Future of Hydrogen

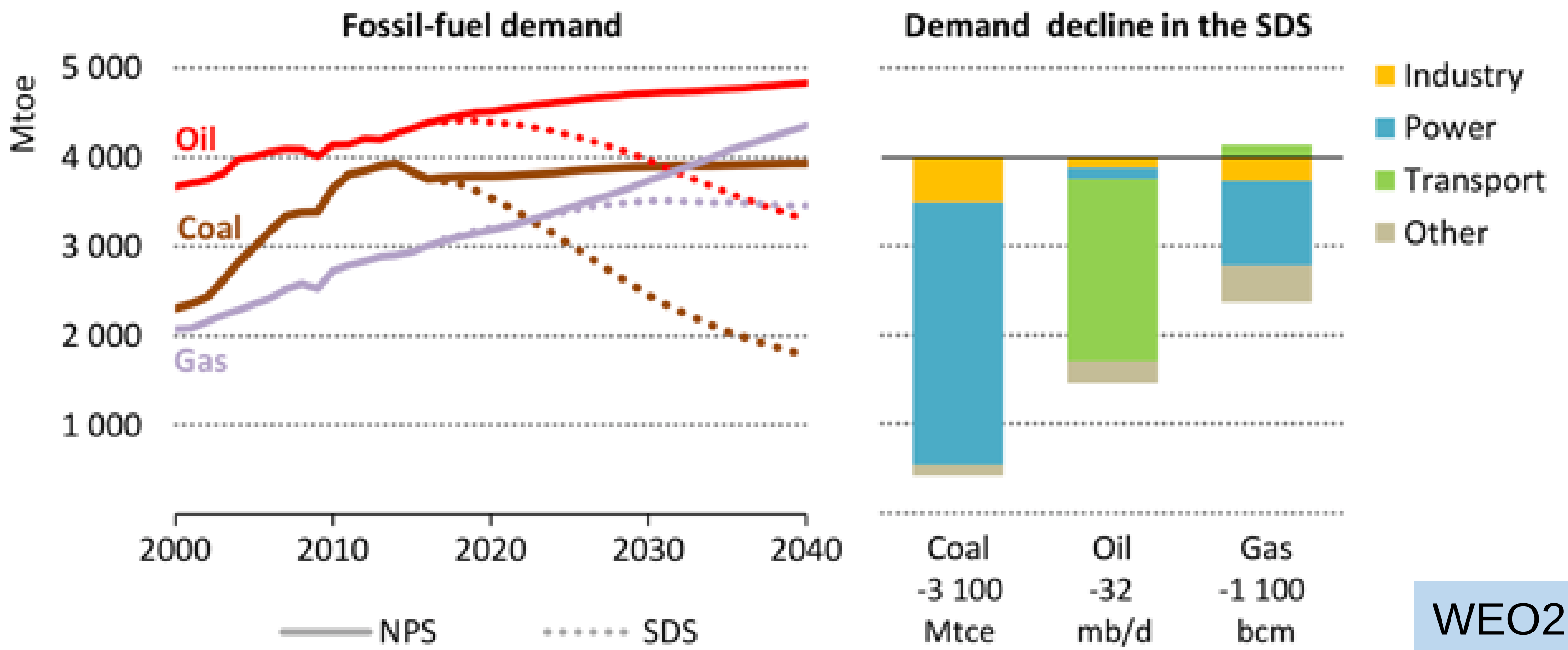
Chairman, the Sasakawa Peace Foundation

Former Executive-Director, International Energy Agency (IEA)

Nobuo TANAKA

Saudi Aramco is worrying about Peak Demand of Oil happening much earlier than expected Development Scenario

