HYDROGEN AS A GAME CHANGER IN ENERGY TRANSITION

WHY
THE ENERGY TRANSITION

Dr. Romanas Savickas

H_2: WHY ENERGY TRANSITION ?

ANNEX

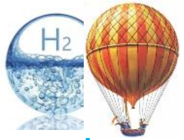
- Hydrogen development history
- Hydrogen potential VS other fuels
- Hydrogen costs
- Hydrogen strategies
- Mapping global Hydrogen supply-demand and import / export potential
- Hydrogen transportation issues
- Discussion on facilitating Green Hydrogen

Dr. Romanas Savickas

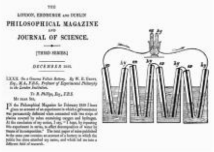
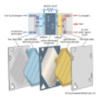
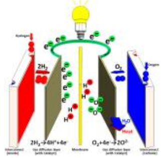
H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre
supported by UNOPS

Scientists have been interested in **Hydrogen** since **1520,** and since the **1800** into as a source of energy.







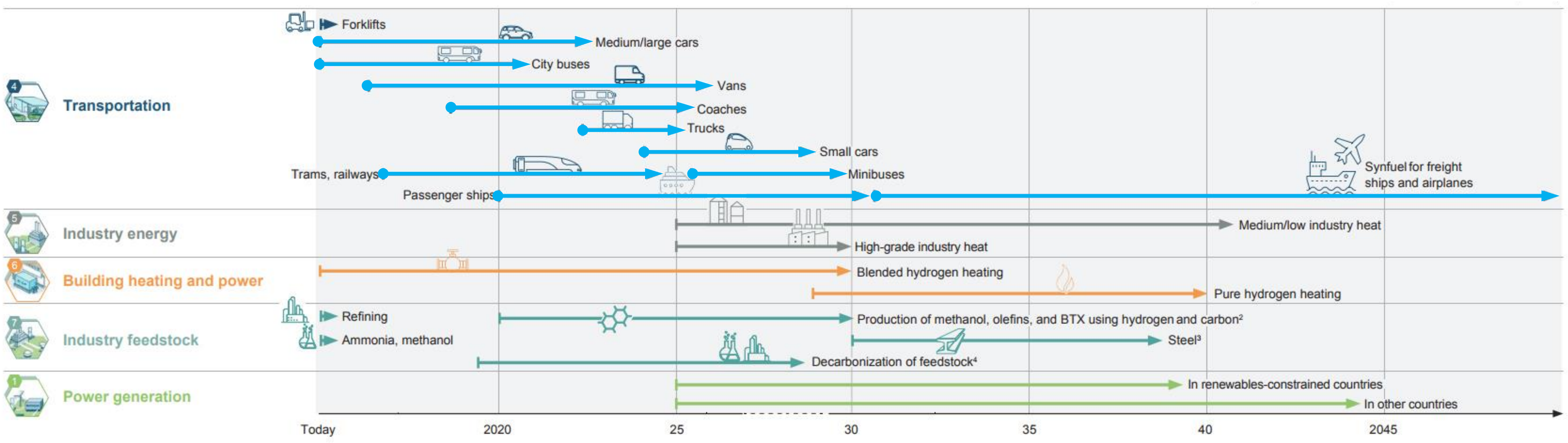
1520 | 1783 | 1800 | 1801 | 1839 | 1889 | 1893 | 1900 | 1939 | 1966 | 1973 | 1988 | Now

Timeline:

- 1520 – **First recorded observation of Hydrogen** by Paracelsus through dissolution of metals (iron, zinc, and tin) in sulfuric acid.
- 1783 – Antoine Lavoisier gave **Hydrogen its name** (Gk: hydro = water, genes = born of)
- 1783 – Jacques Charles made the **first flight** with his **hydrogen balloon** "La Charlière".
- 1800 – William Nicholson and Anthony Carlisle **decomposed water into hydrogen and oxygen by electrolysis with a voltaic pile**.
- 1801 – Humphry Davy discovers the **concept** of the **Fuel Cell**.
- 1839 – Christian Friedrich Schönbein **published the principle of the fuel cell** in the "Philosophical Magazine".
- 1889 – Ludwig Mond and Carl Langer **coined the name fuel cell** and tried to build one running on air and Mond gas.
- 1893 – Friedrich W. Ostwald experimentally determined the interconnected **roles of the various components of the fuel cell**.
- 1900 – Count Ferdinand von Zeppelin launched the **first hydrogen-filled Zeppelin** LZ1 airship.
- 1939 – Rudolf Erren – Erren engine – US patent 2,183,674 – **Internal combustion engine using hydrogen as fuel.**
- 1966 – General Motors presents Electrovan, the world's **first fuel cell automobile**.
- 1973 – The **30 km Hydrogen pipeline** in Isbergues.
- 1988 – **First flight** of Tupolev Tu-155. This was a variant of the Tu-154 airliner designed **to run on hydrogen**.

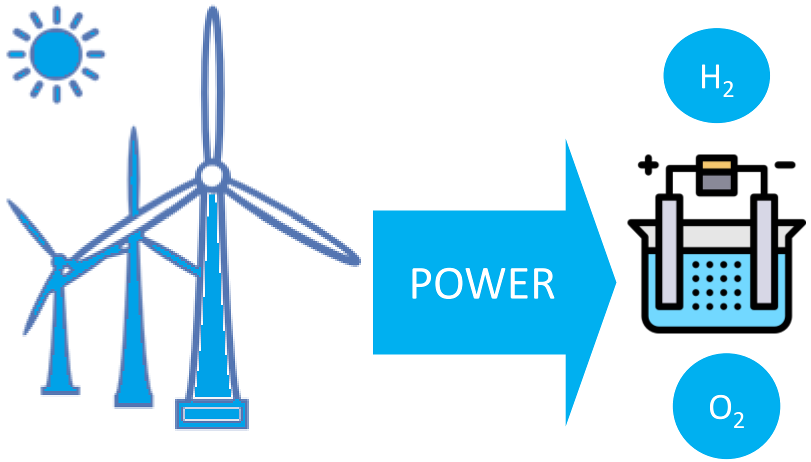
H_2: WHY ENERGY TRANSITION ?

Timeline of **future development** of Hydrogen technologies:



H_2: WHY ENERGY TRANSITION ?

