Hydrogène Rêve ou réalité

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Une conférence de:

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RUQDD | RÉSEAU UNIVERSITAIRE QUÉBÉCOIS EN DÉVELOPPEMENT DURABLE

Mercredi 15 novembre 2023
EN LIGNE
Zoom

Le Québec s'est fixé une cible de réduction des émissions de GES de **37,50 %** sous le niveau de 1990 d'ici 2030 et la **carboneutralité** à l'horizon 2050.

La stratégie couvre les usages de l'hydrogène les plus prometteurs

- **Applications stationnaires et non-énergétiques**
  - Procédés industriels : Raffinage du pétrole et sidérurgie
  - Chimie verte : Ammoniac, engrais, méthanol etc
- **Applications de mobilité**
  - Piles à hydrogène (PaH) : Transport lourd et ferroviaire
  - Carburants synthétiques carboneutres : Transport maritime et aérien.
- **Application énergétique**
  - Stockage et équilibrage : Réseaux autonomes / mines et gestion de pointe hivernale
- **Application de chaleur**
  - Usages gaziers : Gaz naturel renouvelable

Key messages

1. **Hydrogen** holds promise as a crucial tool in **decarbonizing "hard-to-abate sectors,"** such as the steel industry and long-haul transport, which cannot be electrified.

2. Due to the technical challenges of **renewable hydrogen (RH2)** production, 99% of hydrogen production still comes from fossil sources; until RH2 can be produced on a large scale, **low-carbon hydrogen (LCH2)** can serve as an interim solution to facilitate the energy transition.

3. Scaling up RH2 production and heightening its contribution to limiting global warming necessitates a **6,000-fold** increase in electrolyser capacity by 2050, according to the IEA.

4. **RH2 is more expensive to produce than fossil hydrogen (3 to 20 X)**. Transport and distribution challenges necessitate investment to convert H_2 into other more "stable" carriers, as well as infrastructure. Government programs are vital for hydrogen to break even.

5. **Hydrogen's flammability** and **potential for leaks** underscore the need for strict adherence to safety standards.

6. **Industrial-scale development of the clean hydrogen industry has proven difficult**, while fossil hydrogen continues to dominate.

Change in terminology

- Hydrogen that was previously called "green" is now called "renewable";
- "Grey" hydrogen becomes "fossil";
- "Blue" and "yellow" hydrogen are grouped under the name "low-carbon";
- The EU is now referring to **"low-carbon hydrogen – LCH2" and "renewable hydrogen – RH2"** by setting a threshold of life cycle GHG emission of **3 kg CO_2-eq/kg H_2** produced;
- The **US DoE has defined "clean hydrogen"** as H_2 produced with a carbon intensity equal to or less than **2 kg CO_2-eq/kg H_2.**

