

Hydrogen as a commodity

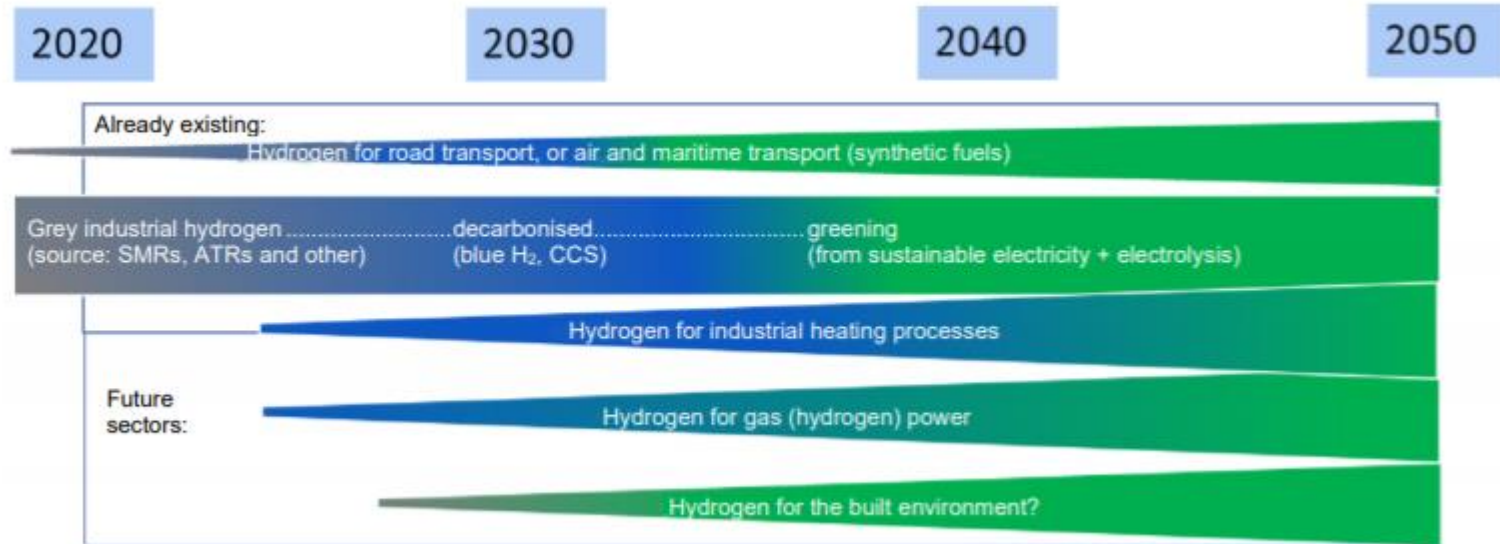
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Current market and future potential

- ❑ Demand mainly from **industry** (strongly linked to production per industrial cluster – at present limited market or trade in hydrogen)
 - › Hydrogen can be used as a fuel for heat processes
- ❑ The hydrogen-fired **power plants** will be promising in scenarios of important peak supply and back-up in the electricity supply
- ❑ Small market for **road transport**
 - › Hydrogen may be important in shipping, in the form of ammonia
- ❑ Parties considering hydrogen in the **heating and power** for buildings (biogas, natural gas/coal with Carbon Capture and Storage - CCS)
 - › solutions where most of the heat demand is covered by hybrid electrification, and green gas and/or hydrogen still covering a small part (mainly the peaks)