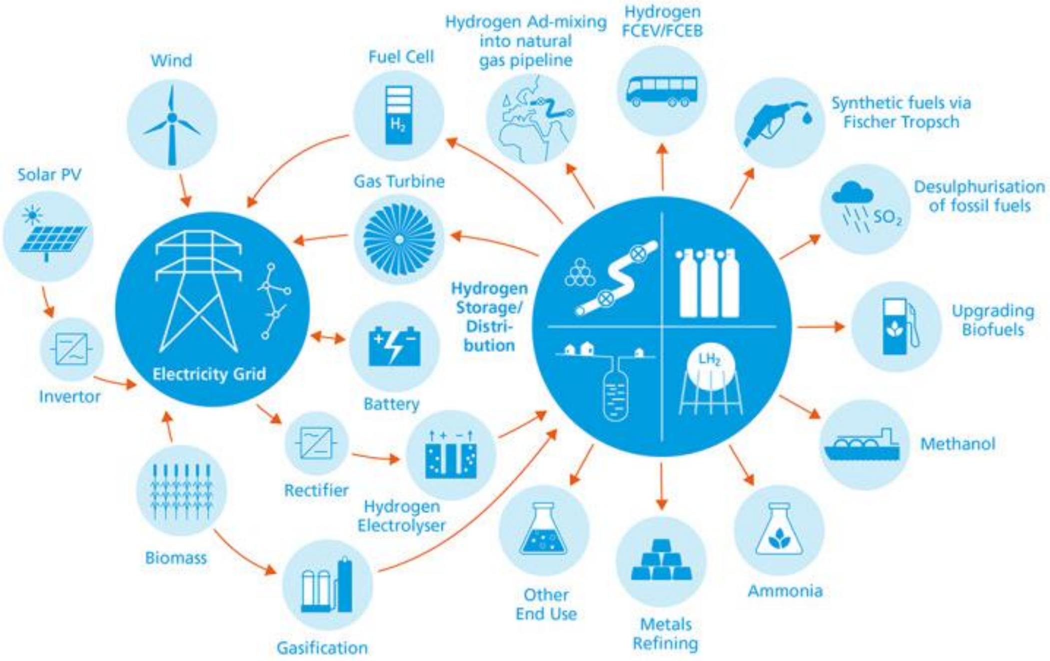
- **Hydrogen H_2** is the most abundant element on the Earth, found naturally combined with other elements.
- Hydrogen is an **energy carrier** and **fuel** which can be used to **store**, **transport**, and **deliver** energy produced from other sources.
- Hydrogen is an attractive **alternative to fossil fuels** as it can be produced by splitting water molecules **do not emitting carbon dioxide** and can be **produced using renewable energy**.



H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre
supported by UNOPS

- Hydrogen could account for **up to 12 % of global energy use by 2050**.
- **IEA** predicts the global demand for hydrogen by **2050** will increase **from 90 to 250 million t/year**.
- Existing data shows that **hydrogen will play an important part** in **Energy Transition** and that all **sustainable hydrogen productions technologies** will play a role.
- Today is important to **define the right priorities to kick-start a hydrogen ecosystem** and start developing required **hydrogen infrastructure**.
- It is important to assess **national potential** to contribute to development of a hydrogen ecosystem and to explore what are the **opportunities for hydrogen export potential** as well as **domestic applications**.



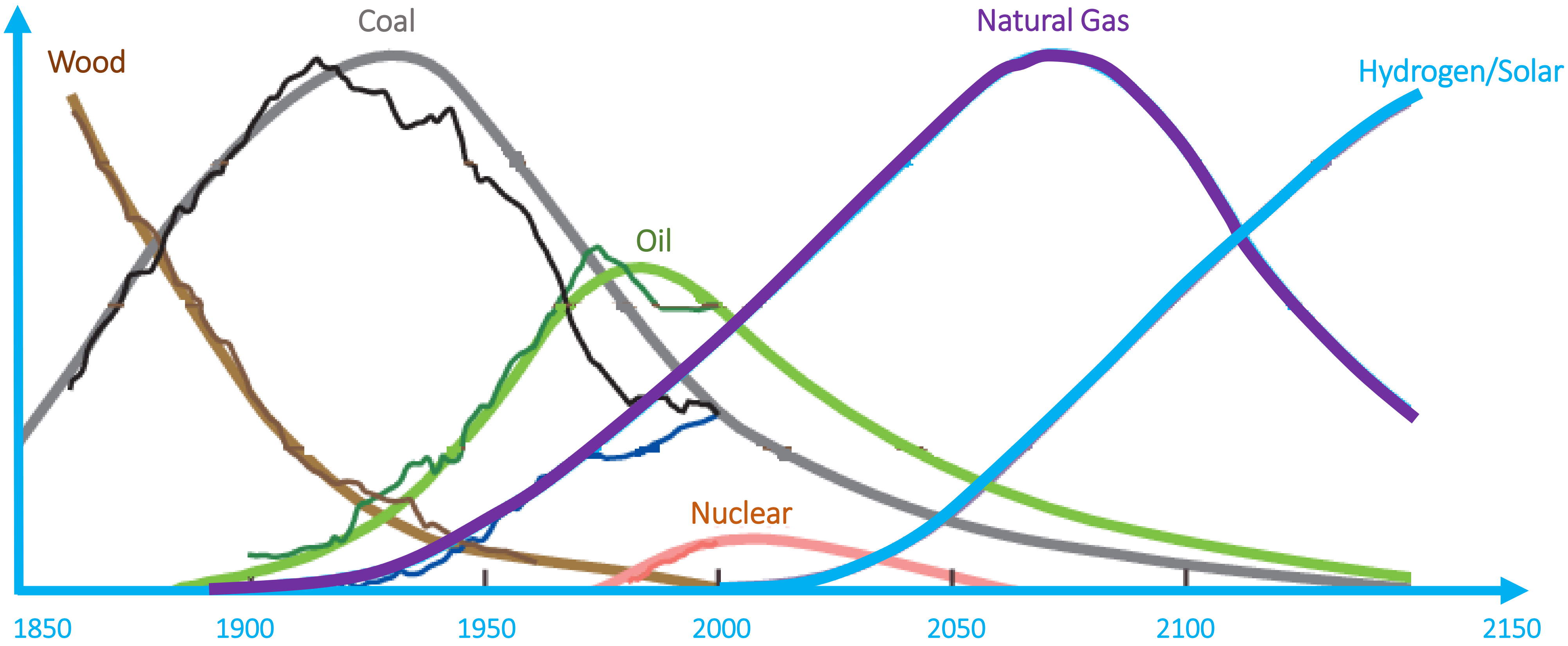
Renewable hydrogen production, distribution, storage and utilisation value chains

https://www.pollutionsolutions-online.com/news/green-energy/42/sbh4-gmbh/giga-scale-green-hydrogen-projects/54578

H_2: WHY ENERGY TRANSITION ?

