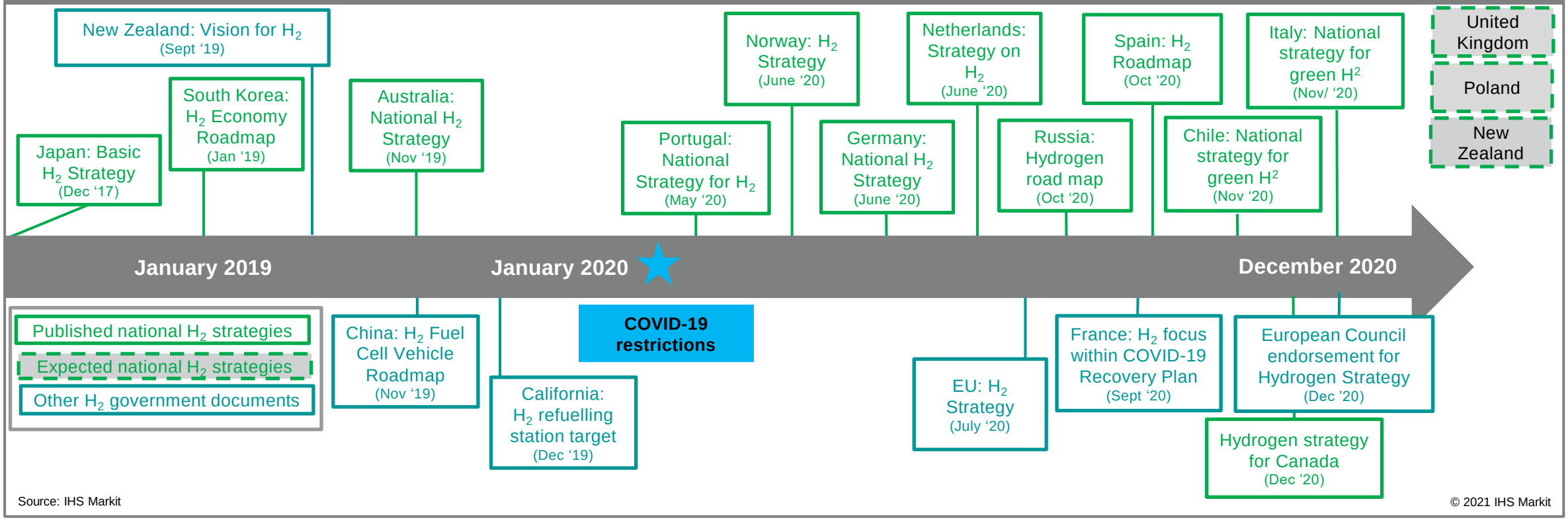


Note: ST = solar thermal; GT = geothermal; HP = heat pump.
Source: IHS Markit

Hydrogen is now integral to the global 2050 vision

Funds allocated to H_2 in COVID-19 recovery plans. Multiple H_2-related policy documents explaining governments' strategic intentions and specific measures to support projects

Timeline of global policy and regulatory documents relating to hydrogen (selected reports)