The Hydrogen Colour Spectrum

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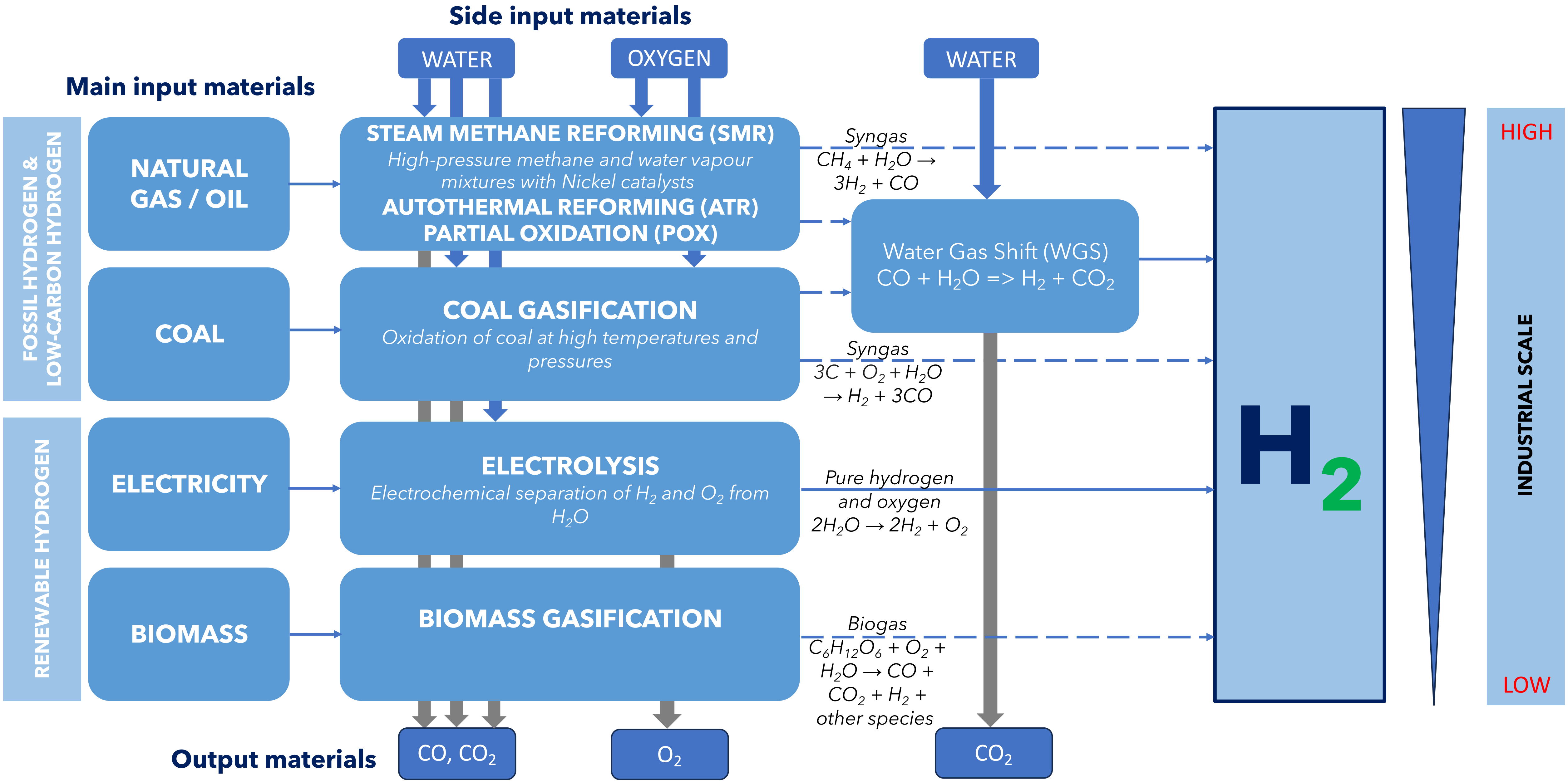
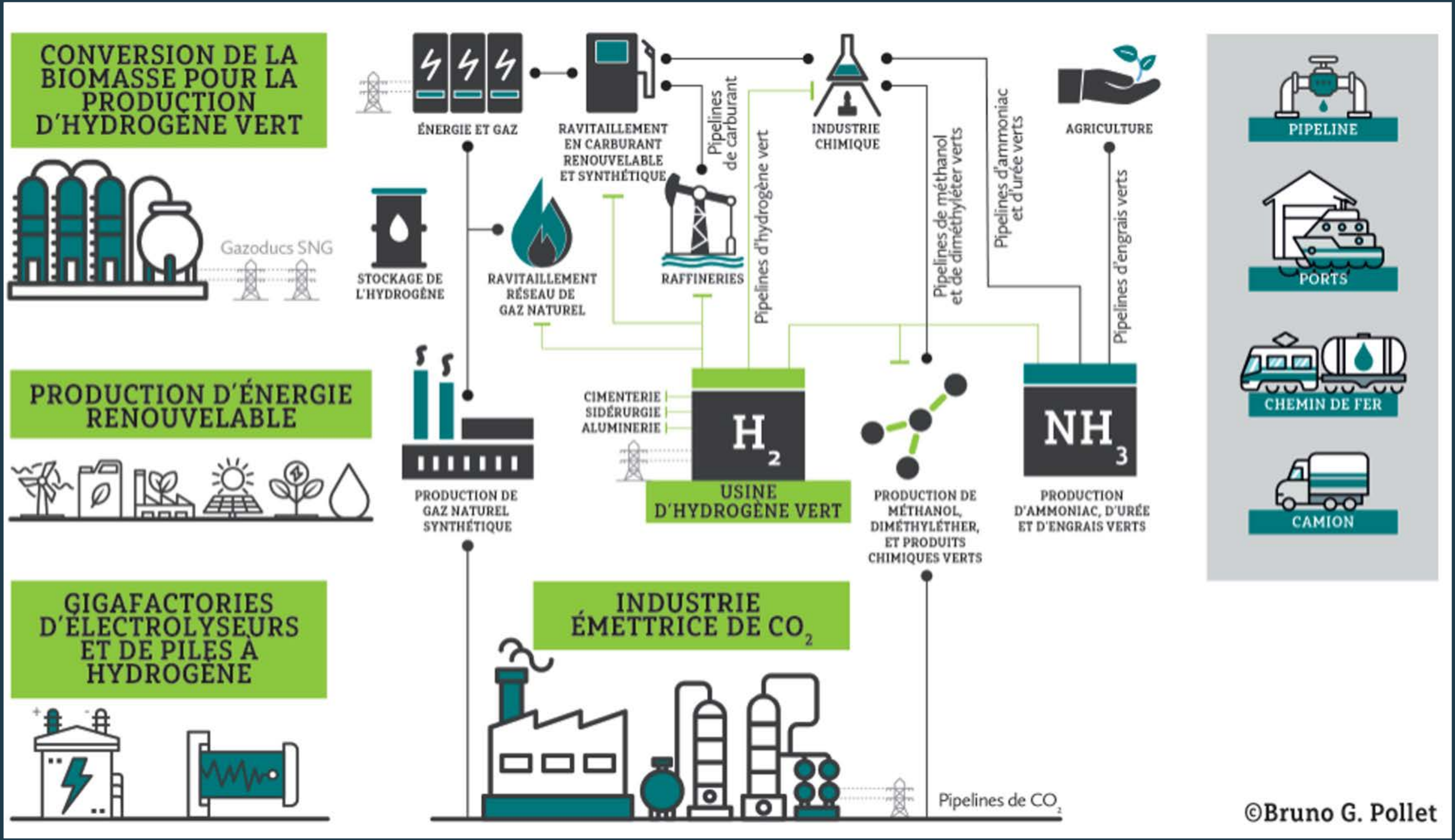
	Colour	Primary Energy / Source of Electricity	Technology	Technology Readiness Level (TRL)	Efficiency	Carbon Footprint	Terminology
Production -Fossil Fuels-	Blue Hydrogen	Natural Gas, Coal + Carbon Capture Sequestration (CCS)	Steam Reforming / Gasification	5-9	80%	Low < 3 kg CO_2-eq / kg H_2	Low-carbon Hydrogen
	Brown Hydrogen	Lignite	Gasification	Mature	<60%	Very High > 20 kg CO_2-eq / kg H_2	High-carbon Hydrogen (Fossil Hydrogen)
	Black Hydrogen	Bituminous Coal		Mature	<60%	Very High > 20 kg CO_2-eq / kg H_2	High-carbon Hydrogen (Fossil Hydrogen)
	Grey Hydrogen	Natural Gas	Steam Reforming	Mature	<85%	Medium to High <15 kg CO_2-eq / kg H_2	High-carbon Hydrogen (Fossil Hydrogen)
