The role of hydrogen for the future energy system

Decarbonising energy systems in Southeast Asia

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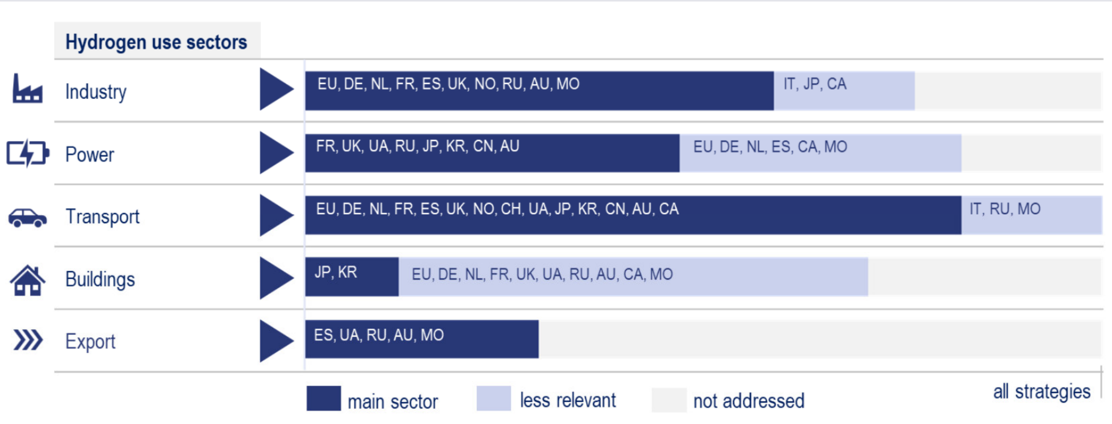
ONLINE ROUND TABLE, 29 OCTOBER 2020

Hydrogen is critical for reaching climate-neutrality as it is needed for decarbonizing hard-to-abate sectors.

Hydrogen target sectors in international hydrogen strategies



WEC (2020): International hydrogen strategies. https://www.weltenergierat.de/wp-content/uploads/2020/10/WEC_H2_Strategies_finalreport.pdf

- **Climate-neutrality** („net zero") goes beyond -80% to -95% GHG emissions
- It encompasses the entire economy including so-called „**hard-to-abate sectors**" for which direct electrification with renewables like wind and solar PV is difficult and molecules may be needed.
- **Industry**: Steel, chemicals, cement
- **Transport**: Aviation, maritime shipping, heavy road transport
- **Power sector**: long-term storage
- **International hydrogen strategies** identify transport, industry and power. (controversy on passenger cars, building heat due to direct electrification potential)

Hard-to-abate sectors need hydrogen's chemical properties, its energy density or storability.

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Electrofuels with and without carbon

E-fuels	Without carbon	Containing carbon
Gaseous	Hydrogen gas (H_2)	Methane (CH_4)
Liquids	Ammonia (NH_3)*	Alcohols (C_xH_yOH) Hydrocarbons (C_xH_y)

**NH_3 is gaseous at normal temperature and pressure but easily handled as a liquid* (*)

Philibert, IEA (2018)

- → The **basic molecule** is hydrogen (**H_2**).
- → Others can be derived from it: ammonia, methane, methanol etc.
- → Including **carbon** molecules raises the question of a sustainable carbon source in the long run
- → Common **expressions**: electrofuels, Power-to-X, synfuels, powerfuels
- → **Similarity in discussion**: Biomass also comes in molecules; scarcity of sustainable biomass globally (iLUC)

The EU hydrogen strategy aims at 40 GW installed electrolysis capacity in the EU by 2030, i.e. 10 Mt H_2 p.a. (333 TWh, LHV), but legislation for actual policy instruments is still lacking.

Hydrogen generation technologies addressed in EU Hydrogen Strategy

Terminology	Renewable/ clean H2	Fossil-based H_2	Fossil-based H_2 with carbon capture / low-carbon H_2	
Source	Wind, solar, hydropower, …	Natural gas, oil, coal	Natural gas	
Process	Electrolysis	Steam reforming (e.g.)	Steam reforming with CCS	Methane pyrolysis (w/o CCS)
Industry jargon	Green	Grey	Blue	Turquoise
Direct GHG emissions	Zero	High	Low, but not zero	(Solid carbon)
Upstream GHG emissions	Depending on carbon intensity	Methane leakage issues		
Cost of production / need for support	High	Low	Medium	Medium-High

