Hydrogen Forum: Europe

An IHS Markit initiative analysing the potential role of hydrogen in a net-zero carbon world

2019

Why a Forum on Hydrogen in Europe now?

- A ‘net zero-carbon world’ has been the announced objective of the revised 2050 energy roadmap that the European Commission released in 2018. If the European Union agrees to adopt this target, then by mid-century it implies there will be no role for the combustion of unabated natural gas in EU countries

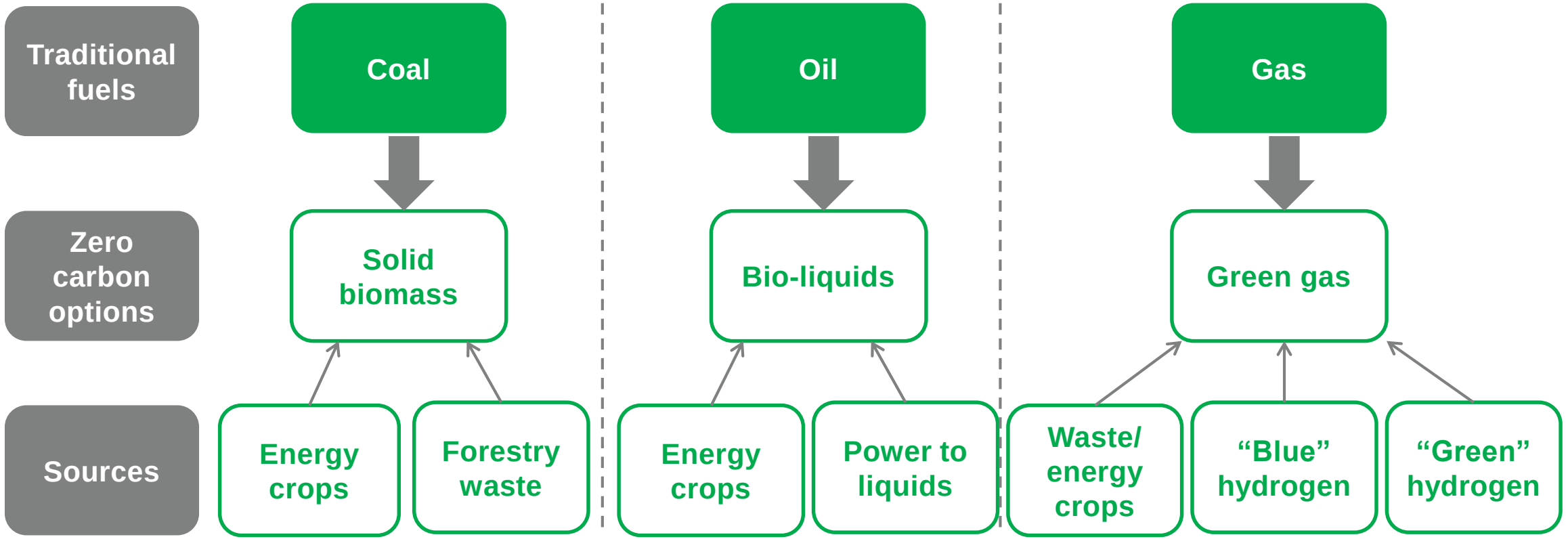
- Hydrogen is one option that is receiving increased attention. Hydrogen and other green gases can both address the short-term need for rapid greenhouse gas abatement and can provide a long-term solution to the difficulties of storing large volumes of energy over long periods of time. Hydrogen can be used in all energy sectors—for power generation, heat, industrial uses and transport

- Energy suppliers, gas infrastructure companies, consumers and government have all started exploring the advantages of hydrogen. Public awareness and policy measures to encourage the development of hydrogen could allow for transformation of the energy industry by using the substantial gas infrastructure already in place while meeting long-term zero carbon targets

- If conditions are right for widely adopting hydrogen, it can provide a transformational opportunity for the European energy transition and for the established European gas industry.