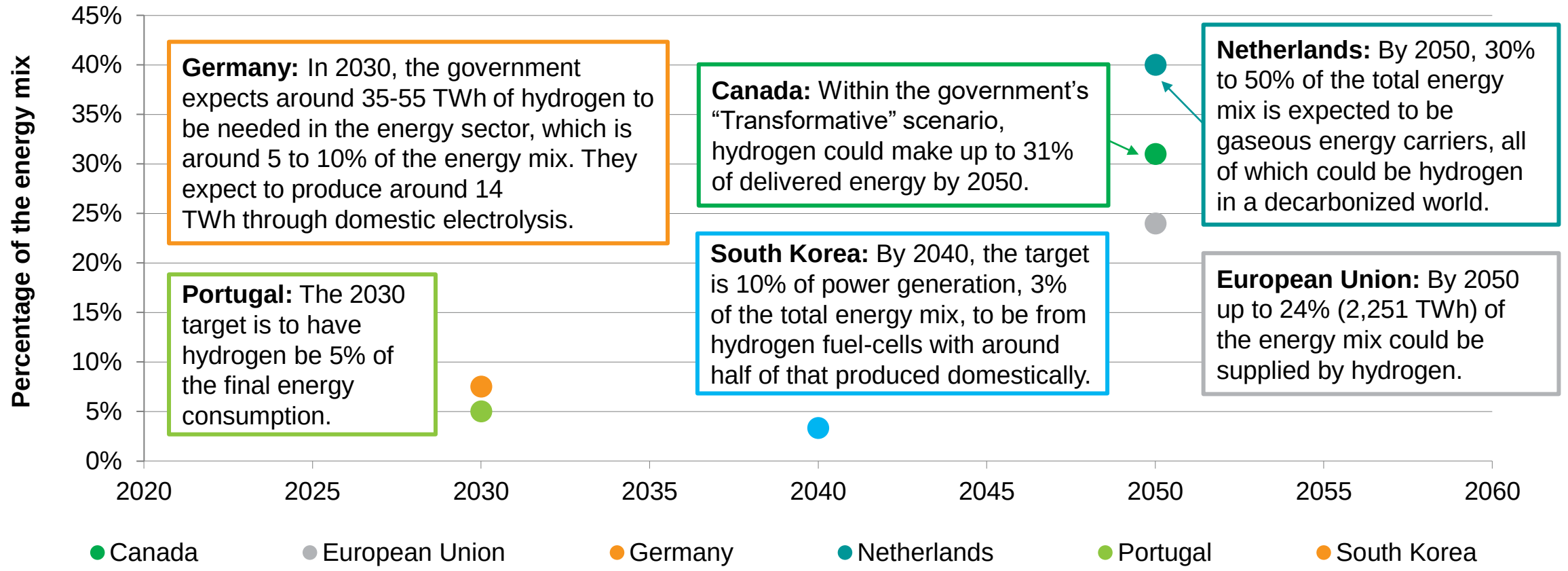
Source: IHS Markit

Decarbonisation of gas firmly on the agenda in many major global markets

Hydrogen is expected to become a significant part of the energy mix

Governments are beginning to propose targets for hydrogen use throughout the energy sector