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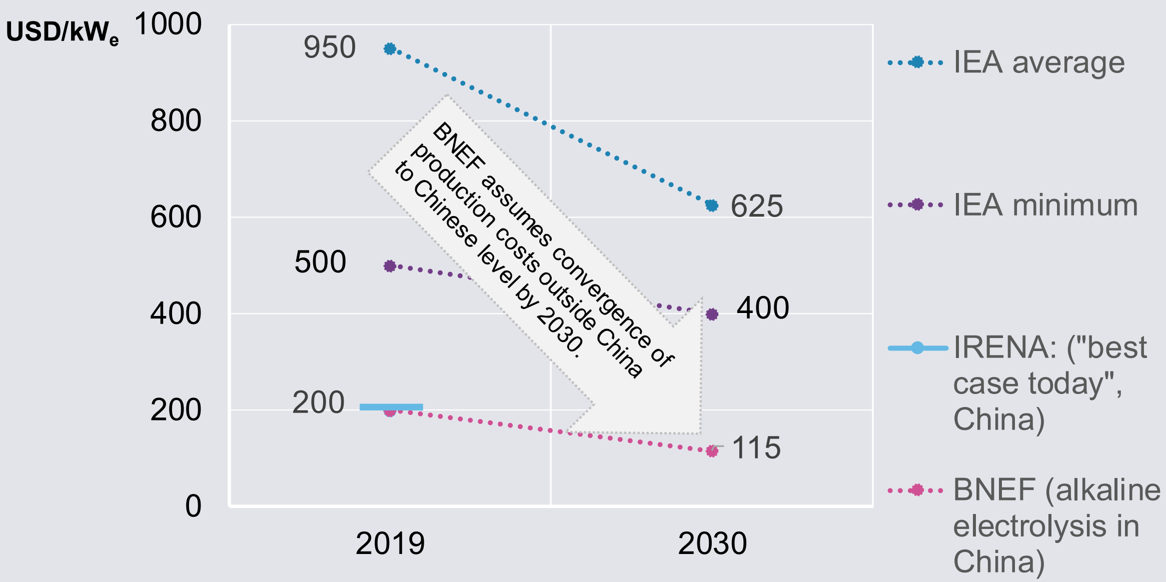
- **EU focus**: Renewable H_2 is priority, low-carbon fossil H_2 with carbon capture will also play role in short/medium term
- **Target sectors:**
  Transport: aviation, shipping, buses and train lines, heavy-duty road vehicles
  Industry: refineries, ammonia and methanol, second phase: steel
- **Several policy instruments** are suggested for covering cost gap of renewable and low-carbon hydrogen
- **Investment needs**:
  220-340 billion EUR for 50-75 GW solar and wind, 24-42 billion EUR for electrolysers

Global competition may bring down the investment cost of electrolysers earlier than conventionally assumed.

CAPEX of alkaline electrolysers 2019 and projection for 2030



https://www.agora-energiewende.de/fileadmin2/Blog/2019/Electrolysis_manufacturing_Europe/2019-11-08_Background_paper_Hydrogen_cost.pdf

- **China is leading** in CAPEX of alkaline electrolysers with 200 USD/kW
- Standard CAPEX assumptions for OECD are much higher.
- Reaching this CAPEX level would lower renewable hydrogen cost considerably.
- Reach cost reduction through "a combination of increased scale, automation and moving production to countries with cheaper workers" (BNEF).
- **Open issues**: Reliability and quality of Chinese low-cost electrolysers

Drivers, inhibitors and risks

Drivers:

→ **Vested interests**: oil and gas industry, manufacturers of internal comb. engine cars, boilers, pipeline operators

→ **New**: hard to abate sectors like steel, chemicals

Inhibitors:

→ **Missing policies**: Strong need for high carbon price or policy support to make renewable H_2 competitive

→ **Sustainability considerations** – when does renewable hydrogen qualify as sufficiently renewable? (EU Renewable Energy Directive), additionality of renewables, guarantees of origins, (see https://ptx-hub.org/)

Risks:

→ The **main pillars** of the energy transition will be energy efficiency, renewable energy and direct electrification. (H_2 share in EU decarbonization scenarios: 10% to 23% in final energy consumption 2050 [see appendix])

→ The agreed long-run solution renewable hydrogen will need a **lot of renewable electricity** – which is not there yet. Possible **H_2 export** countries need to decarbonize themselves, too.

→ Producing hydrogen from electricity is associated with considerable **conversion losses** (see appendix).