UN environment programme
copenhagen climate centre
supported by UNOPS

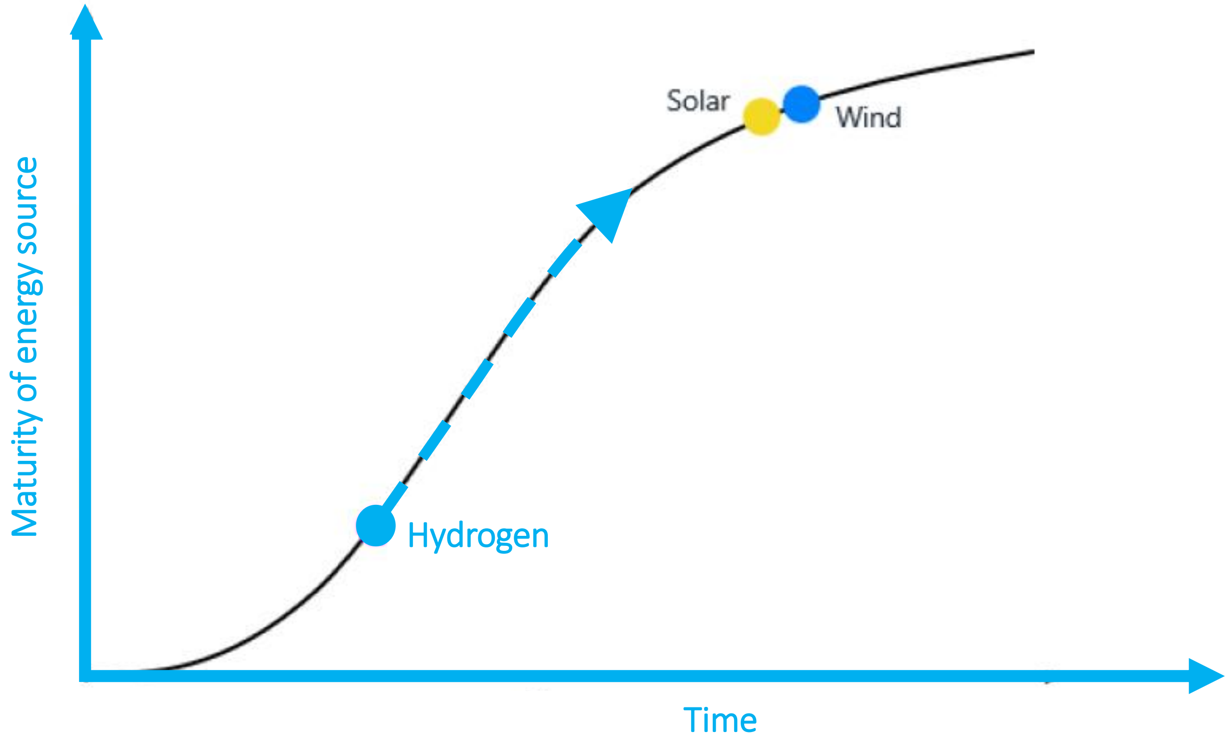
Historical data of various **Fuel** types utilisation phase **VS Hydrogen**



Dr. Romanas Savickas

H_2: WHY ENERGY TRANSITION ?

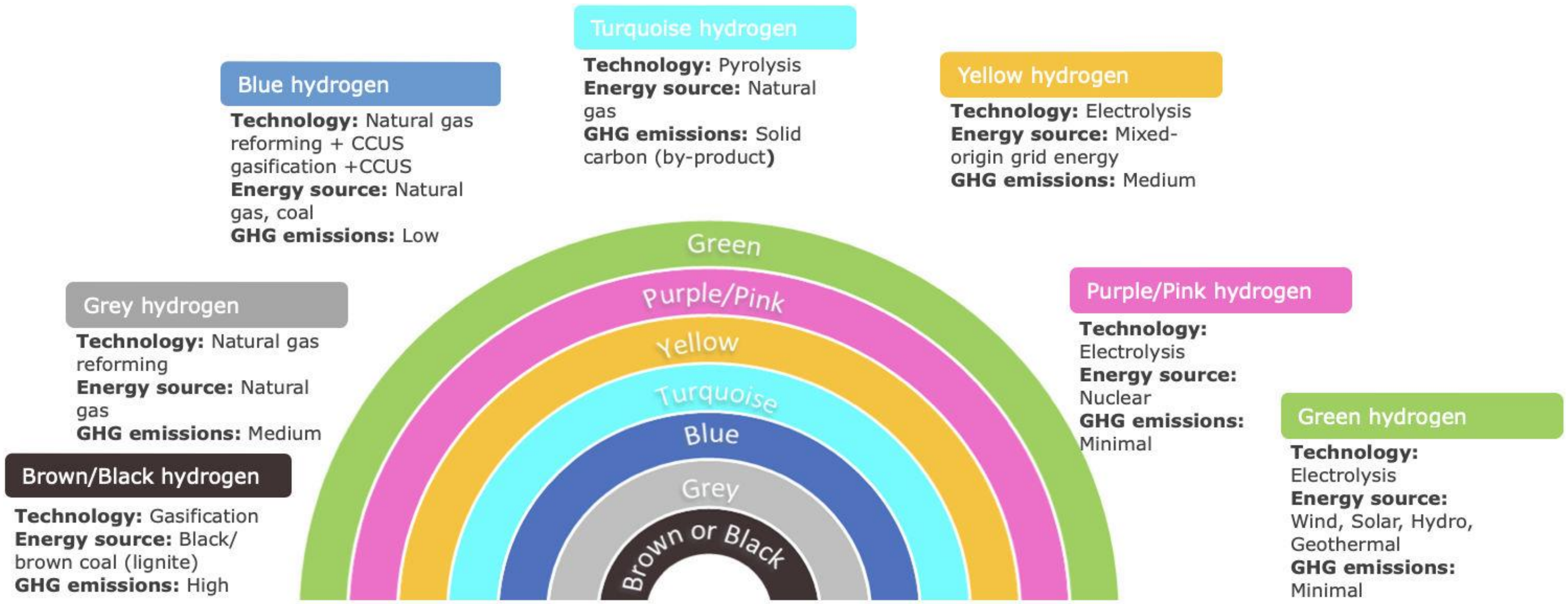
- **Hydrogen technology** is catching up on the **maturity curve** with Solar and Wind power



H_2: WHY ENERGY TRANSITION ?