Target hydrogen use within the energy sector

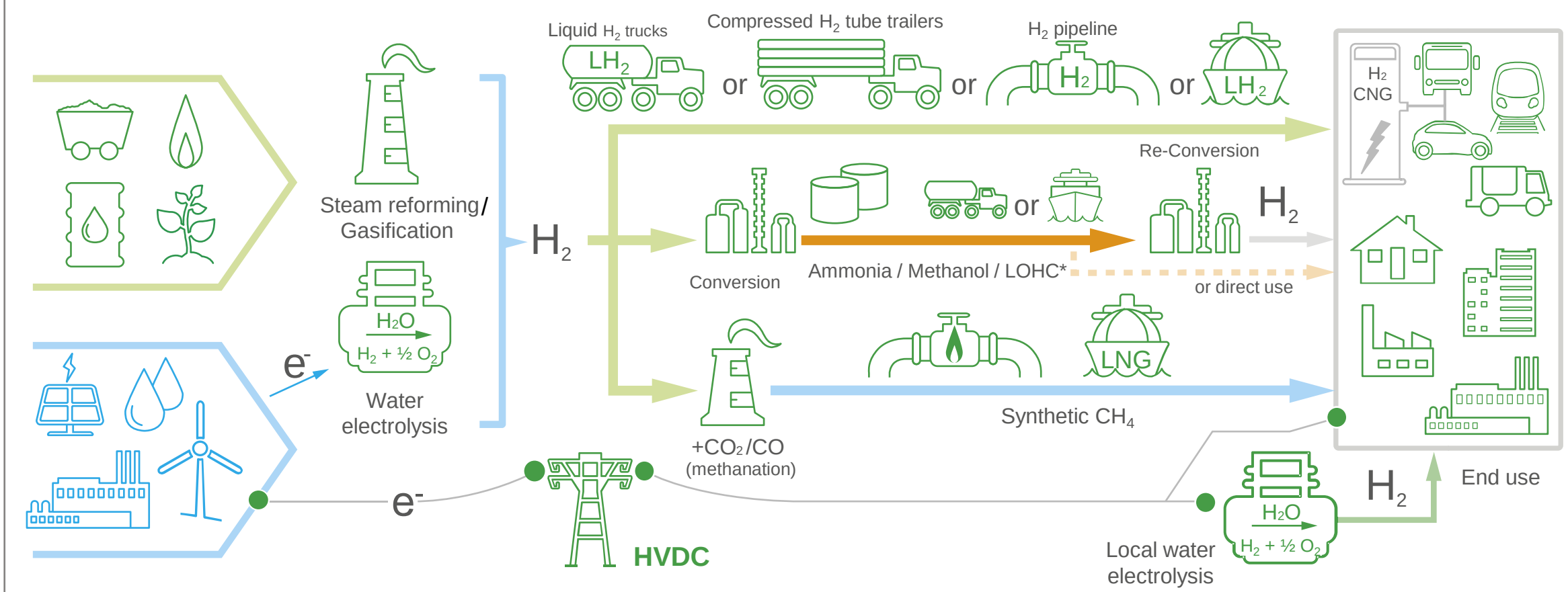


Source: IHS Markit

Costs of low-carbon hydrogen

The low-carbon hydrogen supply chain

IHS Markit Hydrogen supply chain techno-economic analysis

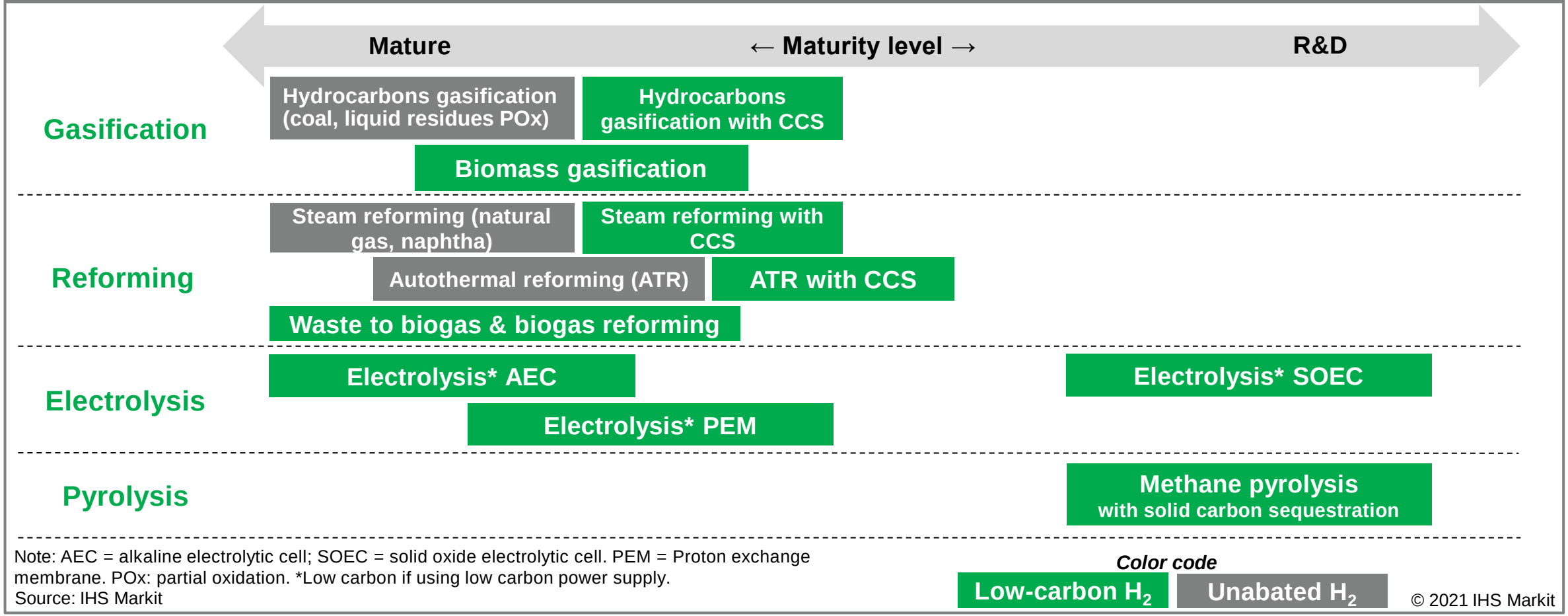


Source: IHS Markit * Liquid organic hydrogen carriers

IHS Markit studies consider a range of H_2 production pathways

Pathways vary in terms of feedstock, scale, commercial availability, maturity, and cost

H_2 production pathways



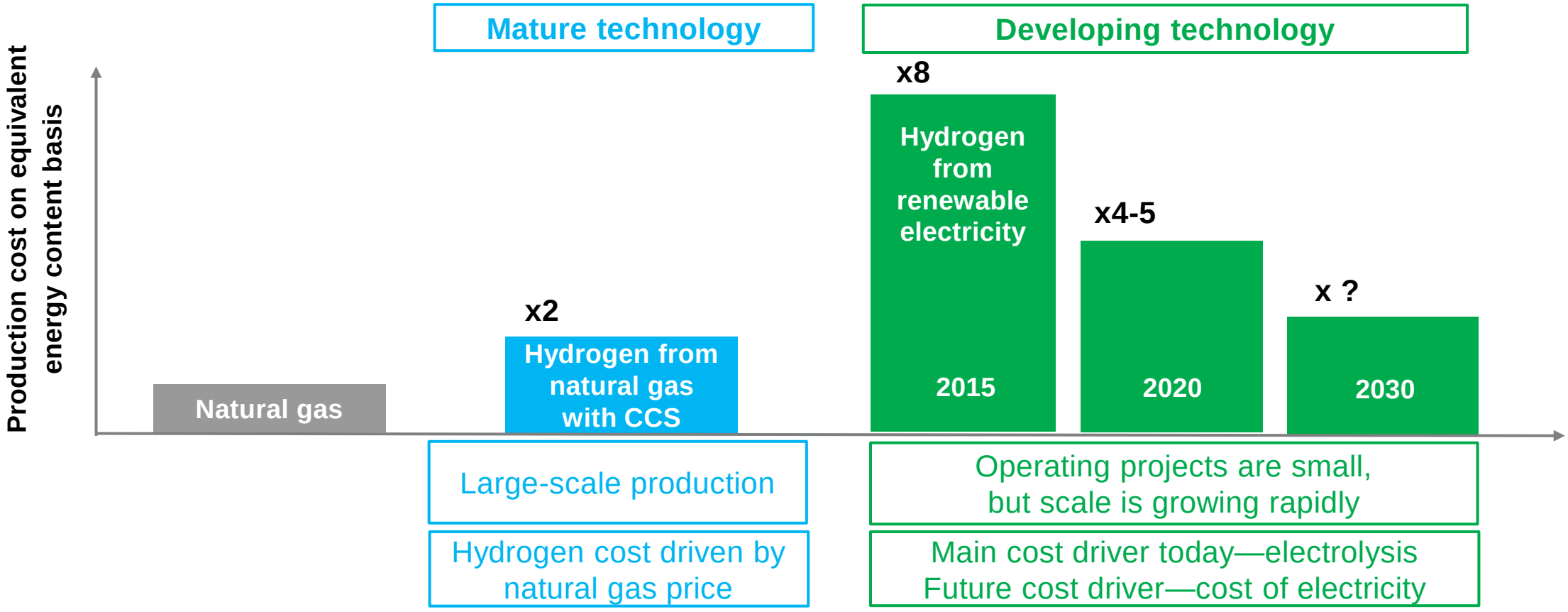
Note: AEC = alkaline electrolytic cell; SOEC = solid oxide electrolytic cell. PEM = Proton exchange membrane. POx: partial oxidation. *Low carbon if using low carbon power supply.
Source: IHS Markit