Why hydrogen? Provides one of many fuel options for a zero-carbon future

Storable energy: From high to zero carbon options



Note: "Blue" hydrogen is hydrogen created from steam reforming of natural gas combined with CCS. "Green" hydrogen is from electrolysis with the electricity provided by renewable sources

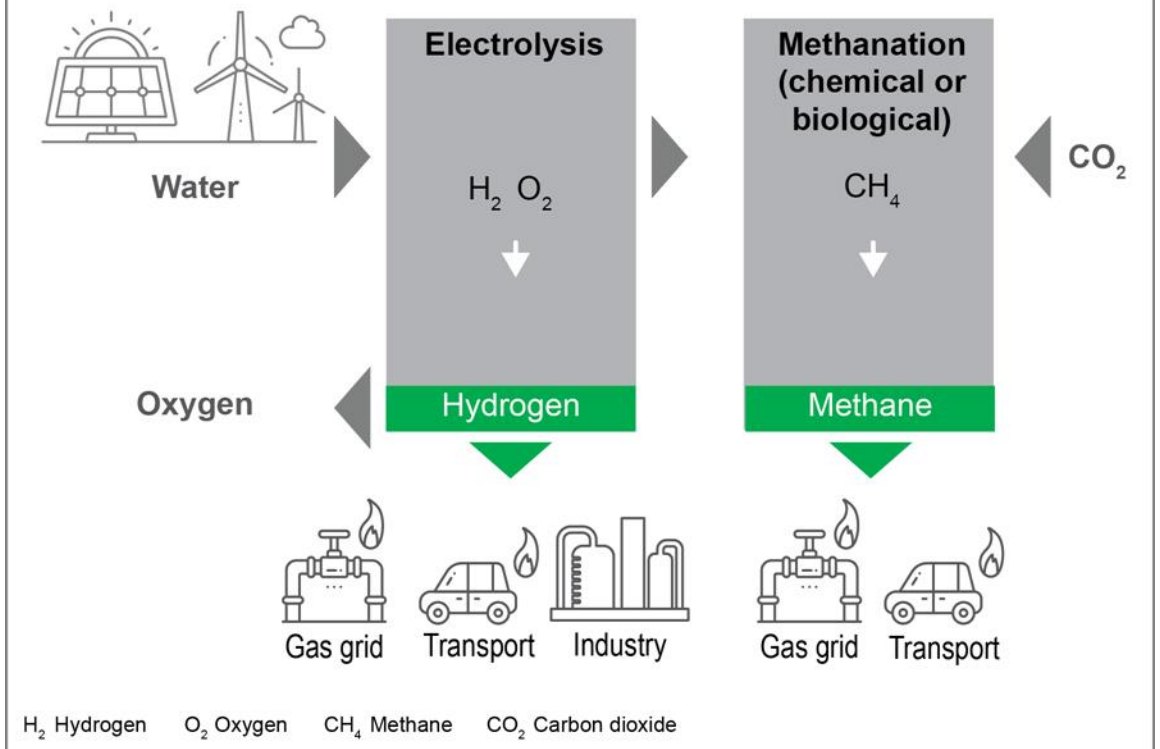
Source: IHS Markit

Gas grid owners and operators are looking at ways to decarbonize gas and ensure the future of their assets

- Gas is a low carbon fuel, but not low enough for 80-95% decarbonization by 2050
- Grid operators are turning to green gas as a possible replacement for natural gas beyond 2030 —so far biogas mostly used for small-scale combined heat and power (CHP)
- Biogas and biomethane are constrained by feedstock availability
- Power to hydrogen, or power to gas, may become a much more important source of green gas
- Clean gas from steam reforming of natural gas plus carbon capture and storage could work synergistically with green gas
- A choice may be needed between blending gases in the grid or converting parts of grid to hydrogen

Hydrogen from power to gas or steam methane reforming plus CCS
Stores electricity and decarbonizes the gas grid