Summary

→ Hydrogen and derivatives are important for decarbonizing **hard-to-abate** sectors.

→ **EU's 2030 target**: 40 GW of installed electrolysis capacity for renewable hydrogen production

→ **Renewable hydrogen** is **still expensive** today compared to fossil hydrogen in the absence of high carbon pricing. Global competition in electrolysers may contribute to faster cost reduction.

→ Not enough **additional renewable electricity** for producing a lot of renewable hydrogen yet. Some countries will need to **import** it**,** such as Germany. Given its scarcity, there will be **competition** for renewable hydrogen between sectors and applications in the short to medium term.

→ **Policy support** is needed to bridge cost gap between renewable hydrogen and conventional technologies and to drive down the learning curve of electrolysis.

→ Current EU discussions are dominated by **sector-specific instruments,** such as Carbon Contracts-for-Difference for steel, or quota obligations for aviation or maritime shipping.

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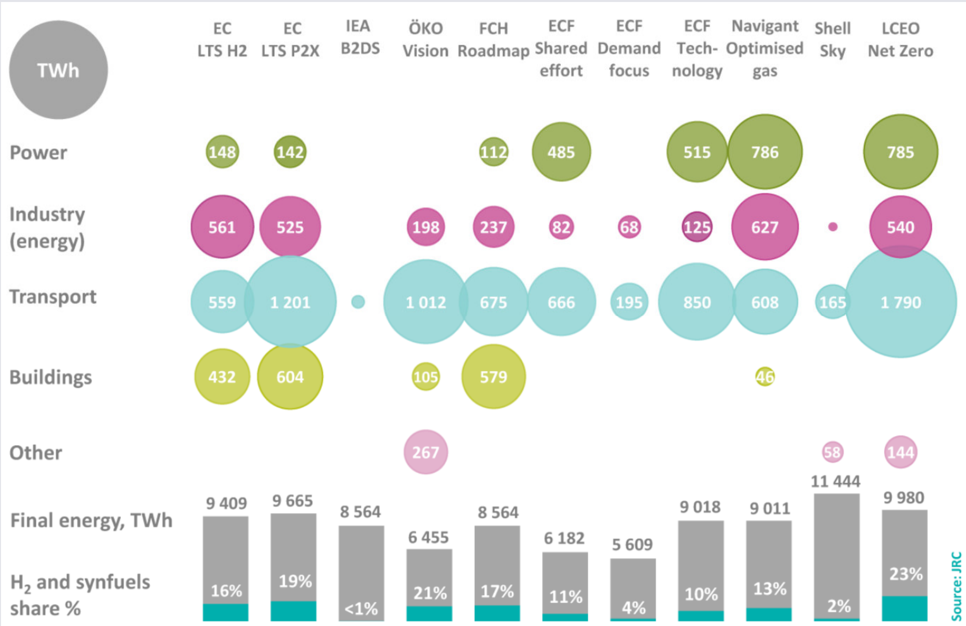
Backup

Consumption of hydrogen and share in final energy in EU decarbonisation scenarios in 2050

Consumption of H_2 for energy use (without H_2 for non-energy use)



