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Establishing Green Hydrogen Ecosystem in Indonesia

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Hydrogen Road to Global Hydrogen Ecosystem Summit (GHES)
18 March 2025

Pusat Studi Energi
Universitas Gadjah Mada

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Overview

Hydrogen Production

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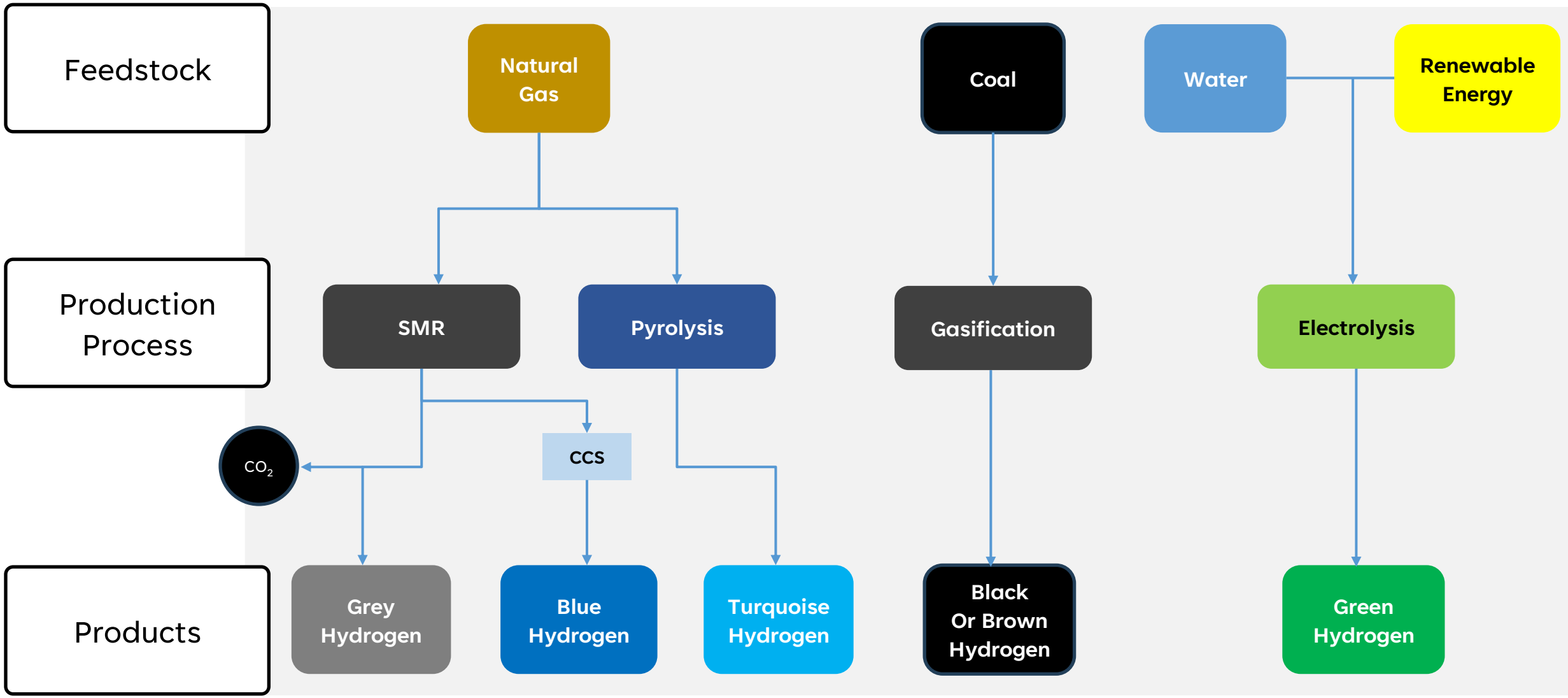
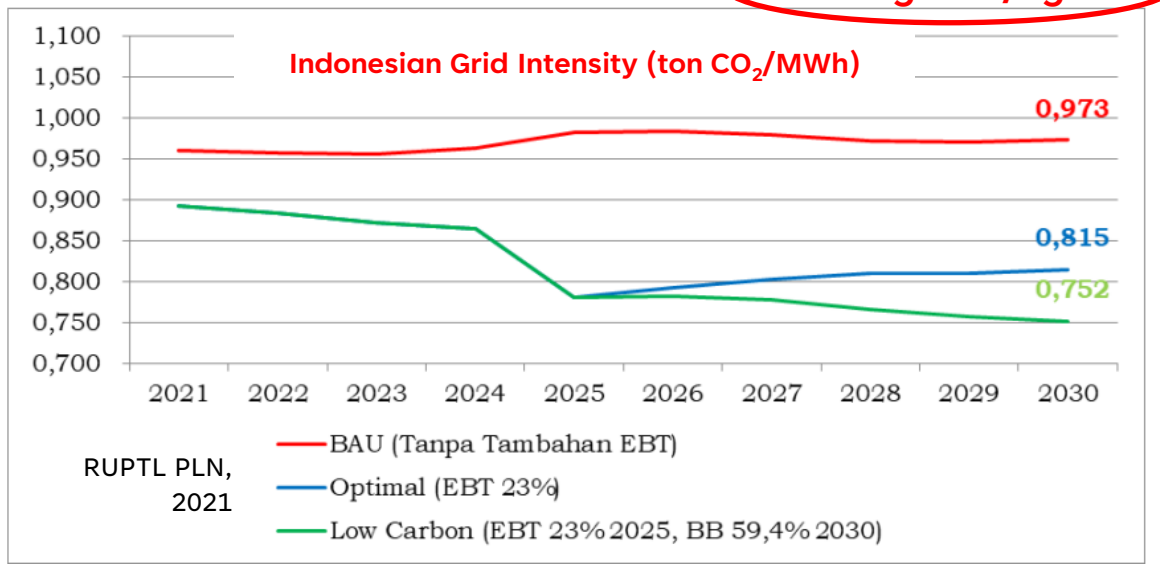