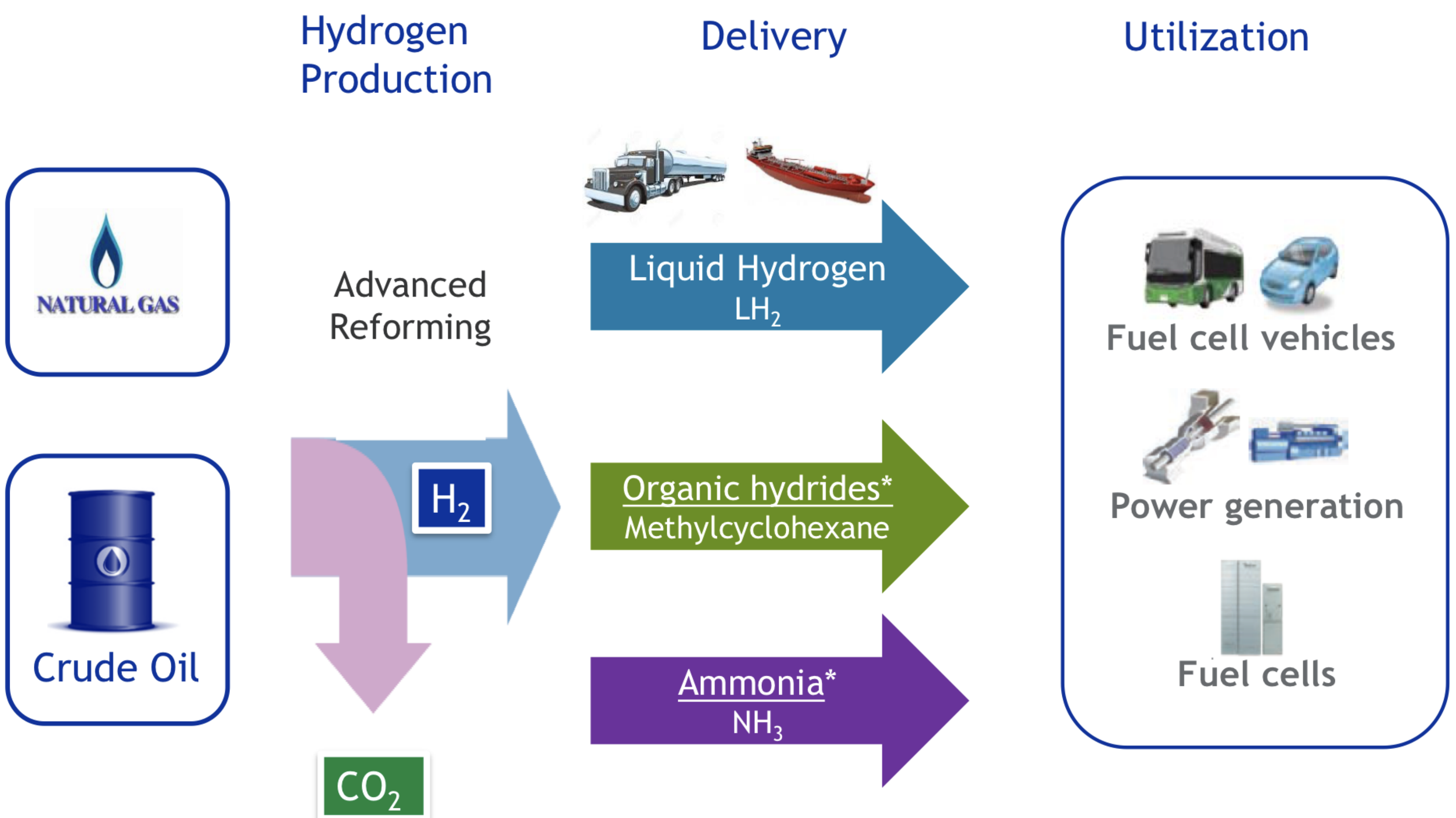
Figure 3.18 ▷ Fossil-fuel demand by scenario and decline by sector in the Sustainable Development Scenario relative to the New Policies Scenario, 2040