Color code

Low-carbon H_2 | Unabated H_2

Hydrogen production costs

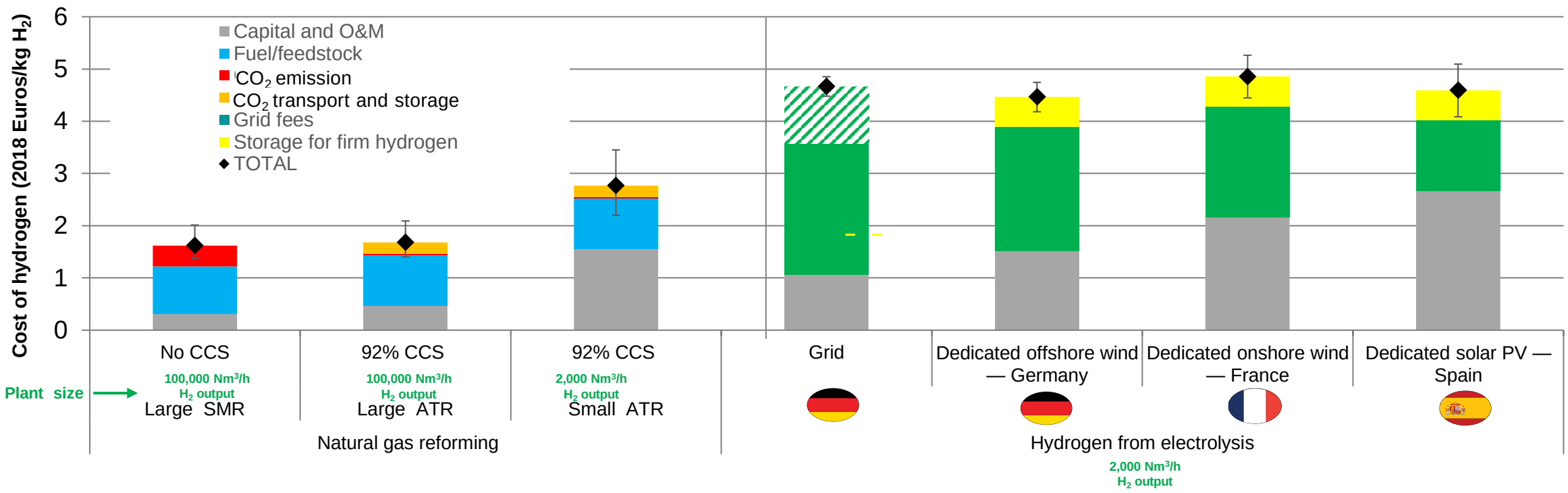
Relationship between the cost of natural gas and the cost of low-carbon hydrogen



Source: IHS Markit

In Europe today, hydrogen from water electrolysis is 2-3 times more expensive than methane reforming with carbon capture and storage