			Autothermal Reforming	Mature	<95%	Medium to High <15 kg CO_2-eq / kg H_2	High-carbon Hydrogen (Fossil Hydrogen)
			Partial Oxidation	6-9	<75%	Medium to High <15 kg CO_2-eq / kg H_2	High-carbon Hydrogen (Fossil Hydrogen)
	Turquoise Hydrogen	Natural Gas Biomethane Refuse Derived Fuels	Pyrolysis	6-8	<50%	Low < 3 kg CO_2-eq / kg H_2 + Carbon Black (CB)	Low-carbon Hydrogen
Production -Biomass-	Green Hydrogen	Biomass	Thermolysis	3	<50%	Low < 3 kg CO_2-eq / kg H_2	Renewable Hydrogen
		Biomethane	Steam Reforming	9	<85%	Low < 3 kg CO_2-eq / kg H_2	Renewable Hydrogen
Production -Electricity-		Renewable Energies (Solar, Wind, Hydro etc)	Water Electrolysis	6-9	<50%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
	Pink Hydrogen	Nuclear		8	<70%	Minimal < 1-2 kg CO_2-eq / kg H_2	Low-carbon Hydrogen
	Yellow Hydrogen	Electrical Network		Mature	<50%	Depending on source for producing electricity	Depending on source for producing electricity