WEO2017

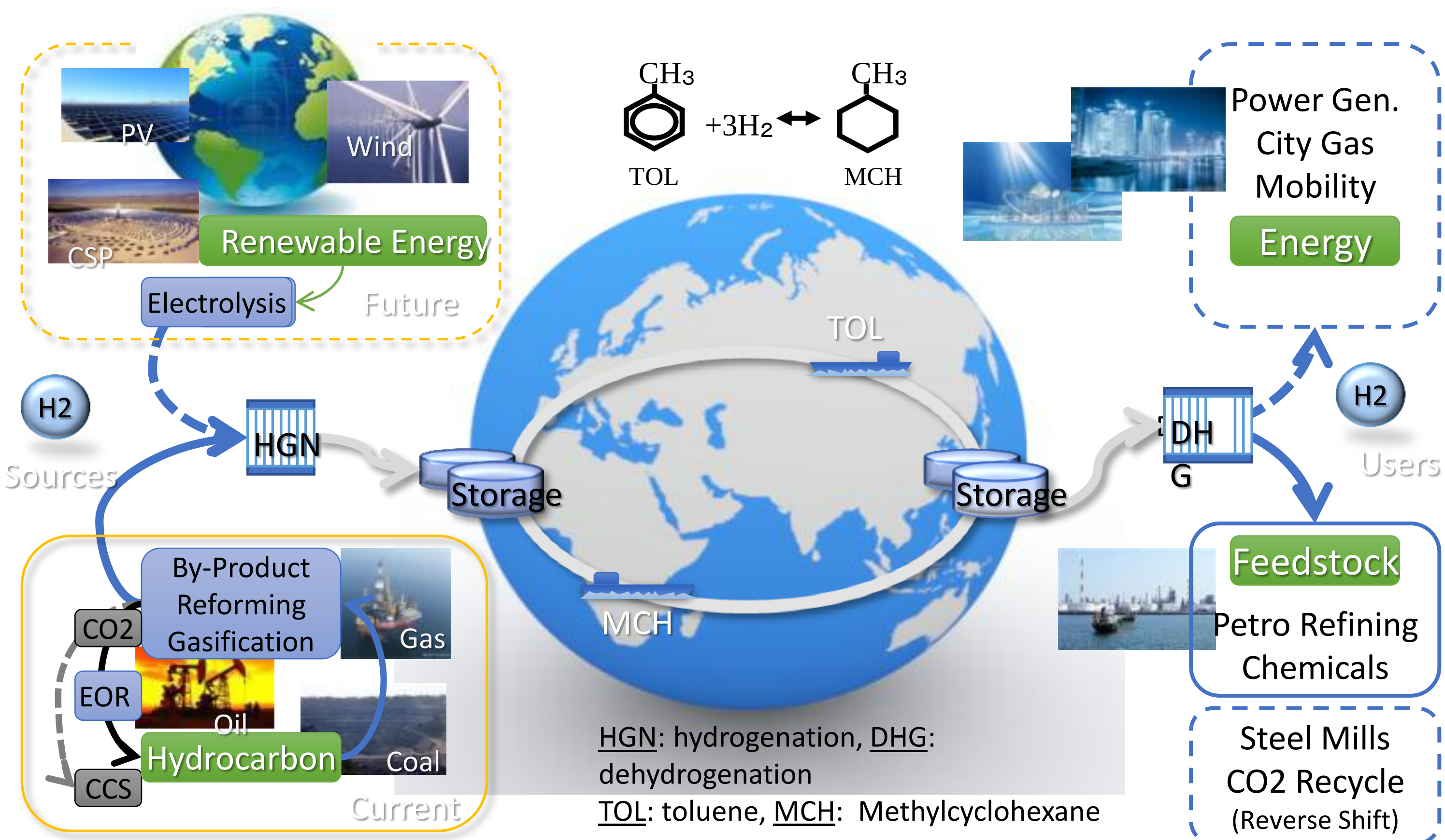
The Stone Age didn't end because we ran out of stones.

Development of CO_2 free hydrogen value chain



Chiyoda's Spera Hydrogen

- Chiyoda established a complete system which enables economic H2 storage and transportation.
- MCH, an H2 carrier, stays in a liquid state under ambient conditions anywhere.



- H2 Supply of a 0.1-0.2mmtpa LNG equivalent scale (M.E. to Japan) could be feasible.

The Strategic Road Map for Hydrogen and Fuel Cells ～Industry-academia-government action plan to realize "Hydrogen Society"～ (overall)

- In order to achieve goals set in the Basic Hydrogen Strategy,

① **Set of new targets to achieve (Specs for basic technologies and cost breakdown goals), establish approach to achieving target**

② **Establish expert committee to evaluate and conduct follow-up for each field.**

		Goals in the Basic Hydrogen Strategy		Set of targets to achieve	Approach to achieving target
Use	Mobility	FCV 200k b y2025 800k by 2030	2025	● **Price difference between FCV and HV** (¥3m → ¥0.7m) ● **Cost of main FCV system** (FC ¥20k/kW → ¥5k/kW; Hydrogen Storage ¥0.7m → ¥0.3m)	• Regulatory reform and developing technology
		HRS 320 by 2025 900 by 2030	2025	● **Construction and operating costs** (Construction cost ¥350m → ¥200m; Operating cost ¥34m→¥15m) ● **Costs of components for HRS** (Compressor ¥90m → ¥50m; Accumulator¥50m → ¥10m)	• Consideration for creating nation wide network of HRS • Extending hours of operation
		Bus 1,200 by 2030	Early 2020s	● Vehicle cost of FC bus (¥105m → ¥52.5m)	• Increasing HRS for FC bus
				※In addition, promote development of guidelines and technology development for expansion of hydrogen use in the field of FC trucks, ships and trains.	
	Power	Commercialize by 2030	2020	● Efficiency of hydrogen power generation (26%→27%) ※1MW scale	• Developing of high efficiency combustor etc.
	FC	Early realization of grid parity	2025	● Realization of grid parity in commercial and industrial use	• Developing FC cell/stack technology
Supply	Fossil Fuel +CCS	Hydrogen Cost ¥30/Nm3 by 2030 ¥20/Nm3 in future	Early 2020s	● Production: Production cost from brown coal gasification (¥several hundred/Nm3→ ¥12/Nm3) ● Storage/Transport : Scale-up of Liquefied hydrogen tank (thousands m³→50,000m³) Higher efficiency of Liquefaction (13.6kWh/kg→6kWh/kg)	• Scaling-up and improving efficiency of brown coal gasifier • Scaling-up and improving thermal insulation properties
	Green H2	System cost of water electrolysis ¥50,000/kW in future	2030	● Cost of electrolyzer (¥200,000m/kW→¥50,000/kW) ● Efficiency of water electrolysis (5kWh/Nm3→4.3kWh/Nm3)	• Designated regions for public deployment demonstration tests utilizing the outcomes of the demonstration test in Namie, Fukushima • Development of electrolyzer with higher efficiency and durability