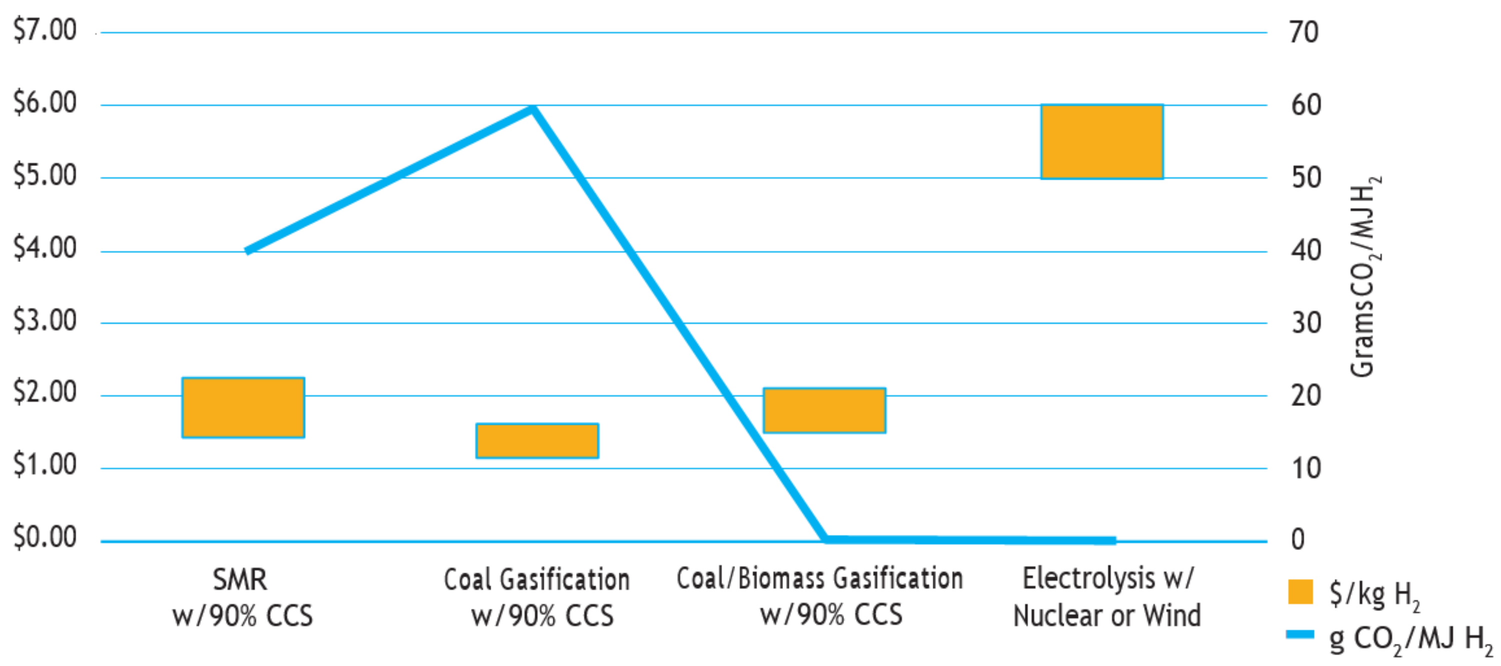
The cost of Hydrogen varies as a function of produced **Hydrogen type** and **region** of Hydrogen production. Hydrogen costs depending on production type:

Hydrogen type		H_2 production costs, USD/kg
	Grey	1.0-1.5
	Blue	1.5-2.5
	Green	4.0-6.0



H_2: WHY ENERGY TRANSITION ?

- H_2 **production from fossil fuels** is the least expensive source of hydrogen.
- **Steam reforming** of natural gas for H_2 production costs vary from **$1.43-2.27/kg** with CO_2 capture and storage (CCS) (highly dependent on natural gas price).
- H_2 from **gasification** to vary between **$1.16-1.63/ kg** for coal and between **$1.31-2.06/kg** for coal/biomass/waste plastic with CO_2 capture and storage (highly dependent on the feedstock price).
- H_2 production cost through **electrolysis** is estimated at **$5-6/kg** with electricity from nuclear or wind resources.
- H_2 from **zero-carbon electricity** (nuclear/wind), is **2.5–4 times more costly** than H_2 from carbon-neutral or net-negative carbon fossil resources.