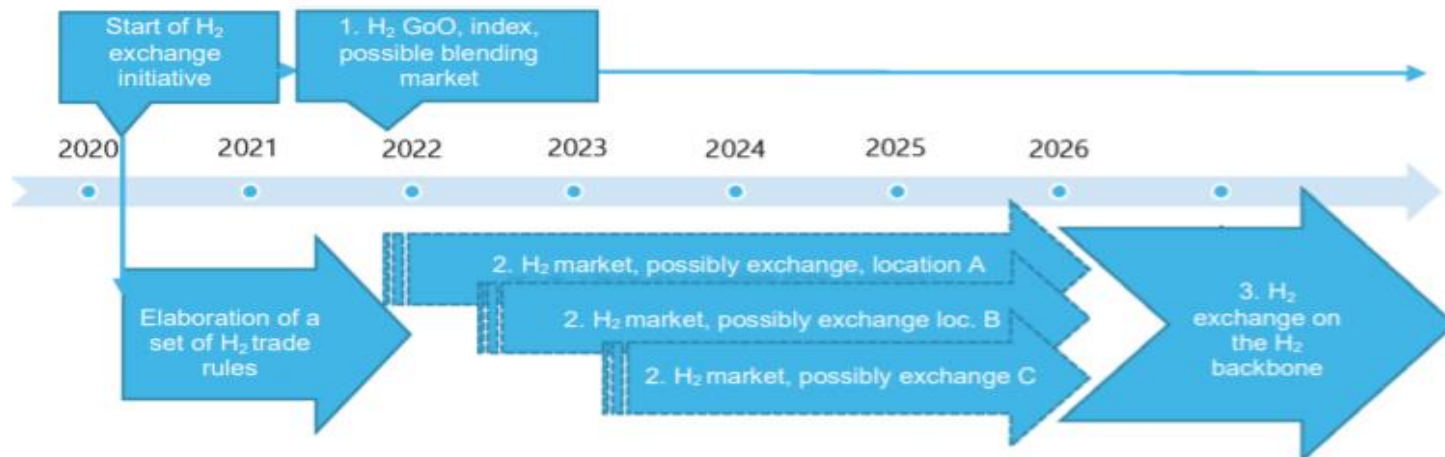
Current market and future potential



- ❑ The global market size of the hydrogen generation market is USD 130 billion in 2020.
- ❑ McKinsey and the Hydrogen Council estimate a globally-traded hydrogen market could be worth USD 2.5 trillion by 2050, including the sale of hydrogen as a commodity and related equipment.

Hydrogen Trading – Current Progress in Europe

- ❑ Hydrogen trading largely based on bilateral deals
 - › Opaque pricing landscape
- ❑ Hydrogen GOs: CertifHy - Europe's first registry
- ❑ Multiple discussions & strategies on developing organized markets
- ❑ Dutch government study (09/20) on creating a hydrogen exchange market by 2027.
 - › It takes time (approx. 6 - 10 years) to realize the necessary hydrogen infrastructure and also to bring the climate-neutral hydrogen production up to the required level