Power to hydrogen and power to gas

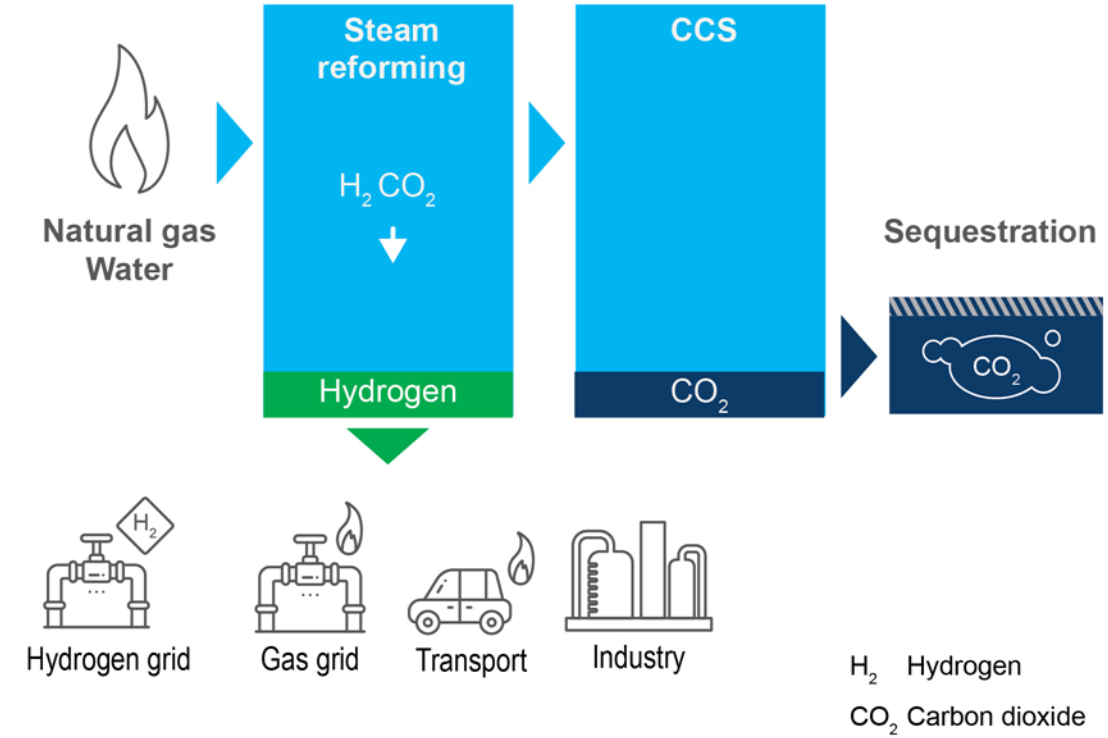


H_2 Hydrogen O_2 Oxygen CH_4 Methane CO_2 Carbon dioxide

Note: CHP - combined heat and power

Source: IHS Markit

Steam reforming of natural gas plus CCS