METI 2017

China is focusing on the hydrogen technology to store abundant electricity generated by renewables

China Hydrogen Alliance & H_2 in China Energy

中国氢能联盟
CHINA HYDROGEN ALLIANCE

- **China Hydrogen Alliance , National-level Hydrogen Industry Organization, established in February, 2018 in Beijing, chaired by China Energy.**

- **Coordinating and promoting hydrogen-related ecological development**
- ***Releasing White Paper on China's Hydrogen Energy***
- **Establishing an innovation platform for the hydrogen industry**
- ***Strengthening international cooperation***
- **Building a hydrogen society in China**

China Energy: H_2 Source Advantage in wide range sources, low cost, low foot print of carbon.

- **With total installed capacity of wind power and solar cells over 35 GW, hydropower over 10 GW, holding a sound fundamental condition to produce hydrogen from renewable energy .**
- **With the capatity of Coal to H_2: over 4 million tons per year.**
- **Build up a 300 thousand tons CCS demonstration project, great beneficial to take down the capital cost of coal to hydrogen project.**

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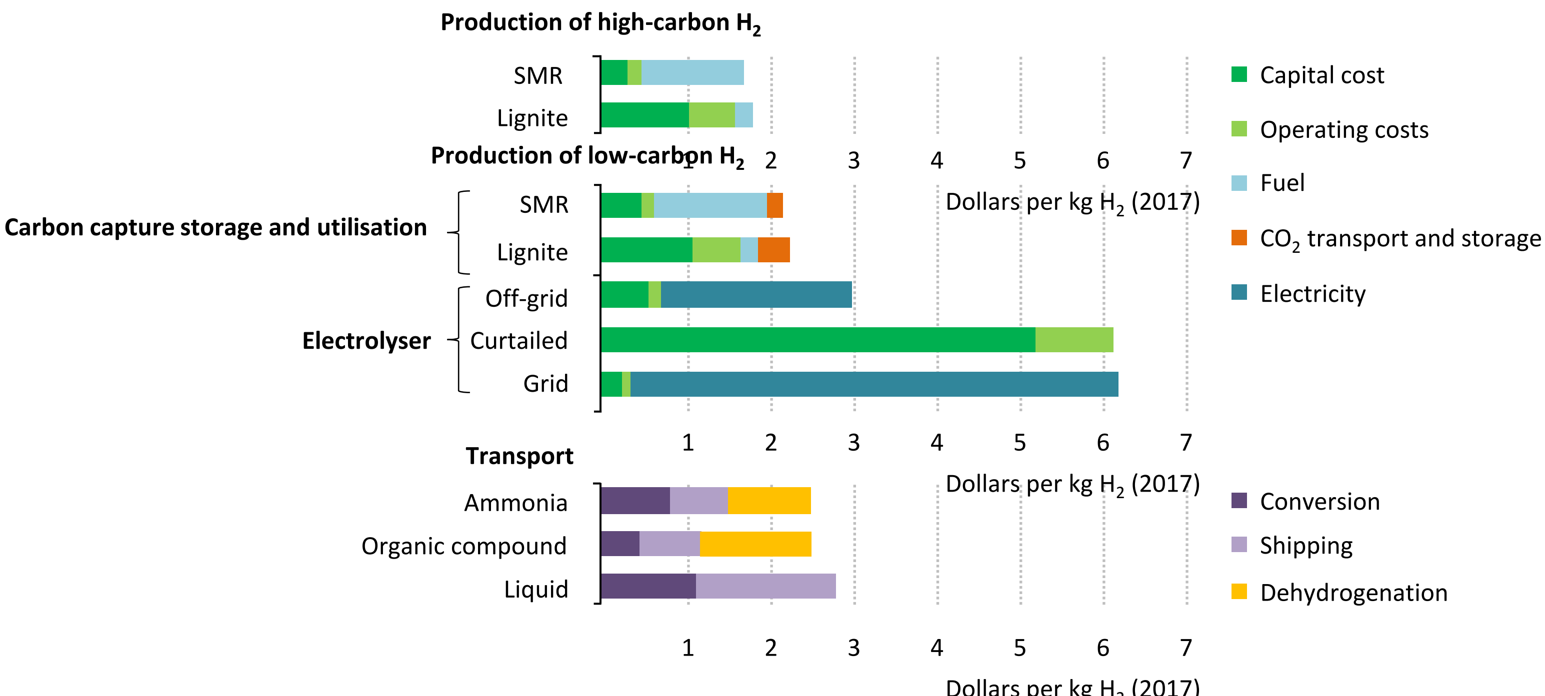
Hydrogen in theWorld Energy Outlook 2018
“Is hydrogen heading back to the future?”