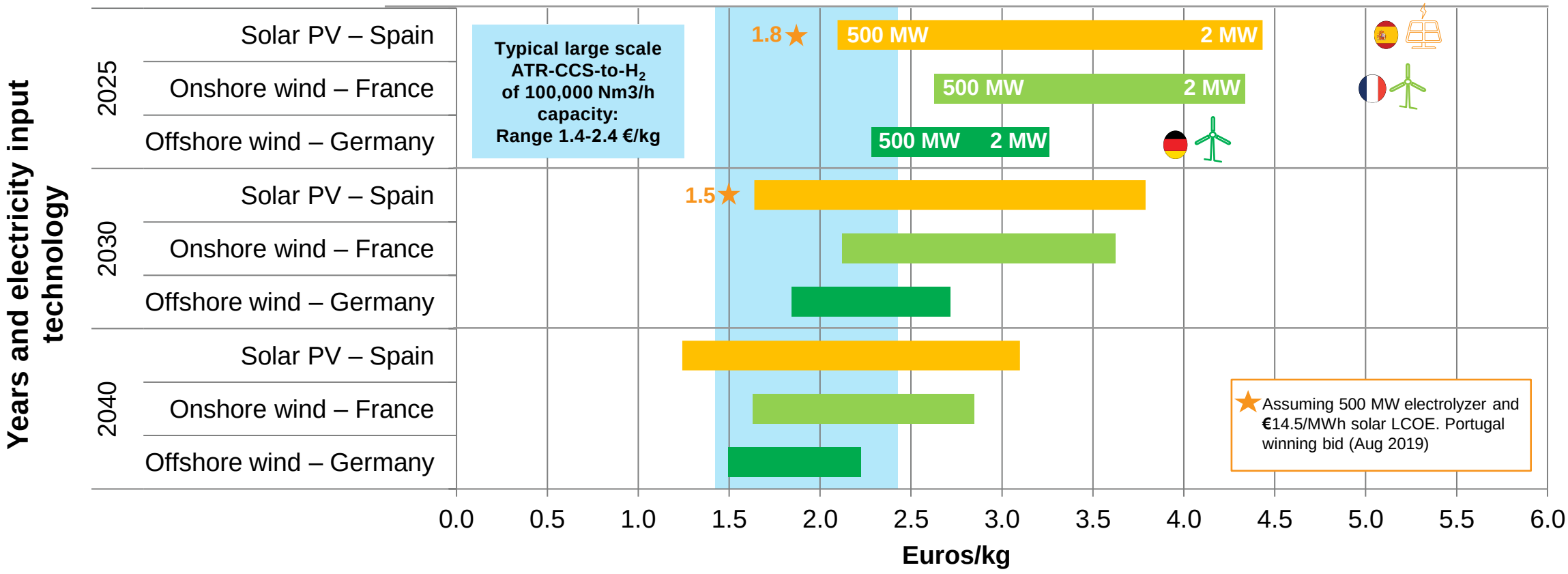
Levelized cost of hydrogen production in Europe – 2020



Source: IHS Markit

If storage for firming hydrogen supply is not needed, the cost of hydrogen can fall below 2 Euros/kg between 2025 and 2030 in Europe

Cost of intermittent hydrogen (without storage) at the boundary of the production facility in Europe
Hydrogen from renewables vs ATR with CCS