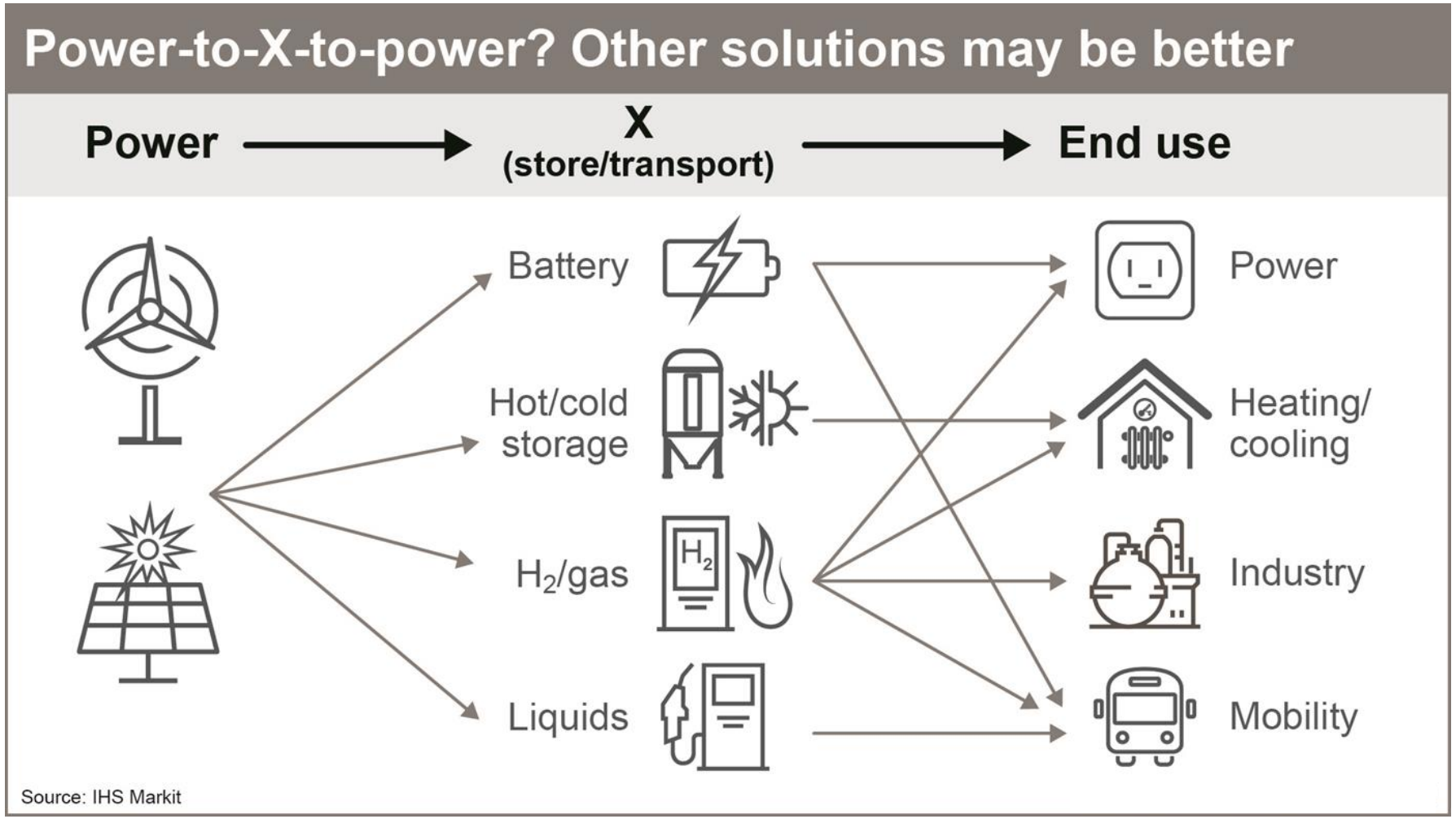


H_2 Hydrogen

CO_2 Carbon dioxide

Source: IHS Markit

Power-to-X-to-power? Other solutions may be better



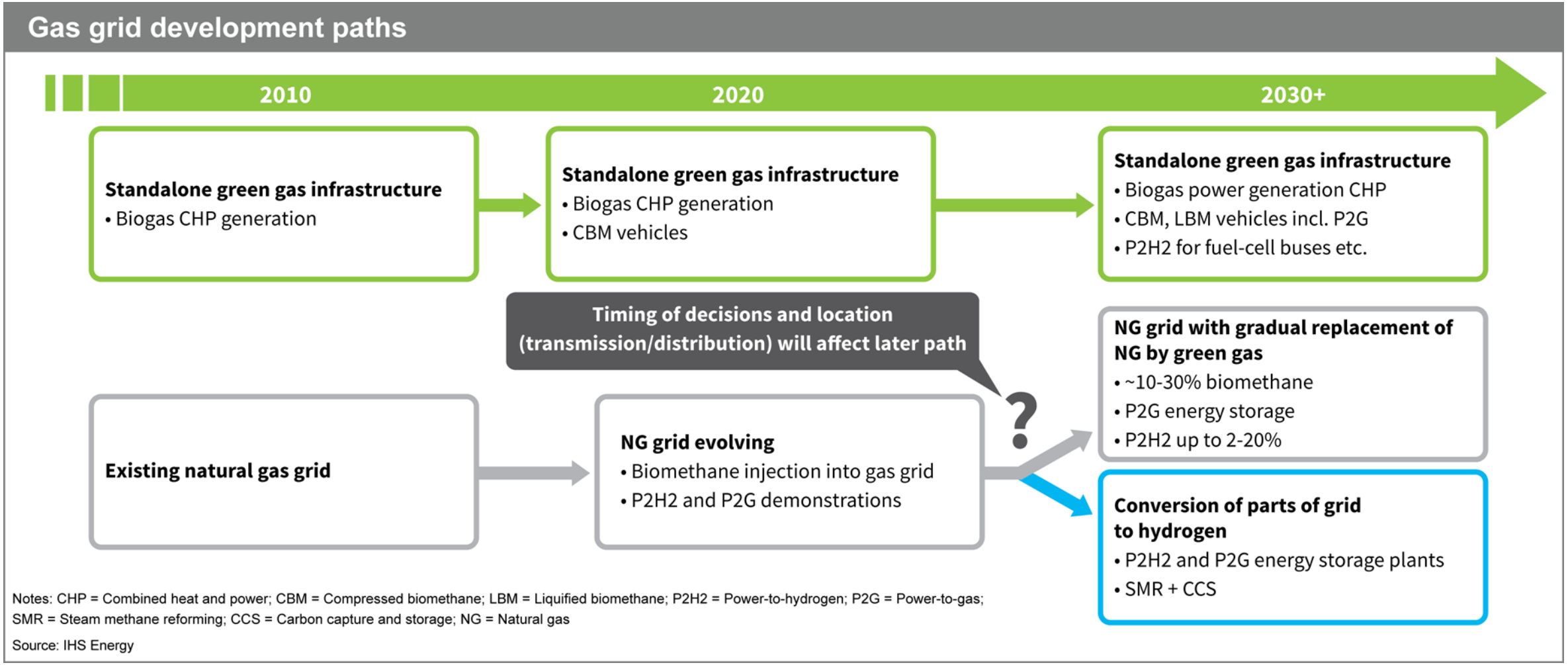
Power to X to power is in direct competition with batteries