Costs for hydrogen production in Australia and transportation to Japan in 2040

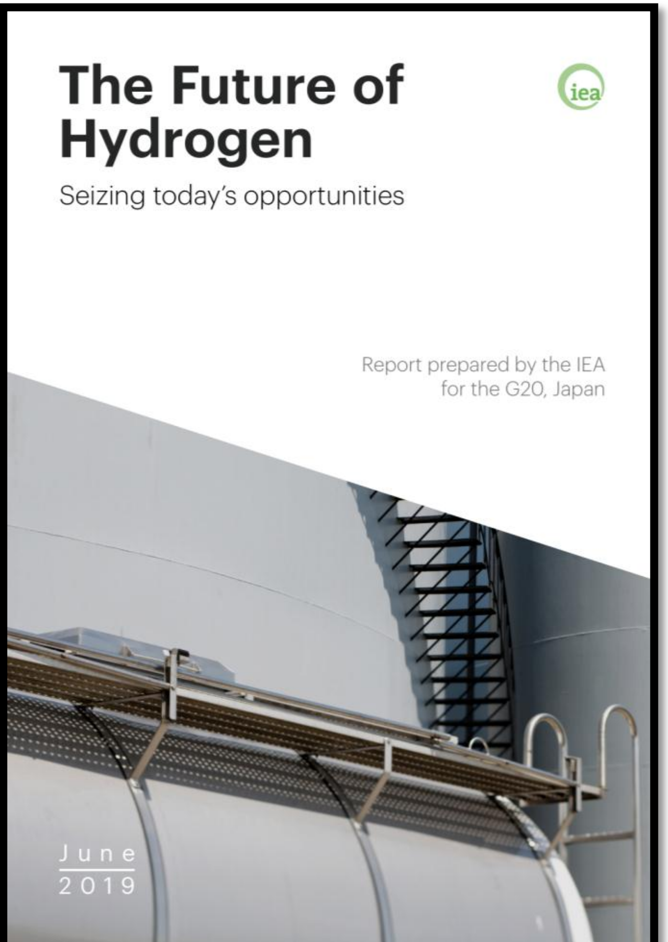
WEO2018



SMR: Steam Methane Reforming

SMR equipped with CCUS is the cheapest source of low-carbon hydrogen, but electrolysers using off-grid renewables could provide hydrogen for $3/kg H2 in 2040

Hydrogen – A common element of our energy future ?



- Momentum currently behind hydrogen is unprecedented, with more and more policies, projects and plans by governments & companies in all parts of the world

- Hydrogen can help overcome many difficult energy challenges

  - ***Integrate more renewables***, including by enhancing storage options & tapping their full potential

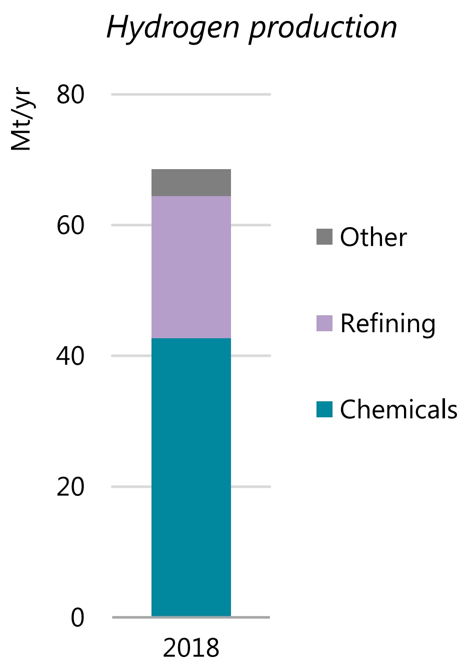
  - ***Help Oil, Coal and Gas exporters*** by providing clean alternatives with CCS

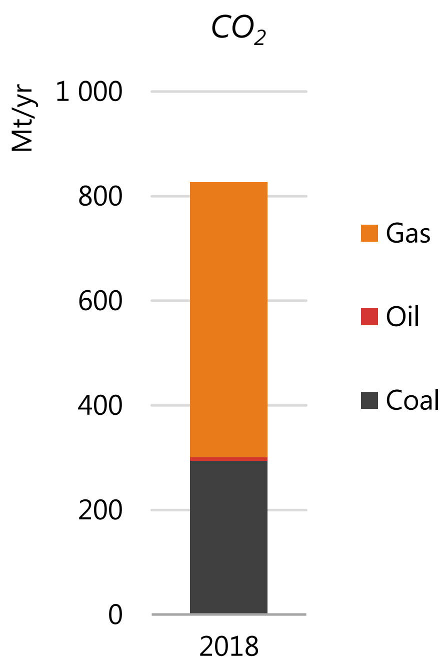
  - ***Decarbonize hard-to-abate sectors*** – steel, chemicals, trucks, ships & planes