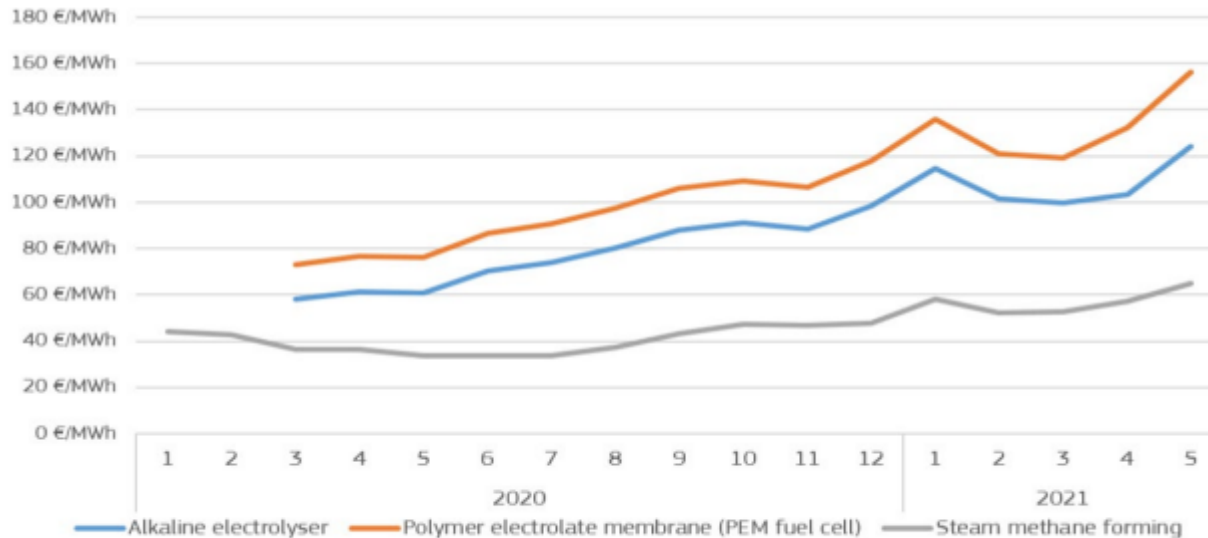


Hydrogen – The case for an organized market

Organized market

- › Economies of scale
- › Transparency
- › Regulation

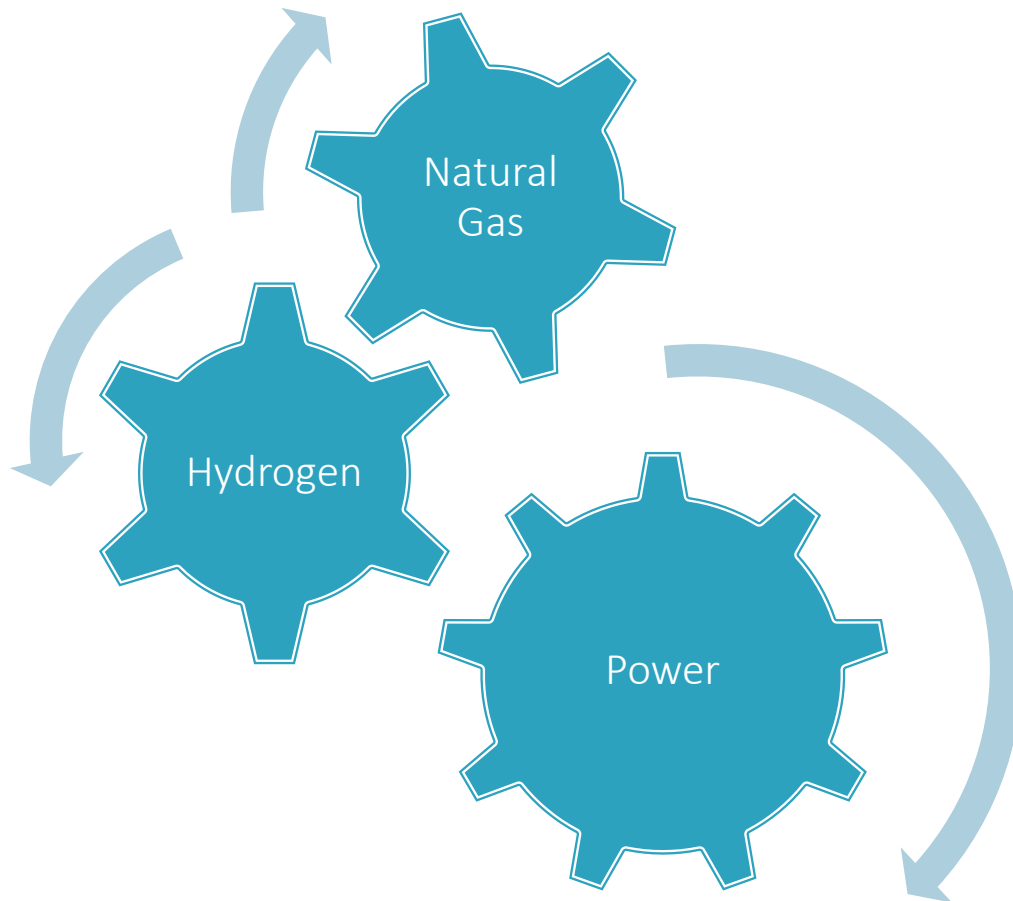
- ❑ Alkaline electrolysis and Polymer Electrolyte Membrane (PEM) technology costs predominantly depend on electricity price
 - › Related to green power (assessment based on green power costs, adding EU wind guarantee of origin prices to wholesale electricity prices)
- ❑ SMR technology cost is driven by the cost of natural gas used for producing hydrogen (by adding CCS costs)



Production cost-based hydrogen price assessments for different technologies (including CAPEX)

Source: S&P Platts. The calculated prices reflect both the commodity production cost and the capital expenditure associated with building a hydrogen facility.