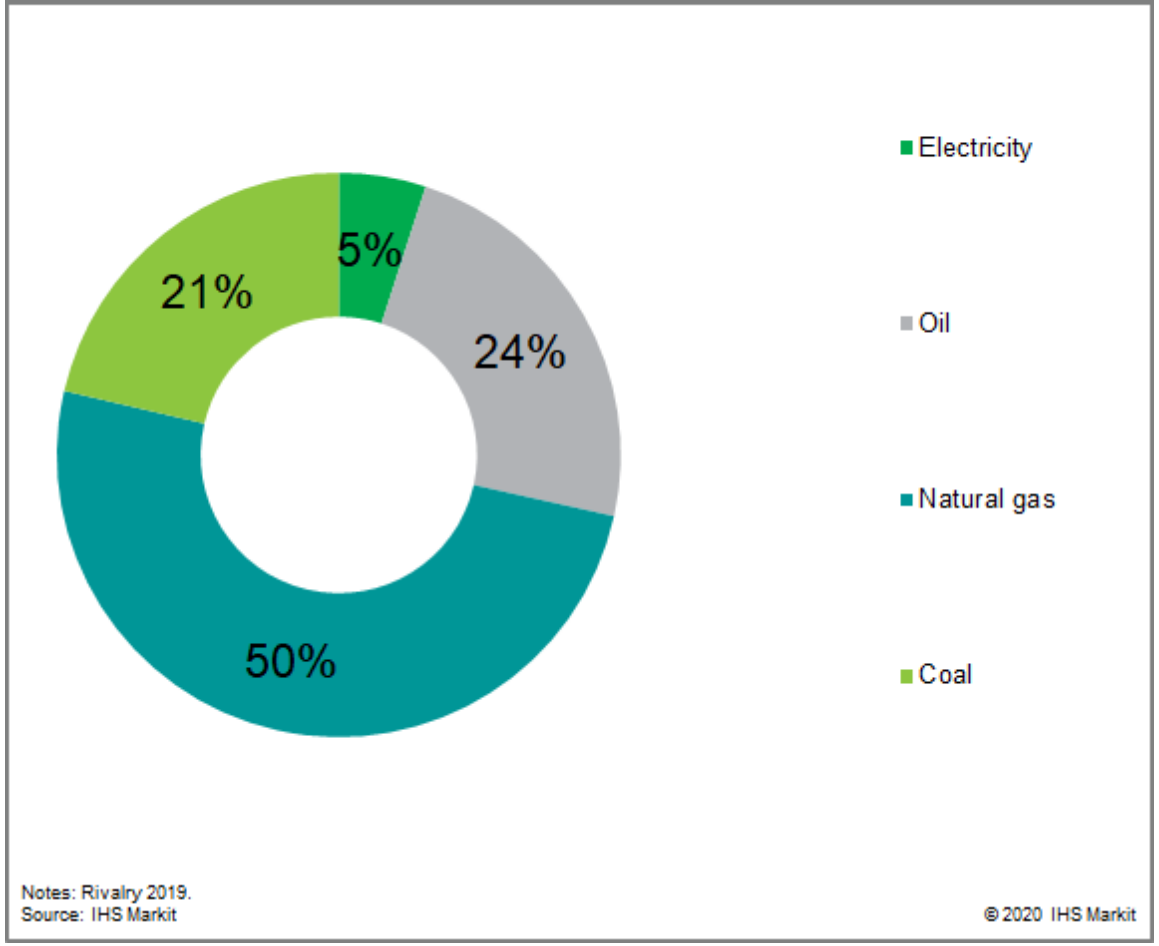
Source: IHS Markit

500 MW 2MW : Input capacity range of installed electrolyzer

Status of low-carbon hydrogen today and potential for growth

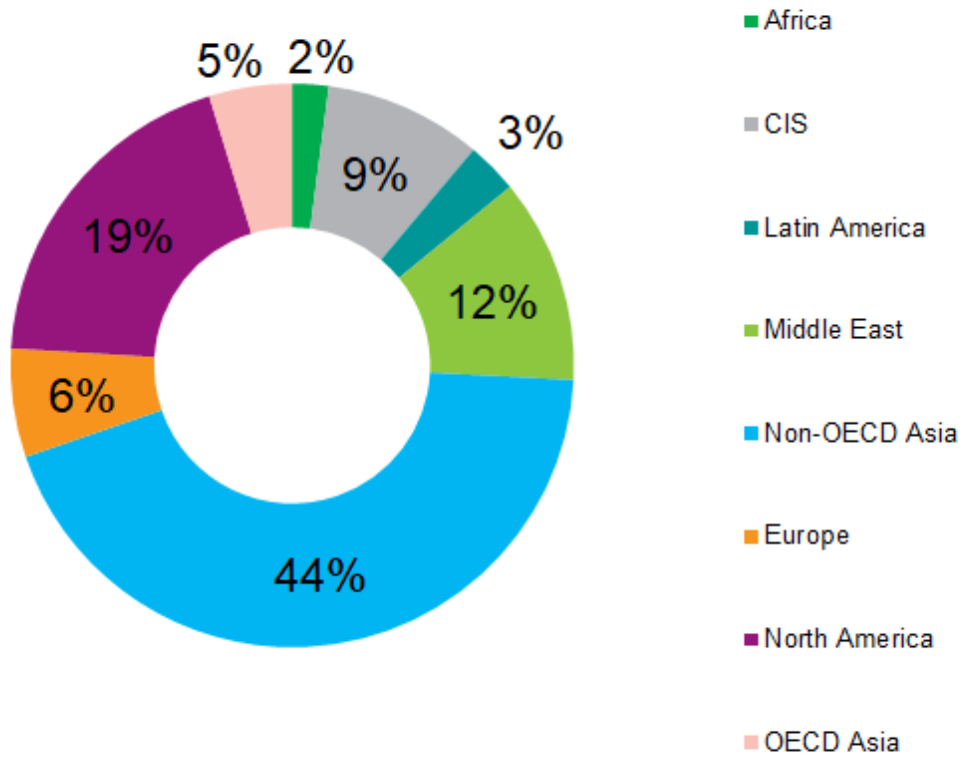
Development of hydrogen as an energy carrier would dwarf current consumption: Current hydrogen demand*—2% of global energy demand.