Production -Others-	Unclassified	Water	Photoelectrolysis	3	15%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
			Photochemical	3	15%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
			Thermochemical	3-5	<50%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
		Biomass	Bioelectrolysis	3	-	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
			Biophotolysis	4	-	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
			Dark Fermentation	8	50-70%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
			Photo Fermentation	8	30-50%	Minimal 0 kg CO_2-eq / kg H_2	Renewable Hydrogen
Naturally Occurring	White Hydrogen						



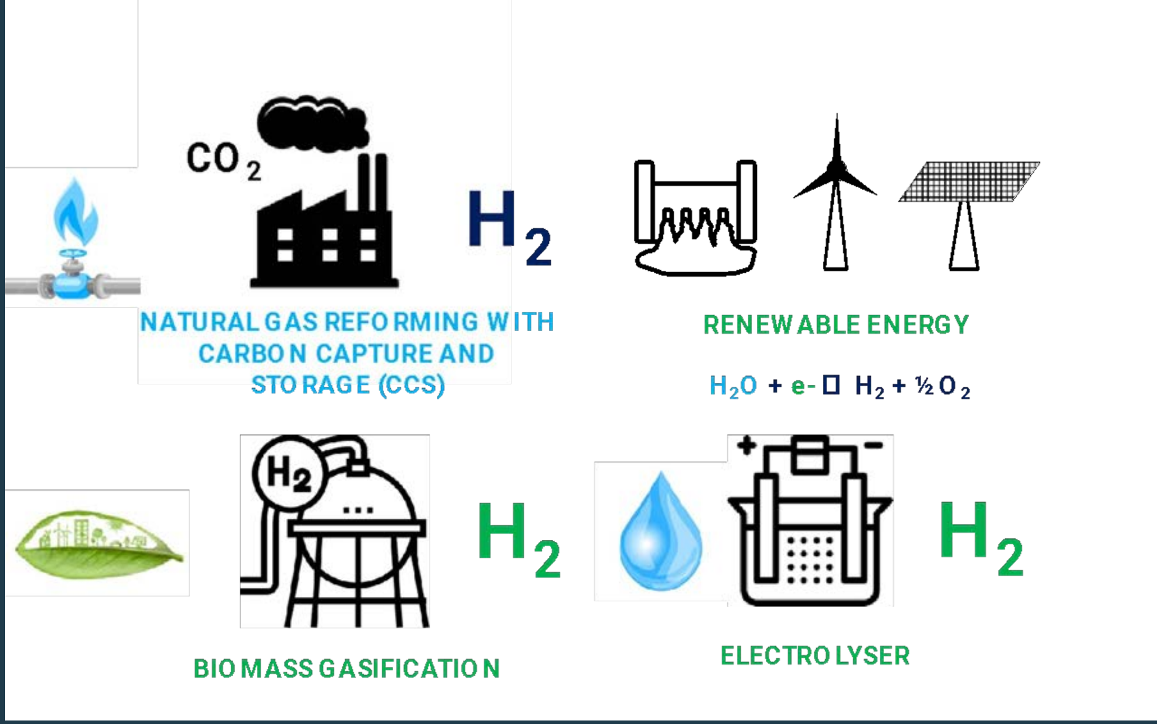
Side input materials
WATER
OXYGEN
WATER
Main input materials
FOSSIL HYDROGEN & LOW-CARBON HYDROGEN
RENEWABLE HYDROGEN
NATURAL GAS / OIL
COAL
ELECTRICITY
BIOMASS
STEAM METHANE REFORMING (SMR)
High-pressure methane and water vapour mixtures with Nickel catalysts
AUTOTHERMAL REFORMING (ATR)
PARTIAL OXIDATION (POX)
COAL GASIFICATION
Oxidation of coal at high temperatures and pressures
ELECTROLYSIS
Electrochemical separation of H_2 and O_2 from H_2O
BIOMASS GASIFICATION
Syngas
$CH_4 + H_2O \rightarrow 3H_2 + CO$
Water Gas Shift (WGS)
$CO + H_2O => H_2 + CO_2$
Syngas
$3C + O_2 + H_2O \rightarrow H_2 + 3CO$
Pure hydrogen and oxygen
$2H_2O \rightarrow 2H_2 + O_2$
Biogas
$C_6H_{12}O_6 + O_2 + H_2O \rightarrow CO + CO_2 + H_2 +$ other species
H_2
HIGH
INDUSTRIAL SCALE
LOW
Output materials
CO, CO_2
O_2
CO_2