Positioning the Hydrogen Market



- ❑ Time granularity
 - › Power (~Hourly or less)
 - › Hydrogen
 - › Gas (~Daily or less)
- ❑ Natural Gas - Power connection
 - › NG fired Power Plants
 - › ~2/3 of Gas demand
 - › ~1/2 Power production
- ❑ Hydrogen - Power connection
 - › Electrolysis
 - › RES installations
- ❑ Hydrogen – NG connection
 - › Infrastructure
 - › Substitution

Building an Organized Hydrogen Market

❑ Building organized markets is challenging

- › Supply
- › Demand
- › Infrastructure
- › Policy
- › Regulation
- › Liquidity



Building an Organized Hydrogen Market

❑ Supply

- › Technological advancements
- › Cost Reduction
- › Diversity / Multiple suppliers
- › Connectivity

❑ Demand

- › Applications
- › Penetration
- › Multiple providers
- › Connectivity

- › (Standardisation)



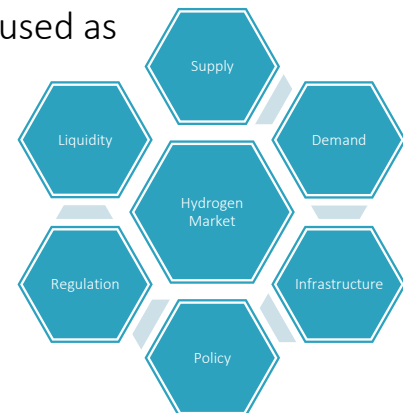
Building an Organized Hydrogen Market

□ Policy

- › Incentives for investments
- › Support for research
- › Awareness
- › Initiatives for change
- › National & Supranational policy creation

□ Regulation

- › Clear and firm
- › Harmonized (EU)
- › Consensus required
- › Takes some time to develop
- › NG regulation could be used as a guide



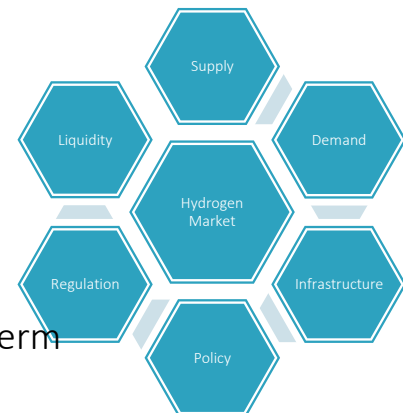
Building an Organized Hydrogen Market

❑ Infrastructure

- › Physical Trading Point or Hub
- › Non-discriminatory access & usage
 - › hydrogen grid
 - › natural gas grid in case of blending
- › European hydrogen network
 - › planning and development
 - › cross border interconnections
- › Harmonized standards and metrics

❑ Organized market

- › Multilateral Trading platforms
- › Sufficient connected production & demand
- › Standardized products
 - › Spot & Derivatives
- › Separate Trading of Guarantees of Origin
- › Liquidity
 - › Not a majority of long-term bilateral contracts



Jump-starting the Hydrogen Market

- ❑ What if we had a Hydrogen mega-project?
 - ❑ Jump-starts supply / Creates economies of scale
 - ❑ Induces demand
 - ❑ Comes with a major change in infrastructure
 - ❑ Speeds up regulation / Facilitates further policy creation
- ❑ However, a holistic approach is required
 - ❑ Actual liquidity does not come easily
 - ❑ Impact to connected markets needs to be extensively analyzed
 - ❑ Cross-market synergies need to be investigated in detail
 - ❑ Fit for purpose approaches and products are required
 - ❑ Follow-up needs to be investigated

Thank you for your attention!

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