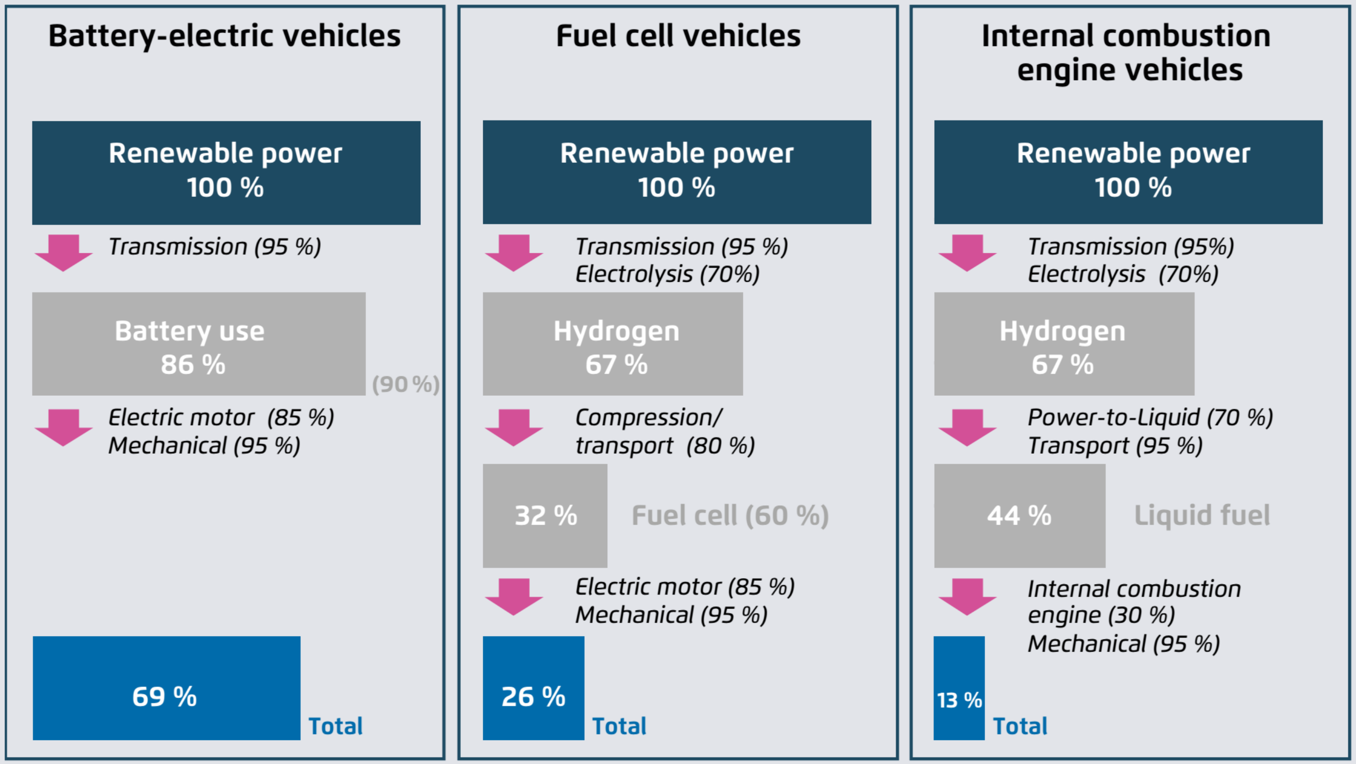
https://ec.europa.eu/jrc/sites/jrcsh/files/final_insights_into_hydrogen_use_public_version.pdf

EU Joint Research Center (2019):

→ "Decarbonisation kicks off new uses of hydrogen, especially in sectors where it is hard to decrease CO2. In most scenarios, hydrogen and derived fuels add up to **between 10% and 23% of the 2050 EU final energy consumption."**

For passenger cars, battery-driven electric vehicles are the energy efficiency benchmarks.

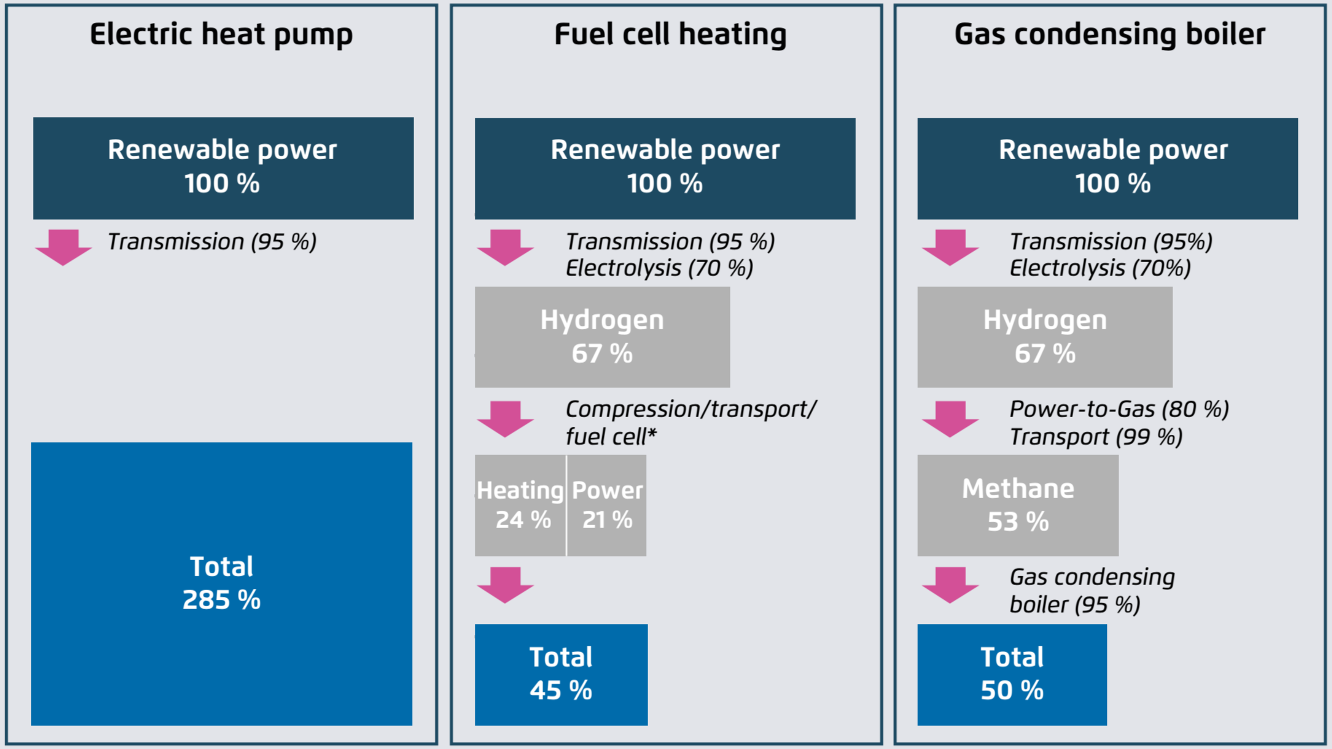
Individual and overall efficiencies for cars with different vehicle drive technologies