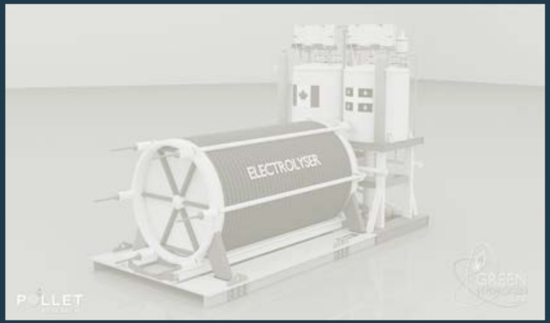
LCH2 and RH2 VALUE CHAIN

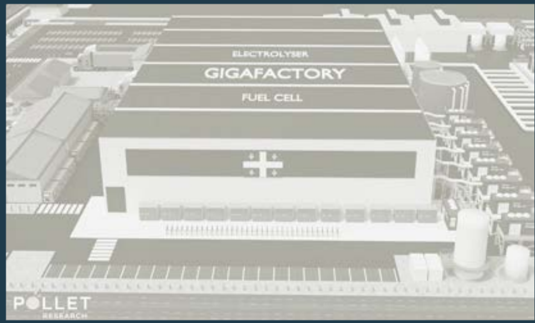


Main LCH2/RH2 Production

- To scale RH2, and to make its contribution to limiting global warming to 1.5 °C, the electrolyser capacity needs to grow **by 6,000-fold** by 2050 from today's levels of **600 MW**.
- **400-550 Mt of RH2** needs to be produced by electrolysis, requiring **3,000-4,000 GW** of electrolysers and **4,500-6,500 GW** of renewables capacity dedicated to RH2 production.







Main Minerals in Electrolysers (and Hydrogen Fuel Cells), Metal Hydrides and Lithium-ion Batteries