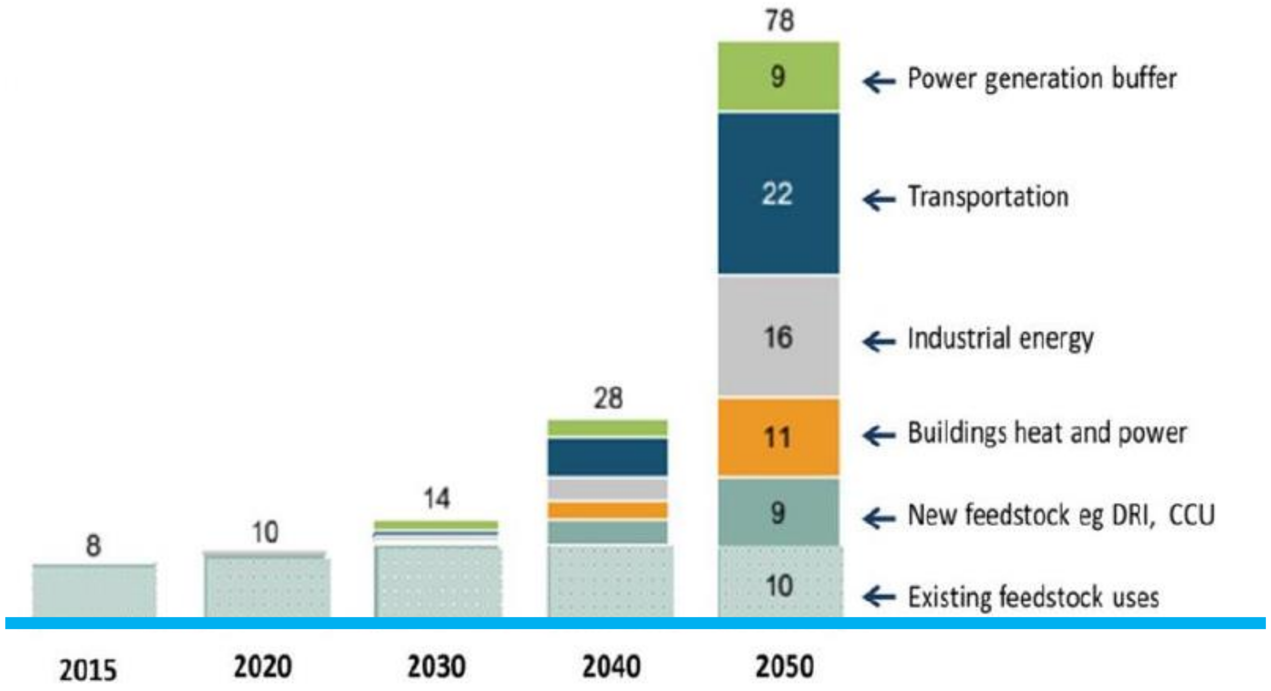


H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre

supported by UNOPS

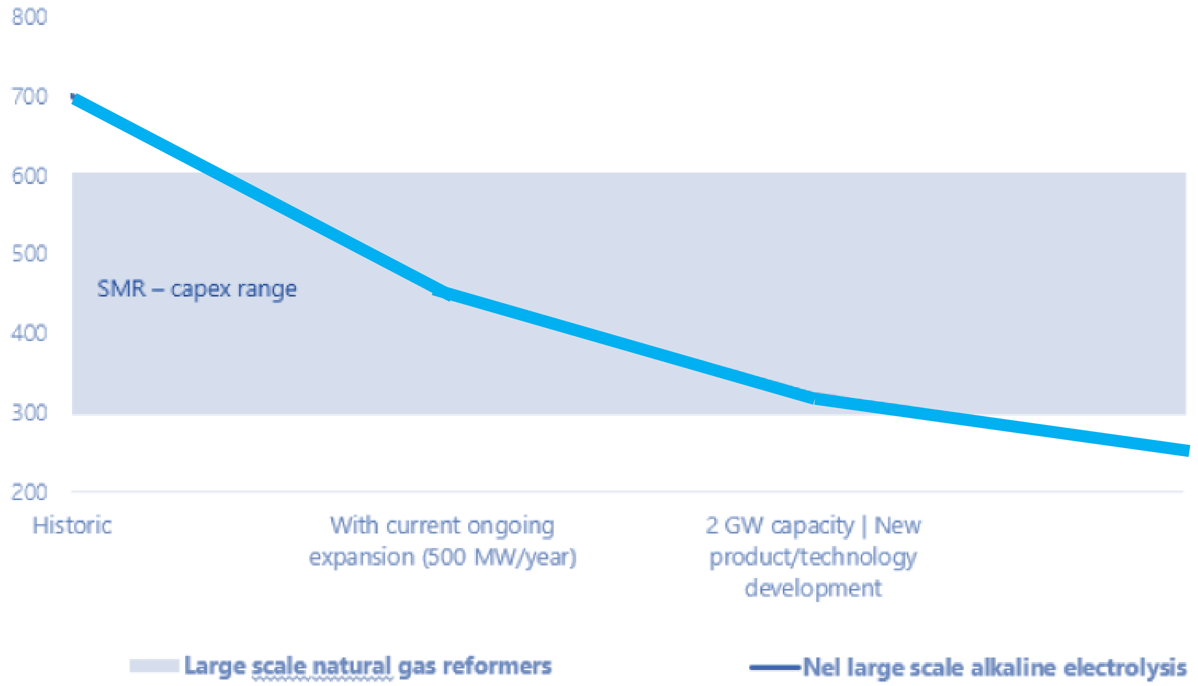
Future Hydrogen demand



Forecast increase in global hydrogen demand (EJ) through to 2050
(Hydrogen Council, 2017)

H_2: WHY ENERGY TRANSITION ?

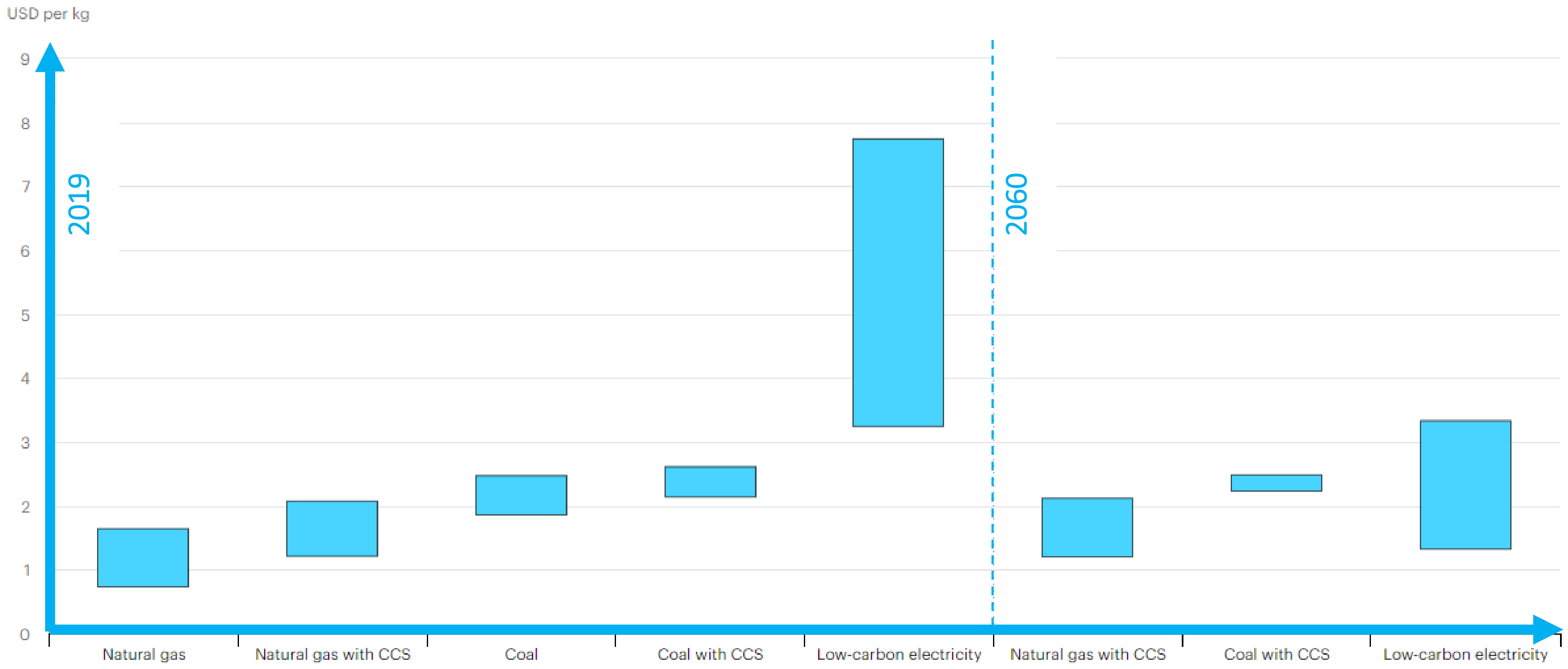
- **Growth** in renewable hydrogen is expected to accelerate **decrease in CAPEX for electrolysers** and planned investments in the hydrogen sector by 2030.
- **Electrolysers market** by 2050 is expected to be **$50-60 bn**.



Capex of steam methane reformers (SMR) vs. Nel's alkaline electrolysers, $/kW

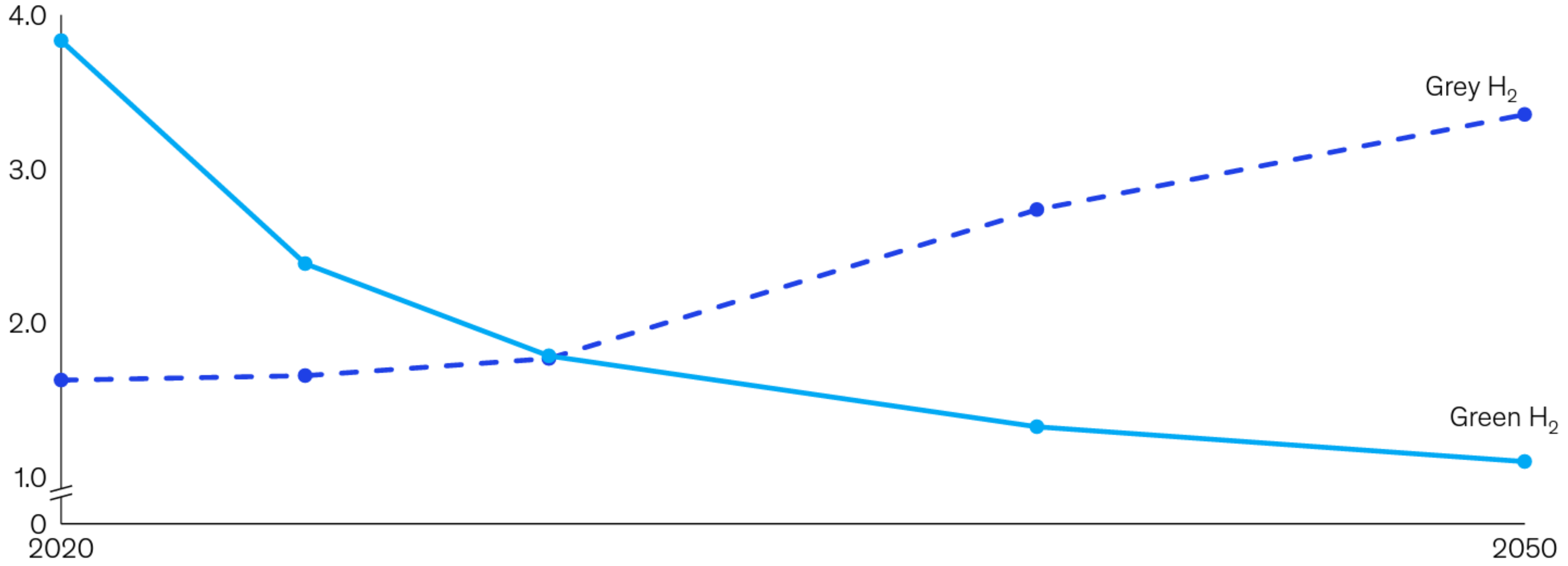
H_2: WHY ENERGY TRANSITION ?