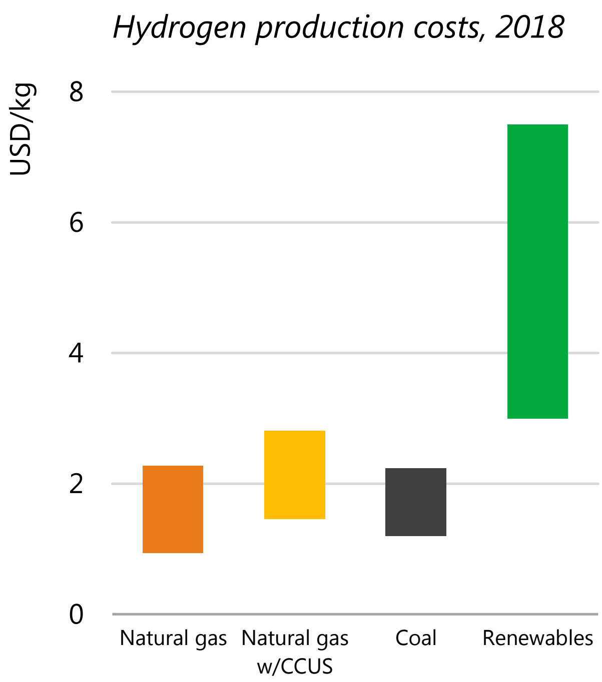
  - ***Enhance energy security*** by diversifying the fuel mix & providing flexibility to balance grids

- But there are challenges: ***costs*** need to fall; ***infrastructure*** needs to be developed; ***cleaner hydrogen*** is needed; and ***regulatory barriers*** persist

Hydrogen is already part of the energy mix



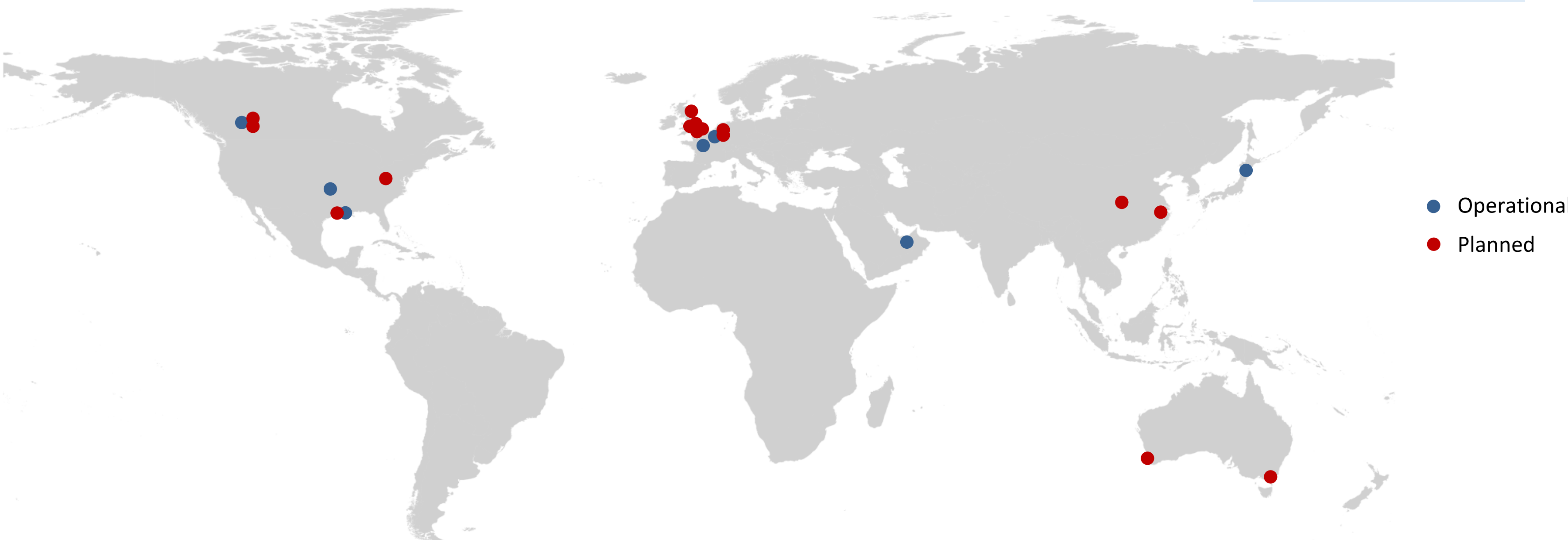




Dedicated hydrogen production is concentrated in very few sectors today, and virtually all of it is produced using fossil fuels, as a result of favourable economics.