- → To travel the same distance, a **combustion-engine vehicle** would need about **five times** as much renewable electricity as a battery-driven vehicle.
- → A **fuel cell vehicle** needs about **two and a half times** as much electricity

Heat pumps have a particular leverage and use renewable electricity especially efficiently.

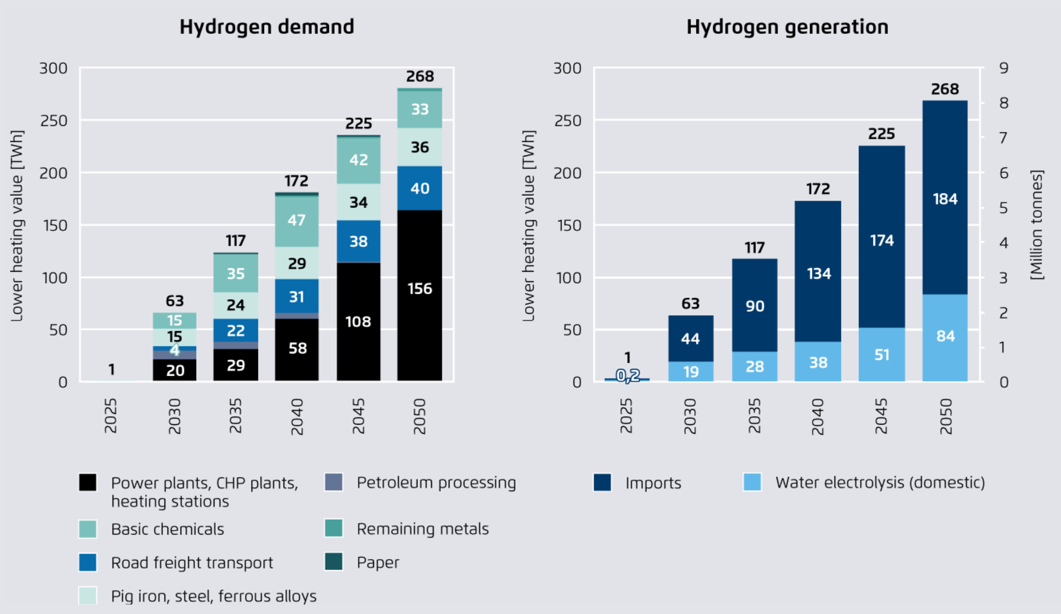
Individual and overall efficiencies for different building heating systems



- → **Boilers with renewable hydrogen** (instead of fuel cells) yield a total efficiency of about 50 to 60 %.
- → The electric **heat pump** withdraws more energy from the environment (air, soil or water) than required in terms of operational power, which is why it can have an efficiency rating over 100%. It can also be used for cooling.

Germany will need to import about 180 TWh CO_2-free hydrogen in a climate-neutral Germany 2050.

CO_2-free hydrogen generation and use in Germany in the „Climate-Neutral 2050“ scenario



https://www.agora-energiewende.de/en/publications/towards-a-climate-neutral-germany-executive-summary/