Hydrogen costs 2019 - 2060



H_2: WHY ENERGY TRANSITION ?

Green hydrogen prices are expected to **halve** over the **next ten years**



H_2: WHY ENERGY TRANSITION ?

- The cost of **Hydrogen** also varies as a function of Hydrogen production **region** / **location**, with **Europe** and **Japan** having relatively **high costs** and strong policy support for hydrogen.

- **Hydrogen importers** stand to benefit from cheaper, low-carbon energy—especially if their domestic renewable energy, nuclear, or CCUS resources are challenging or expensive to develop.

- According to the IEA, **in the future**, it may be **cheaper in some instances** for some countries to **import hydrogen than to produce it domestically.**

H_2: WHY ENERGY TRANSITION ?

- **Europe** leads globally in the number of **announced hydrogen projects**, with Australia, Japan, Korea, China, and the USA following as additional hubs. There is a **gap in Eastern Europe and Central Asia**.

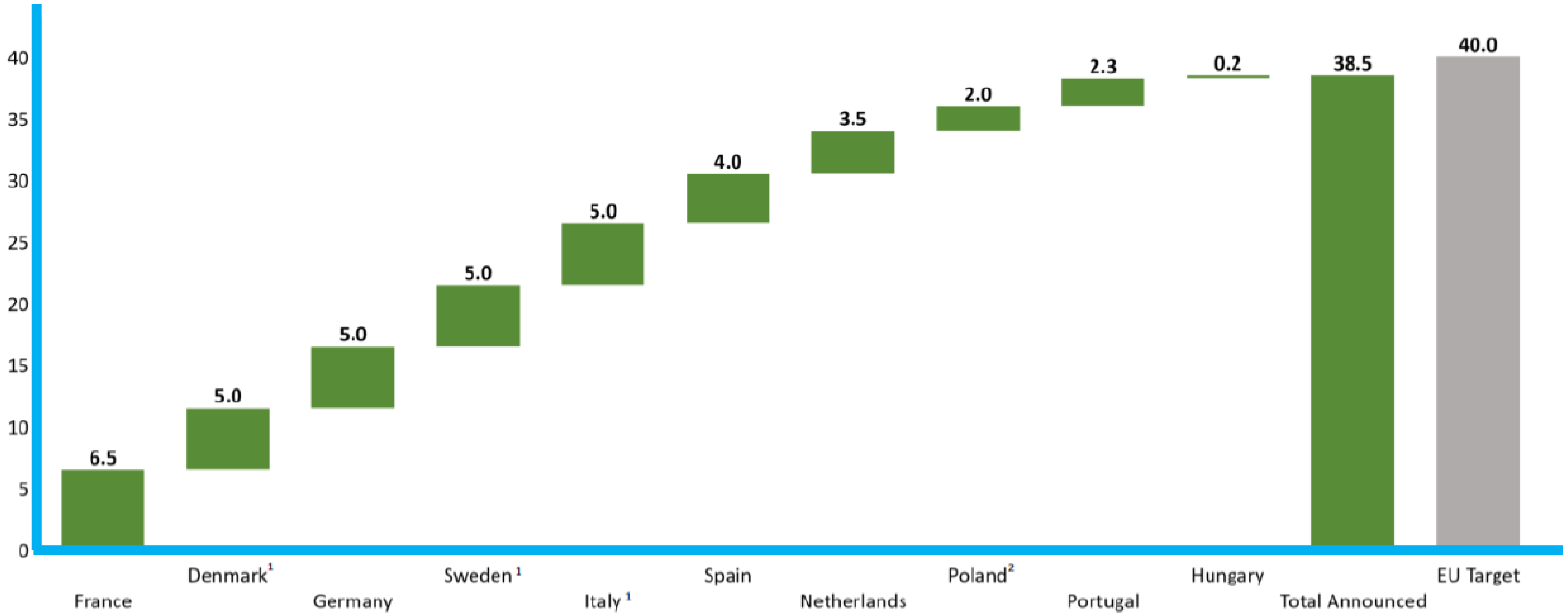
- **European Union** aims to increase the **production of hydrogen by 10 million tons by 2030** and **imports 10 million more tons of hydrogen**.

- This will lead to the **creation of 80 GW of electrolysers capacity** (doubled the size of original 50 GW target).

H_2: WHY ENERGY TRANSITION ?