Hydrogen Production

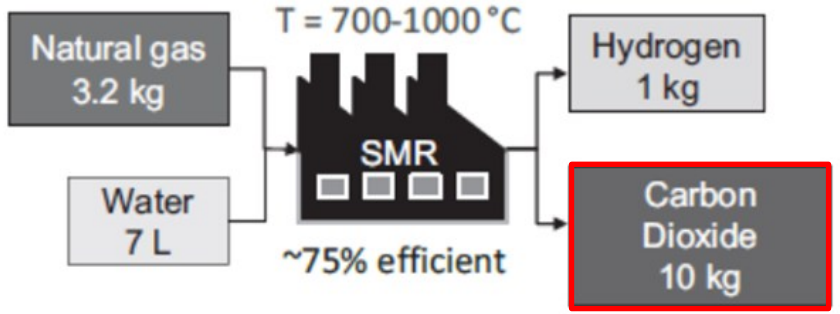
±60.7 kg CO2/kg H2



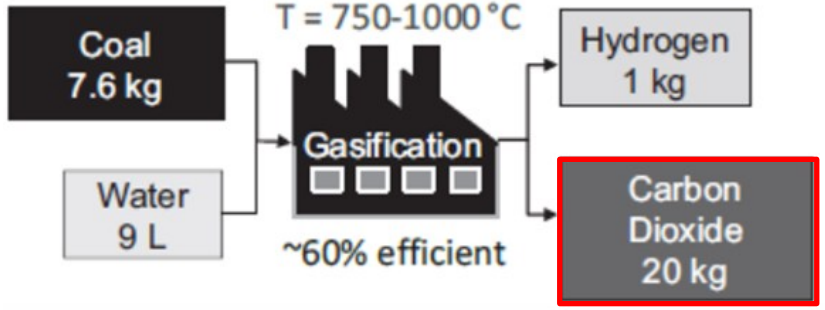
RUPTL PLN, 2021

Renewable energies should be prioritized

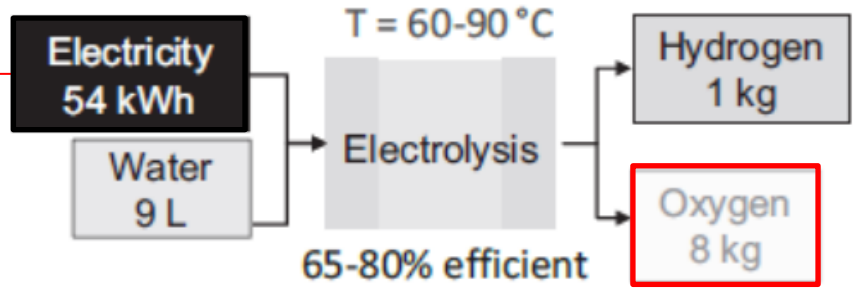
Grey Hydrogen



Black/brown Hydrogen



Green Hydrogen



Hydrogen Economy (Fiona J. Beck, David Gourlay, Michelle Lyons et al., 2021)