Power to heat requires a heat sink

Power to gas could replace natural gas in industry—need is often for hydrogen

Power to liquids and power to gas competes with gasoline or diesel

As Europe seeks to decarbonize gas, a decision between a methane/hydrogen mix and hydrogen-only may be needed for the gas grid

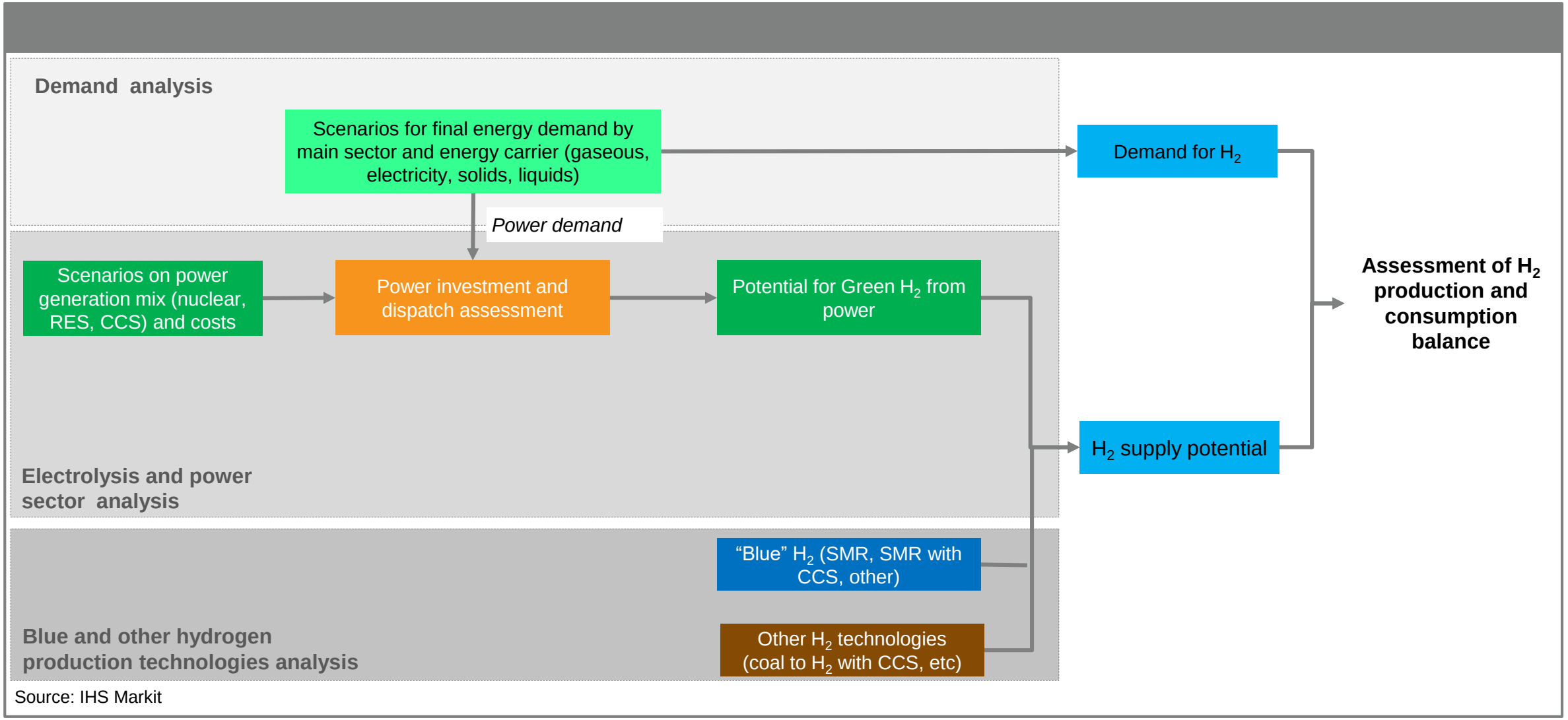


IHS Markit Study—Hydrogen: The Missing Piece of the Zero Carbon Puzzle?