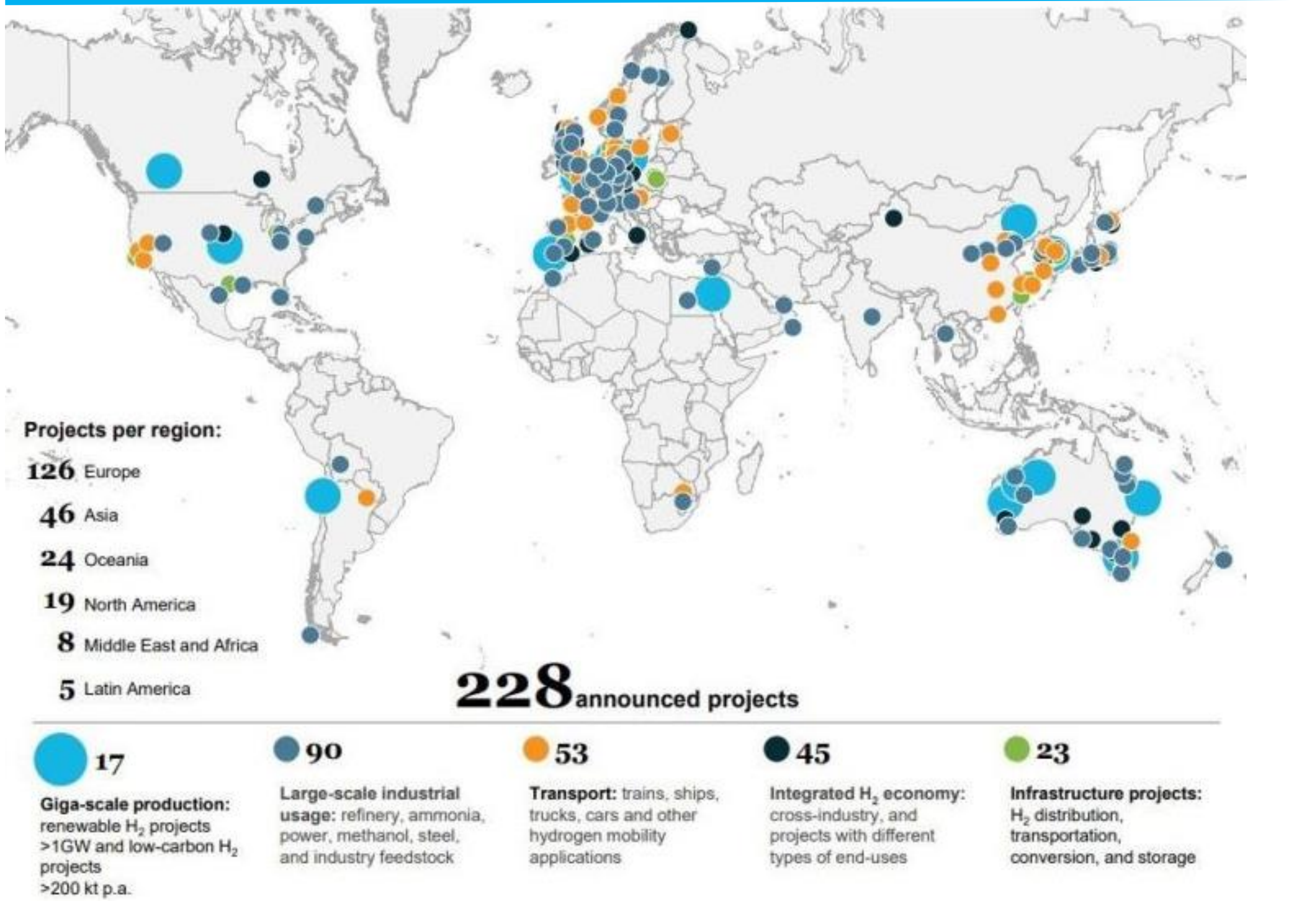
UN environment programme | copenhagen climate centre
supported by UNOPS

- There is a **global commitment** to increase the electrolysers capacity to achieve targeted production goals. The total commitments announced are equal **to an increase of electrolysers capacity to 38.5 GW by 2030 (EU target)**.



H_2: WHY ENERGY TRANSITION ?

- A new Hydrogen Council report shows **over 30 countries with a national H_2 strategy** and budget, and 228 projects in the pipeline.
- Governments worldwide **committed > USD 70 bln in public funding**. Momentum exists along the entire value chain and is accelerating **cost reductions** for hydrogen **production**, **transmission**, **distribution**, **retail**, and end **applications**.
- Underpinned by a global shift of regulators, investors, and consumers toward decarbonization, **H_2 is receiving unprecedented interest and investments**.

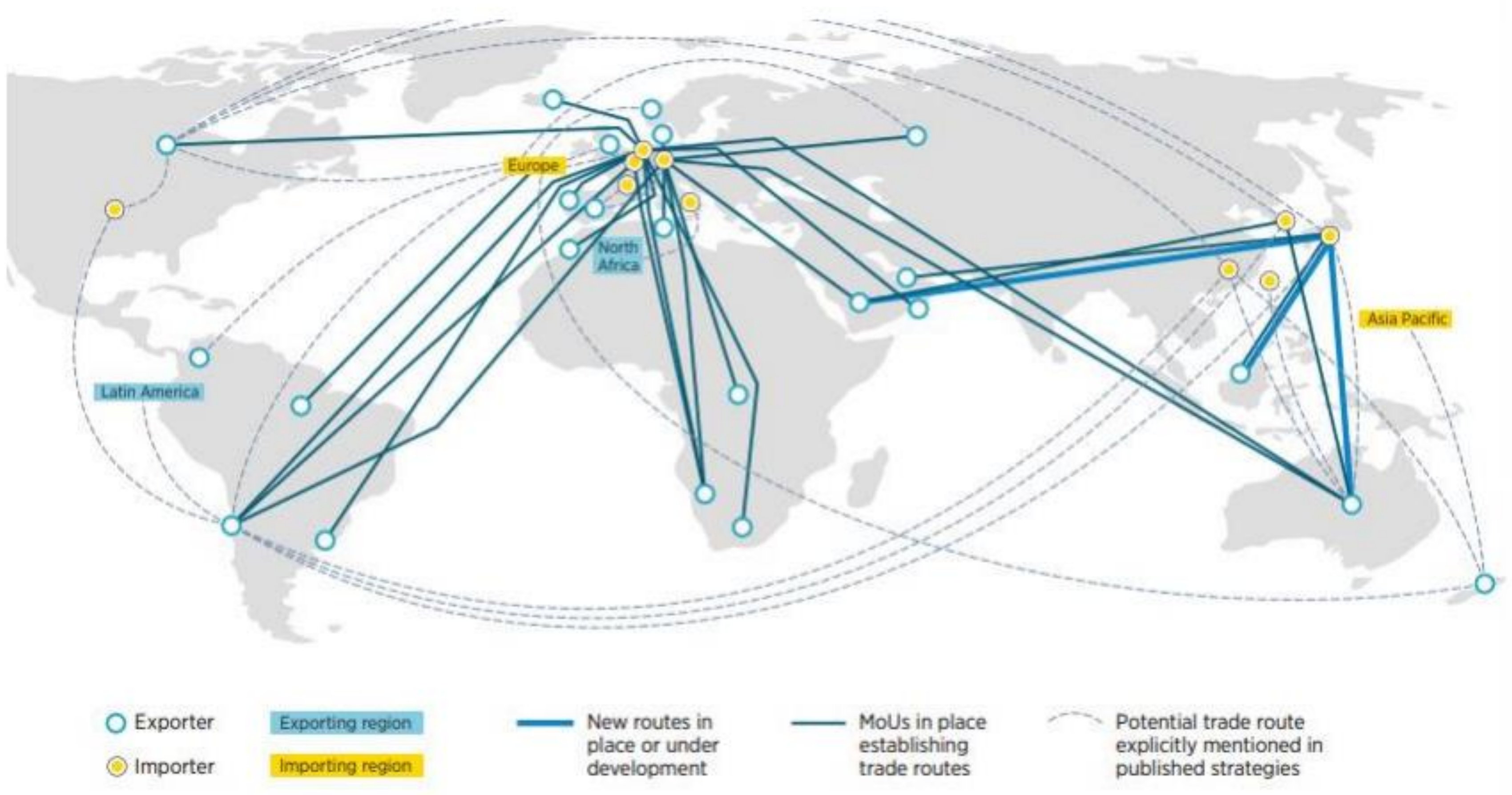


H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre

supported by UNOPS

Hydrogen **trade (import/export) routes** 2022 (forecast)