Hydrogen production with CO_2 capture (BlueH) is coming online

IEA Hydrogen Report to G20

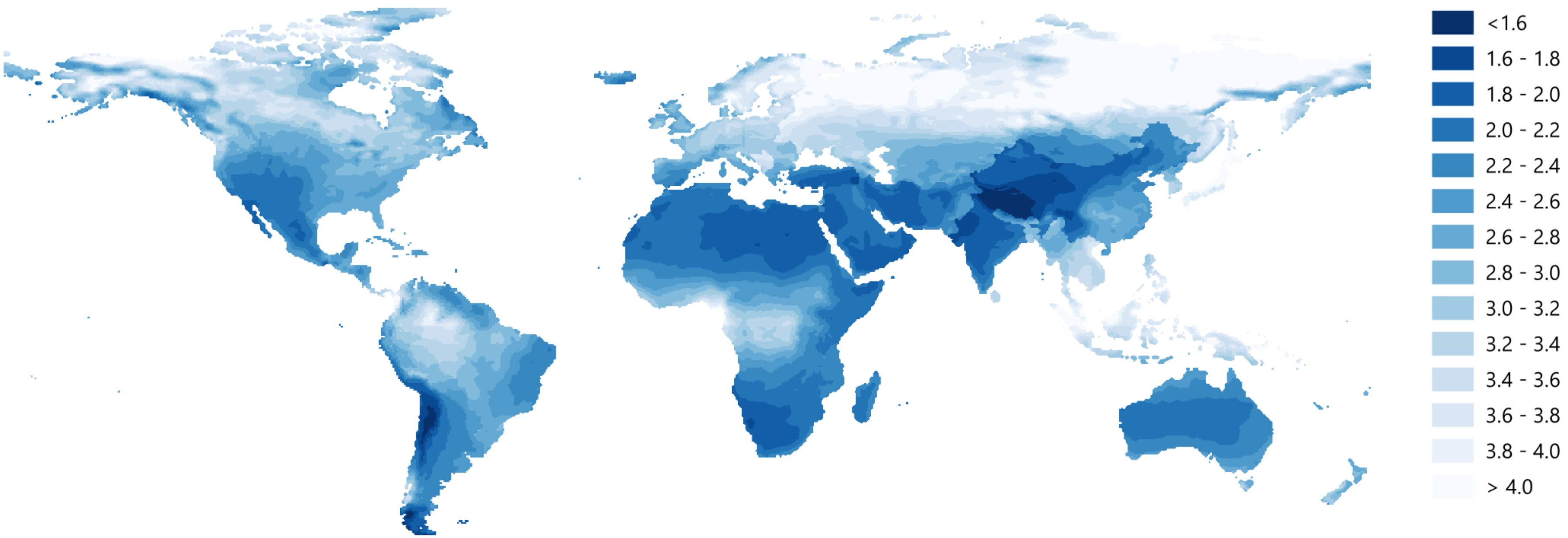


Low-carbon hydrogen from fossil fuels is produced at commercial scale today, with more plants planned. It is an opportunity to reduce emissions from refining and industry.

Renewables hydrogen (Green H) costs are set to decline

IEA Hydrogen Report to G20

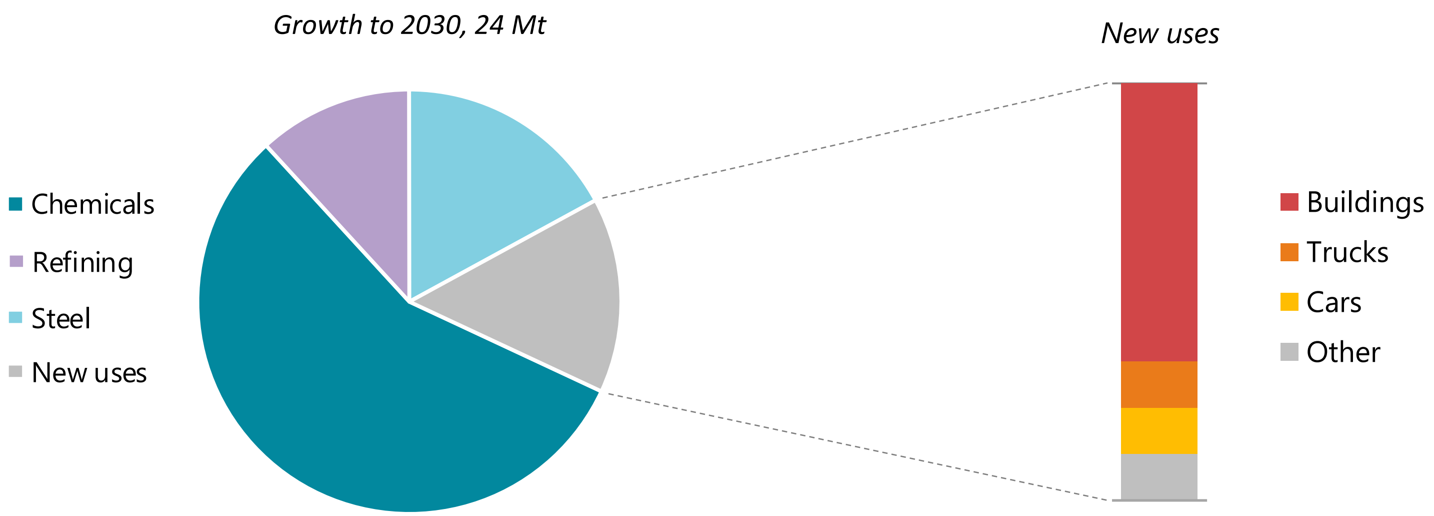
Long-term hydrogen production costs from solar & wind systems