Topics Quantified

- Comparison of costs of producing low-carbon hydrogen
- Power to hydrogen from curtailed electricity—amount available to 2050
- The role of low-carbon hydrogen in space and water heating
- The tipping points for the use of hydrogen in heavy transport
- Defining the plausible demand for low-carbon hydrogen in Europe
- Matching low-carbon hydrogen production to demand
- Implications for hydrogen deployment in different segments of the energy business

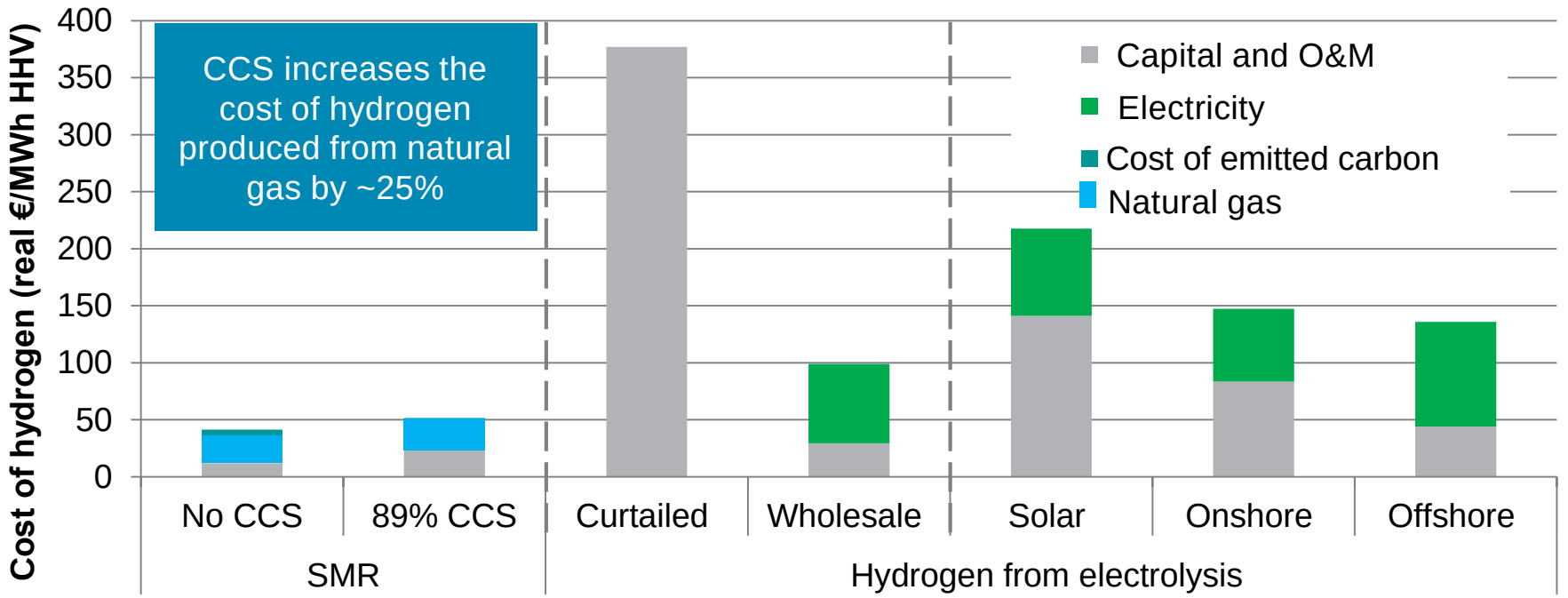
Overall Quantitative Approach



Source: IHS Markit

Currently H_2 produced from natural gas is significantly lower cost than H_2 from electricity…but electrolyser costs may fall rapidly

Levelized cost of hydrogen (Current, at the boundary of the production facility / Germany)



Notes: Hydrogen price at the boundary of the production facility. Natural gas price = €20/MWh, Carbon = €20/tonne, Curtailed = 5% (utilisation) / €0MWh, Wholesale = 95% / €50/MWh Solar: 15% / €55/MWh, Onshore wind: 25% / €46/MWh, Offshore wind: 54% / €66/MWh. Excludes electricity grid charges and taxes and levies