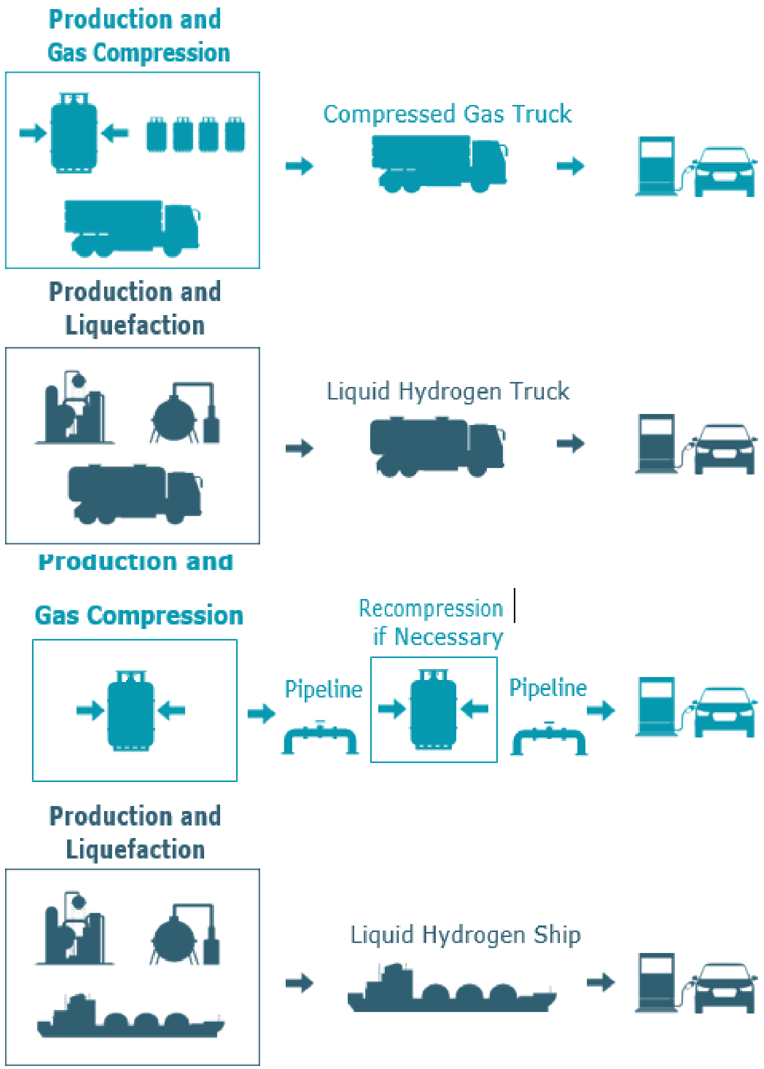


Dr. Romanas Savickas

H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre
supported by UNOPS

- **Transportation** of Hydrogen is a **challenge to be solved**. Hydrogen has high energy density per unit mass, but a **low-volumetric energy density** (~30% of methane at 15°C/1bar) and an ability to permeate metal-based materials.
- Transportation requires **high pressures** / **low temperatures** / chemical processes to be stored compactly.
- **Gaseous** Hydrogen is transported by either **tube trailers** or **pipelines** (~300 km).
- **Liquid** Hydrogen for shorter distances/small volumes is transported by **road tankers** (~1.000 km) or longer distances/larger volumes by **ships** (between countries).



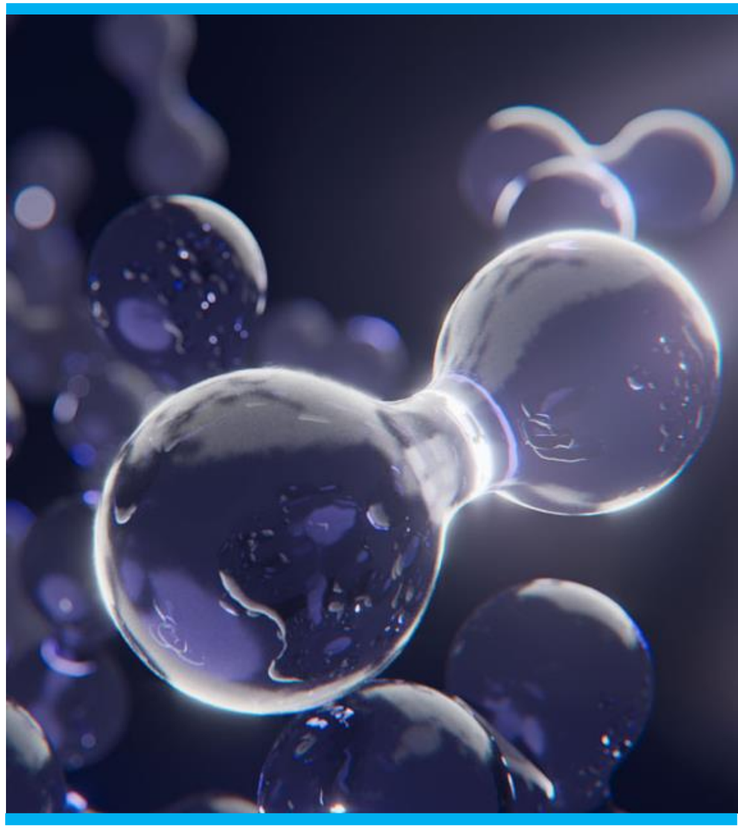
CONCLUSIONS

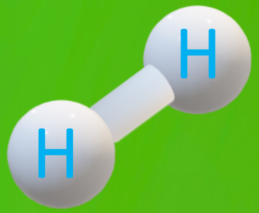
H_2: WHY ENERGY TRANSITION ?

UN environment programme | copenhagen climate centre
supported by UNOPS

CONCLUSIONS:

- Hydrogen could account for **up to 12 % of global energy use by 2050**.
- Existing data shows that **hydrogen will play an important part** in energy transition and that all **sustainable hydrogen productions technologies** will play a role.
- Most countries in their **Hydrogen strategies** give priority to a **Green Hydrogen**.
- Today is important to **define the right priorities to kick-start a Green Hydrogen ecosystem** and start developing required **Hydrogen infrastructure**.
- It is important to assess **global potential** to contribute to development of a hydrogen ecosystem and to explore what are the **opportunities for Hydrogen import/export potential** as well as **domestic applications**.





THANK YOU

Dr. Romanas Savickas
romanas.savickas@un.org

LinkedIn
https://www.linkedin.com/in/romanassavickas/

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme 50 1972-2022