Hydrogen supply by fuel inputs (2019)



Notes: Rivalry 2019.
Source: IHS Markit

Hydrogen consumption by region (2019)

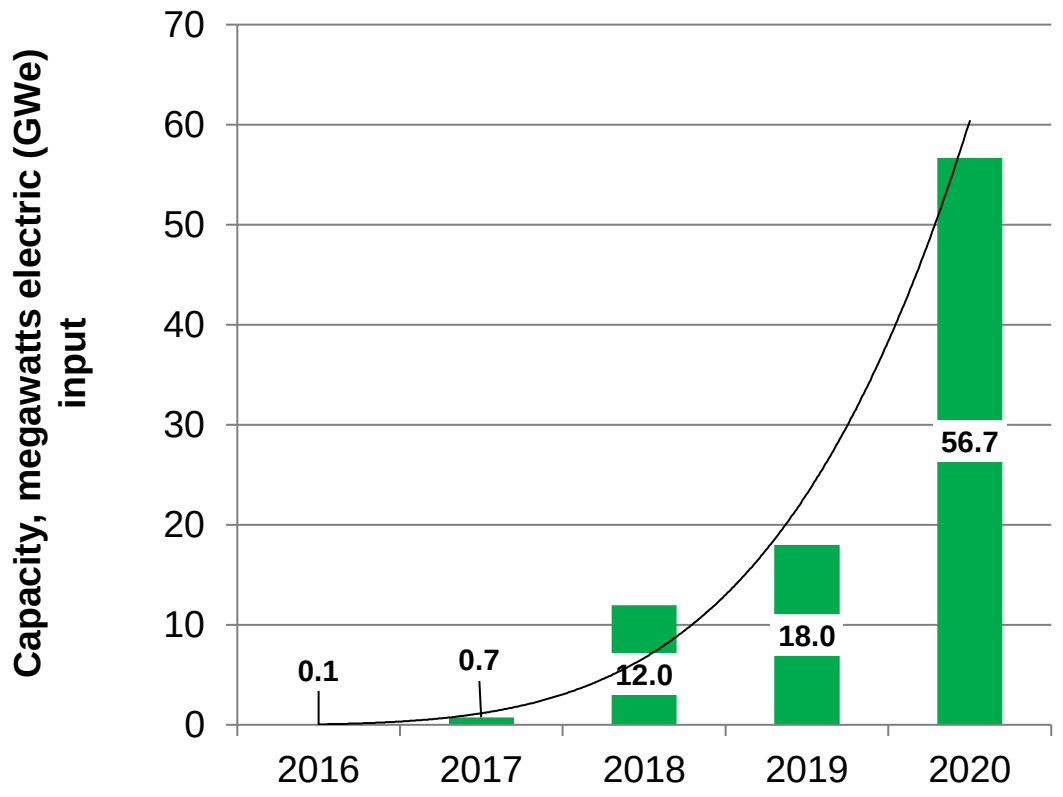


Notes: Rivalry 2019.
Source: IHS Markit

* Demand for hydrogen in refineries and chemical sector

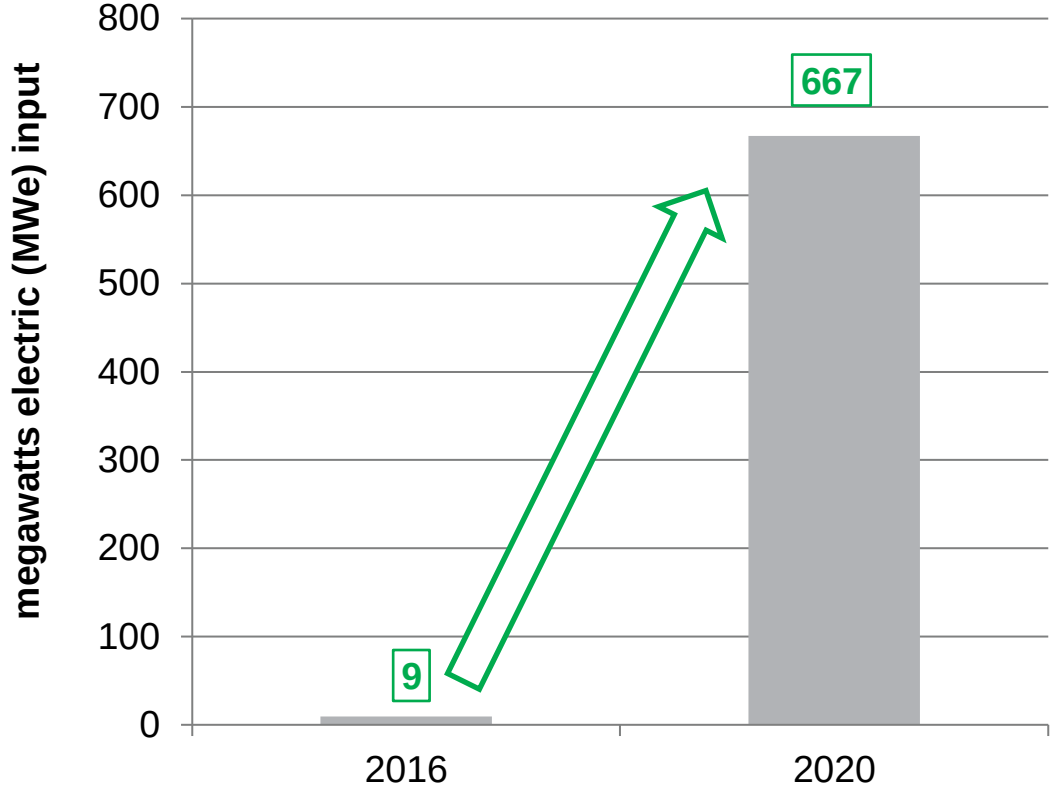
The global pipeline for Power-to-Hydrogen grew exponentially in 2020 and is now close to 60 GW. Size of planned projects moved from 11 MW to 600+ MW