Source: IHS Markit

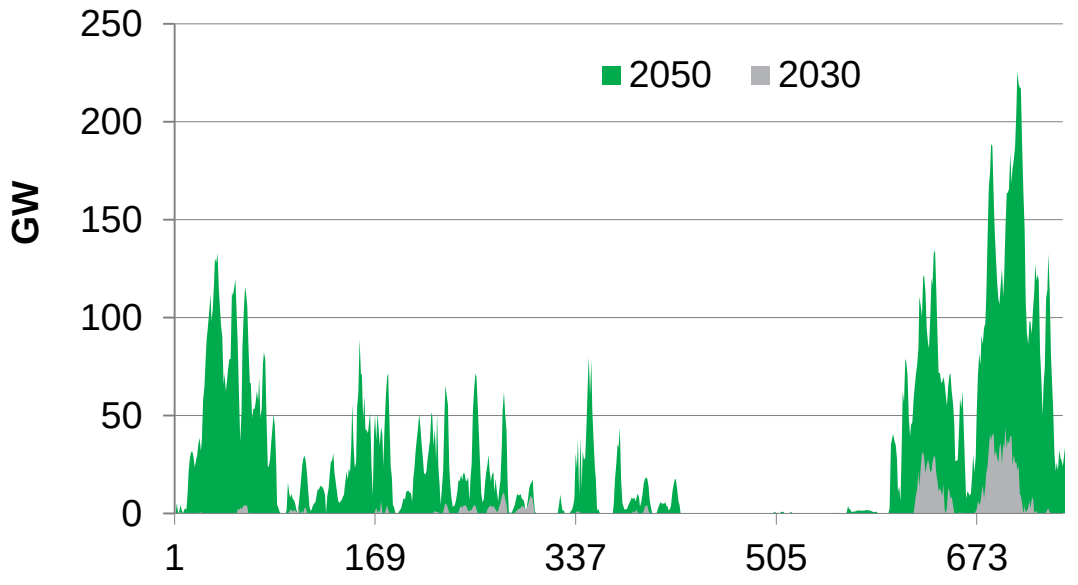
Carbon emissions per kWh of hydrogen

Fuel/ technology	kg CO_2 per kWh(HHV) of natural gas/H_2
Natural gas	0.18
SMR with no CCS	0.23
SMR with 89% CCS	0.03
Grid electricity (Germany 2020)	0.52

Source: IHS Markit

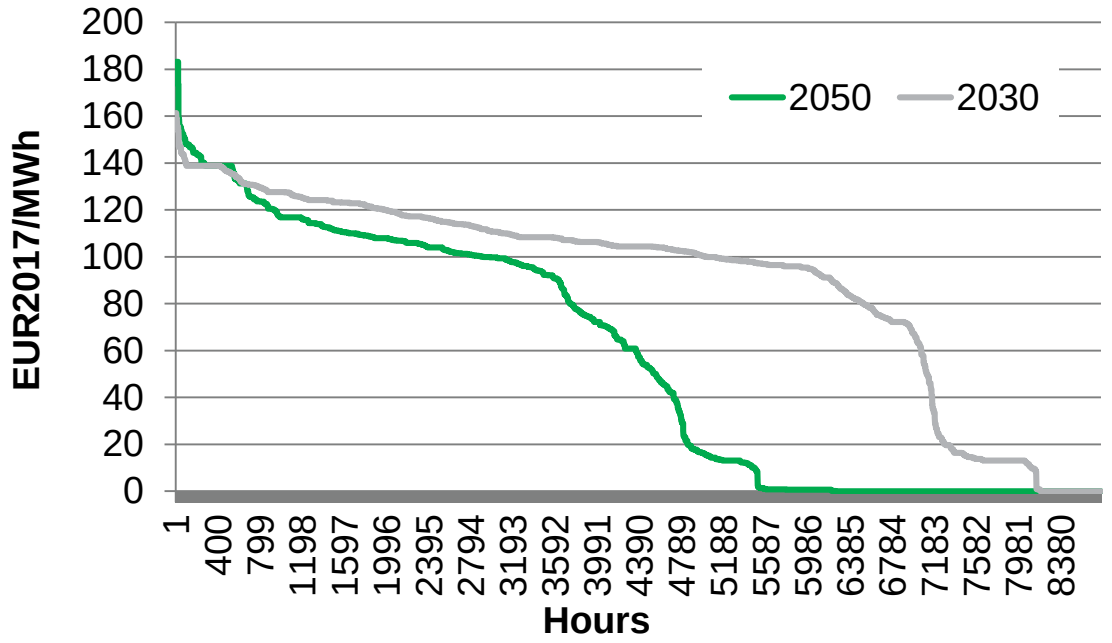
Increasing renewable penetration will lead to a rise in curtailment.
Power-to-X can capture this unused energy