The declining costs of solar PV and wind could make them a low-cost source for hydrogen production in regions with favourable resource conditions.

The challenge to 2030: expand hydrogen beyond existing applications

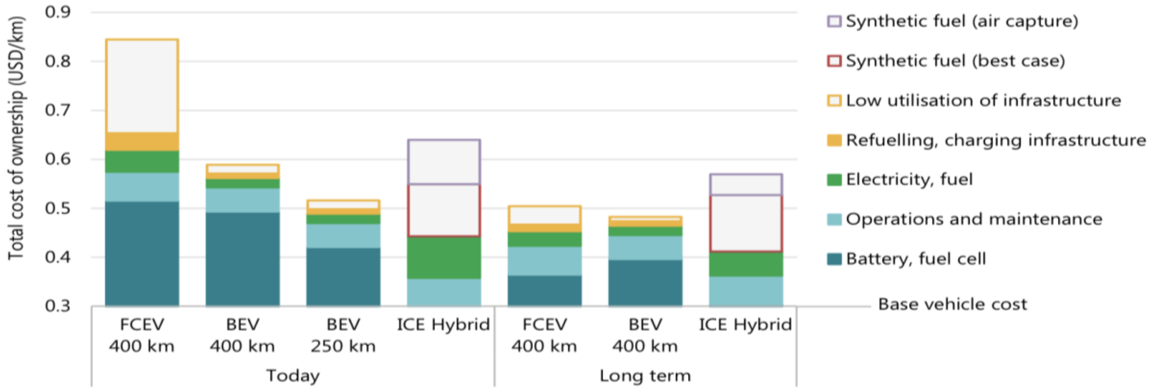
Growth in hydrogen use based on announced policies, 2018-2030



Dependable demand from current industrial applications can be used to boost clean hydrogen production; policies & industry targets suggest increasing use in other sectors, but ambition needs to increase.

Cost Competitiveness of FCVs and BEVs

Figure 54. Total cost of car ownership by powertrain, range and fuel

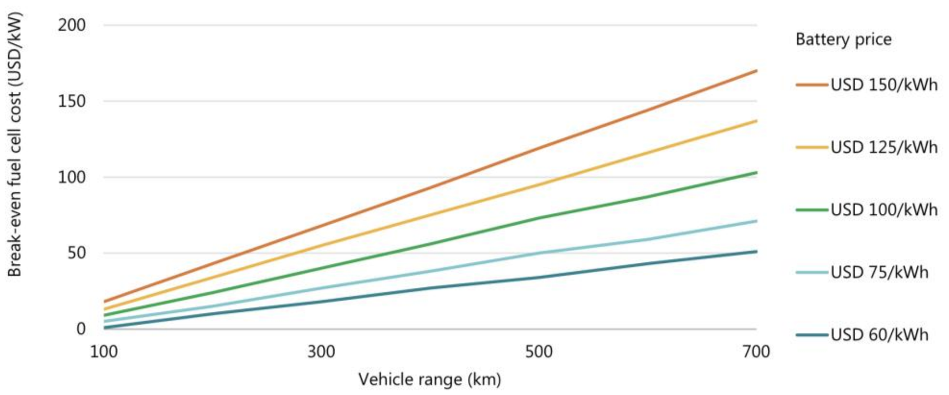


Notes: ICE = internal combustion engine. The y-axis intercept of the figure corresponds to base vehicle "glider" plus minor component costs, which are mostly invariant across powertrains. More information on the assumptions is available at www.iea.org/hydrogen2019.

Source: IEA 2019.

FCEV costs could break even with BEV costs at a range of 400 km. Cost reductions in fuel cells and storage tanks, together with high utilisation of stations, are the keys to achieving competitiveness.

Figure 55. Break-even fuel cell cost to be competitive with BEV in the long term



Note: More information on the assumptions is available at www.iea.org/hydrogen2019.

Source: IEA 2019.

Fuel cell electric cars are most competitive on a total cost of ownership basis with BEV cars over longer driving ranges. To break even with battery costs below USD 100/kWh could require achieving fuel cell costs below USD 60/kW.

IEA Hydrogen Report to G20

Four key opportunities for scaling up hydrogen to 2030