Global evolution of the electrolysis pipeline (GW)



Source: IHS Markit

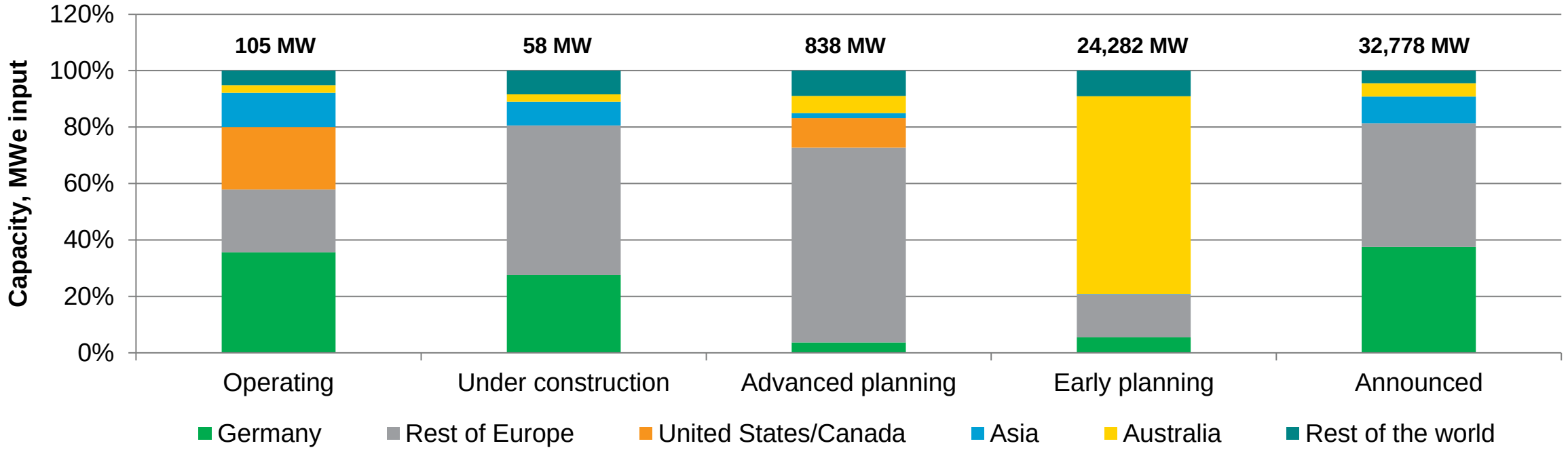
Average planned capacity in 2016 and 2020 (MWe)



Source: IHS Markit

Europe will continue to dominate short-term additions with ~70% of capacity in advanced stage of development and 20% of early-stage capacity

Power-to-X project pipeline by region and status* (as of January 2021)



Notes: *Project status definition: Advanced planning = projects that have completed the feasibility study and are moving forward with front-end engineering and design, applying for permits, issuing purchase orders for equipment, or taking a final investment decision; Early planning = projects with a feasibility study in progress; Announced = earliest-stage projects—projects announced with very limited information on the partners and stakeholders, the capacity of hydrogen production, the online date, etc. In many of these cases, details of the electrolysis capacity are not provided and are estimated from the renewable power capacity announced.

Source: IHS Markit

Low-carbon hydrogen is now at the heart of the long-term visions of many companies and governments. Investment expected to accelerate

- Hydrogen will be a major part of the future energy mix—20-50% of energy use in a net-zero carbon scenario
- Hydrogen is versatile through the full value chain—from production to end use. All parts of the energy system would be impacted by large-scale hydrogen development
- Momentum is increasing and policies are targeting barriers to hydrogen development—e.g. limited infrastructure, low demand, high costs
- Hydrogen produced by electrolysis dominates current announcements, but hydrogen from natural gas (with CCS) will play a major role in future supply
- The market model emerging for hydrogen is similar to natural gas—moving in time to an international traded market with large-scale, regulated infrastructure

IHS Markit Customer Care

CustomerCare@ihsmarkit.com
Americas: +1 800 IHS CARE (+1 800 447 2273)
Europe, Middle East, and Africa: +44 (0) 1344 328 300
Asia and the Pacific Rim: +604 291 3600