Hourly economic curtailment over the month of January in 2030 and in 2050 (EU)



Notes: Does not include local curtailment resulting from transmission or distribution constraints
Source: IHS Markit

Price duration curve—Germany



Note: this chart assumes that all thermal plants have been converted to H_2 assuming a H_2 price of EUR50/MWh HHV.
Source: IHS Markit

In 2050, the share of zero-price hours will range from 1 percent to 37 percent across Europe, reflecting different power generation mixes, but also varying levels of interconnection

Zero-price hours' as potential power supply for P2H$_2$: modelled here for 2030 and 2050

Structure of the Hydrogen Forum

Deliverables and scope of work can evolve based on participants feedback

- Two meetings during the year -- June and end October/November 2019

- Location: a 'hydrogen-interesting' location.
  - Suggested first meeting: **June 12-13, 2019 Marseille, France, June 12th visit of Jupiter 1000**
  - Second meeting: to be determined

- A two-day session for each meeting – the first day will include a tour of a hydrogen facility followed by dinner, the second day is a workshop day with a presentation and discussion of analysis on specific topics.

- For the first session – suggested topics for analysis:

  - **Supply**:
    - Comparison of a broader set of hydrogen production options from biomass/waste; a further review of costs
    - Compare costs of hydrogen production with biomethane and synthetic gas
  - **Infrastructure**:
    - Comparison of the costs of transporting hydrogen compared with electricity and natural gas
    - What is the tradeoff for infrastructure between synthetic methane and hydrogen?
  - **Expanded tipping points:**
    - Compare the costs of biomethane and synthetic gas with hydrogen in transport and space heating

Client suggestions for topics

Hydrogen Supply Options

- Use of biomass to produce hydrogen
- Thermal methane pyrolysis or “Gas splitting” – Breaking methane molecule into hydrogen and solid carbon
- Conversion of hydrogen to methane by recycling CO_2 from the air
- Hydrogen plus a carbon source converted to liquid fuels for the transport sector e.g. methanol, biodiesel, ammonia (as a transport fuel)
- Import of hydrogen produced from renewable sources outside Europe in liquid form: liquefied hydrogen or ammonia
- Refineries could produce hydrogen by electrolysis instead of using SMRs

Transmission/Distribution

- Cost and technical limitations of converting grid to hydrogen vs blending hydrogen with natural gas

Hydrogen Demand

- Opportunities in micro CHP
- Use in district heating
- Analysis of the light duty vehicle sector
- Comparison of the use of biomethane with hydrogen in all end-use sectors
- Altering the overall power generation mix—does using hydrogen imply a different power mix? e.g less renewable capacity required because hydrogen provides a storage option
- What is the route to market in the different sectors – is there a different risk profile?

Regular Tracking of Policies and Events

- Quarterly newsletter on hydrogen
- Review of policies on hydrogen in each of the countries in Europe and a global overview

Implications for different segments of the business

Key Questions for Upstream Oil and Gas Companies:

- Can blue hydrogen offer a long term future for natural gas via steam reforming plus CCS?
- Will the costs of blue hydrogen be lower than green hydrogen from renewable electricity?
- Will there be opportunities in international trade in hydrogen?

Key Questions for Electric Utilities:

- What is the role of hydrogen storage in integrating intermittent renewable power?
- Is large scale hydrogen power feasible?
- Can hydrogen electrolysers offer ancillary services?

Key Questions for Financial Institutions:

- How will projects be financed?
- Will there be policy support for hydrogen?

Key Questions for mobility sector:

- Could hydrogen be a major means to decarbonise trucks, buses, cars?
- What refueling infrastructure would be needed?

Key Questions for Industrial End-users:

- Can green/blue hydrogen replace conventional sources of process hydrogen?
- Can fossil fuel heat sources be replaced by hydrogen?

Key Questions for Gas Distributors:

- How much hydrogen can the gas grid accommodate?
- Is a mix of methane/hydrogen or partial conversion to hydrogen-only optimal?
- What heating technologies/appliances are most suitable for use with hydrogen

The H_2 Study Team

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