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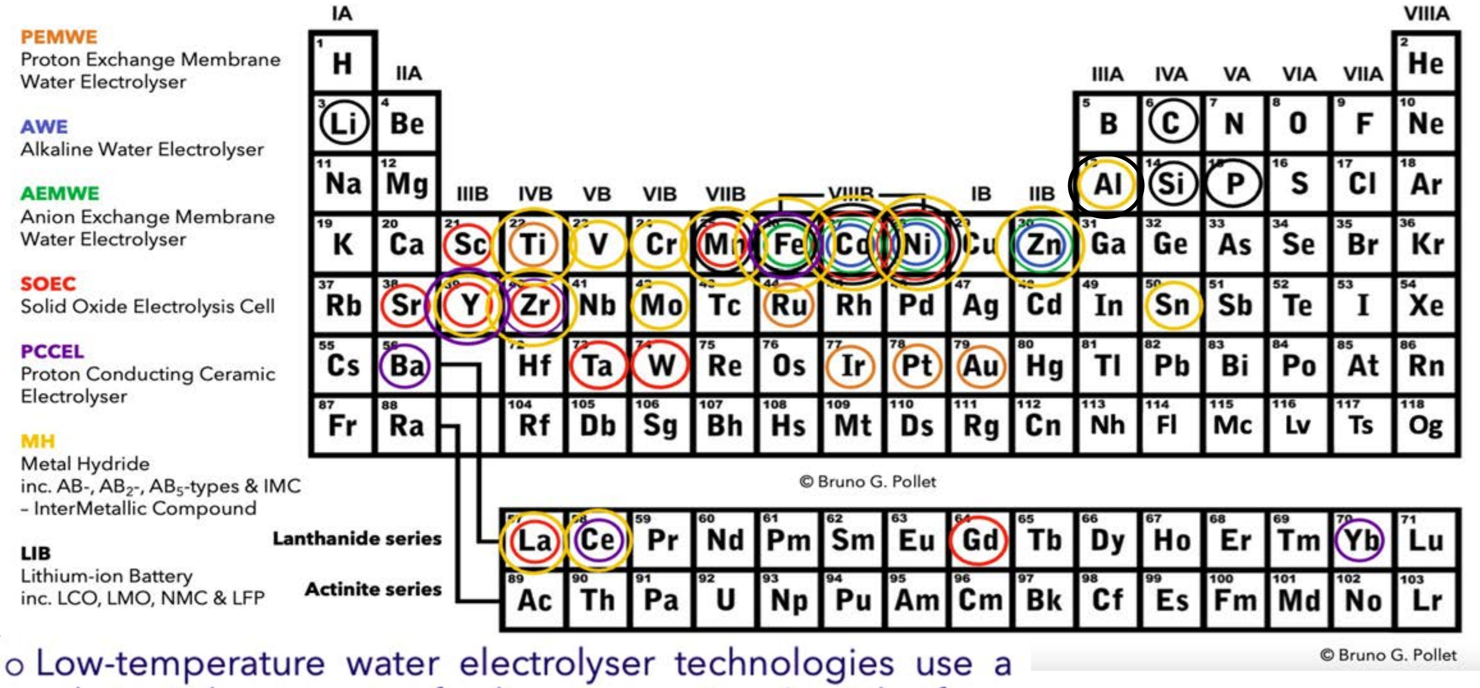

- Low-temperature water electrolyser technologies use a substantial amount of ultrapure water (mainly from freshwater supplies) to produce H_2 (and O_2)
- To produce 1 kg of H_2, 9 times the amount of pure water is necessary, i.e., **9 litres** (assuming 100% efficiency)
- **40 GW** of electrolysers installation by 2030, producing up to **10 m tonnes** of RH_2

40 GW = 10 billion kg of H_2

≈

90 billion litres of pure water

Main Barriers

- Production, transportation, and distribution costs as well as infrastructure development;
- Policy and regulatory framework development and harmonization between regions;
- Lack of market structure and off-takers (demand uncertainty);
- Lack of financial support in the early stage of deployment;
- Access to natural resources; and
- Environmental and safety issues.

The IEA's annual Global Hydrogen Review 2023 (September 2023)

- Commercial interest in LCH2 continues to increase that would potentially deliver a 50% increase over the total identified in last year's report;

- **4%** of projects have achieved **FID** representing a doubling from 2022, why?

  - ✓ Rising equipment and financing costs.
  - ✓ Countries being slow to support projects.
  - ✓ Insufficient government strategies for achieving H_2 targets.
  - ✓ Absence of global standards and certification mechanisms for LCH2.

- The majority of projects will use water electrolysis (WE) and renewable electricity (**71%** or **27 Mt of RH2 production**) and the rest for with CCUS (**29%** or **10Mt**);

- Strong interest in WE - electrolyser manufacturers continue to increase; and

- WE manufacturers have announced large expansion plans, with an annual manufacturing capacity of **155 GW/year** by 2030.

Questions?

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