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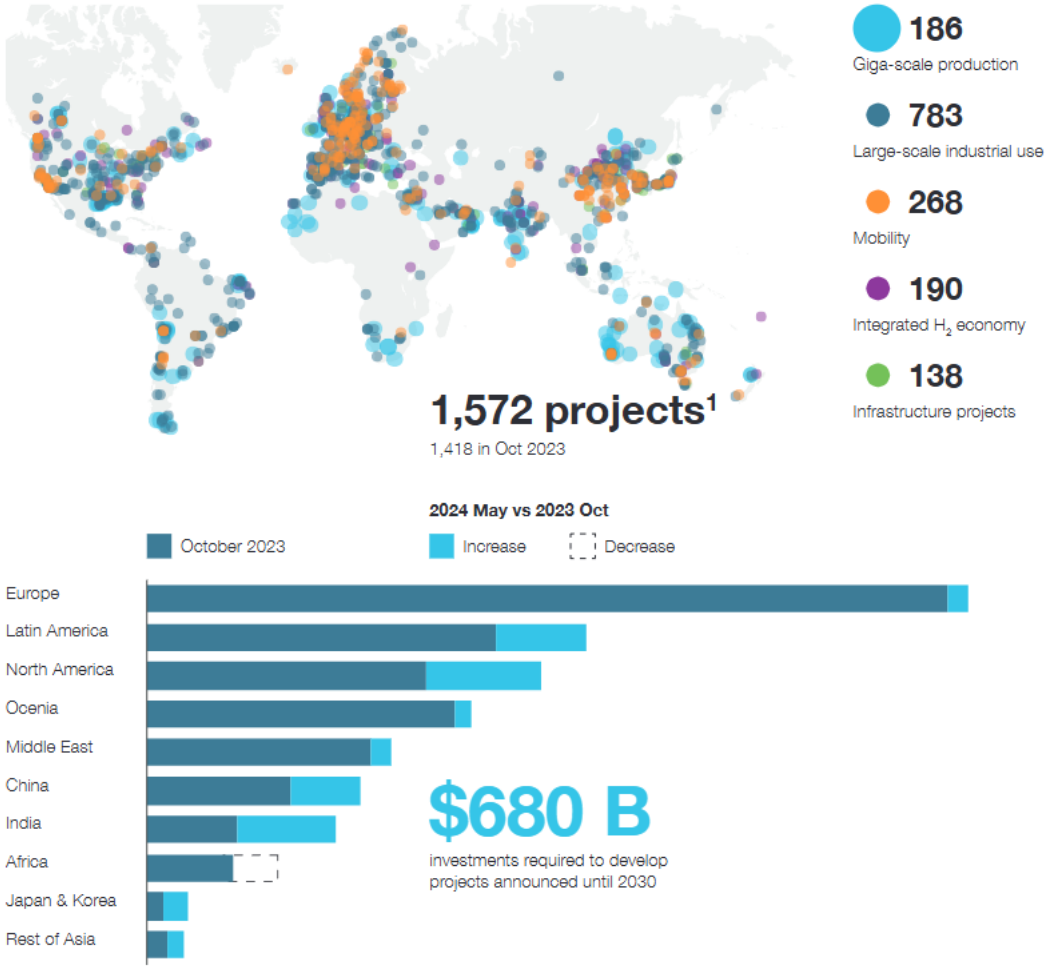
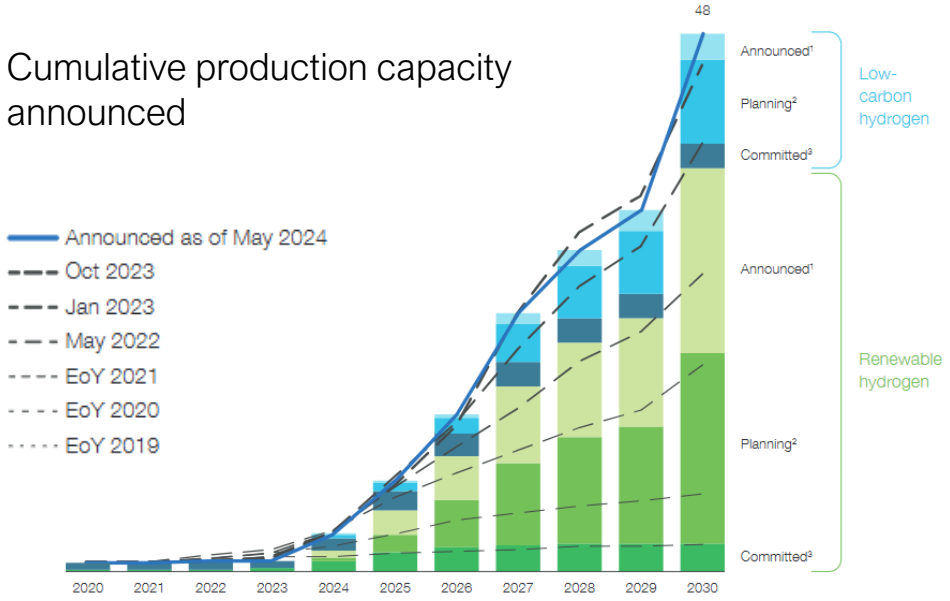
Opportunities

Hydrogen momentum

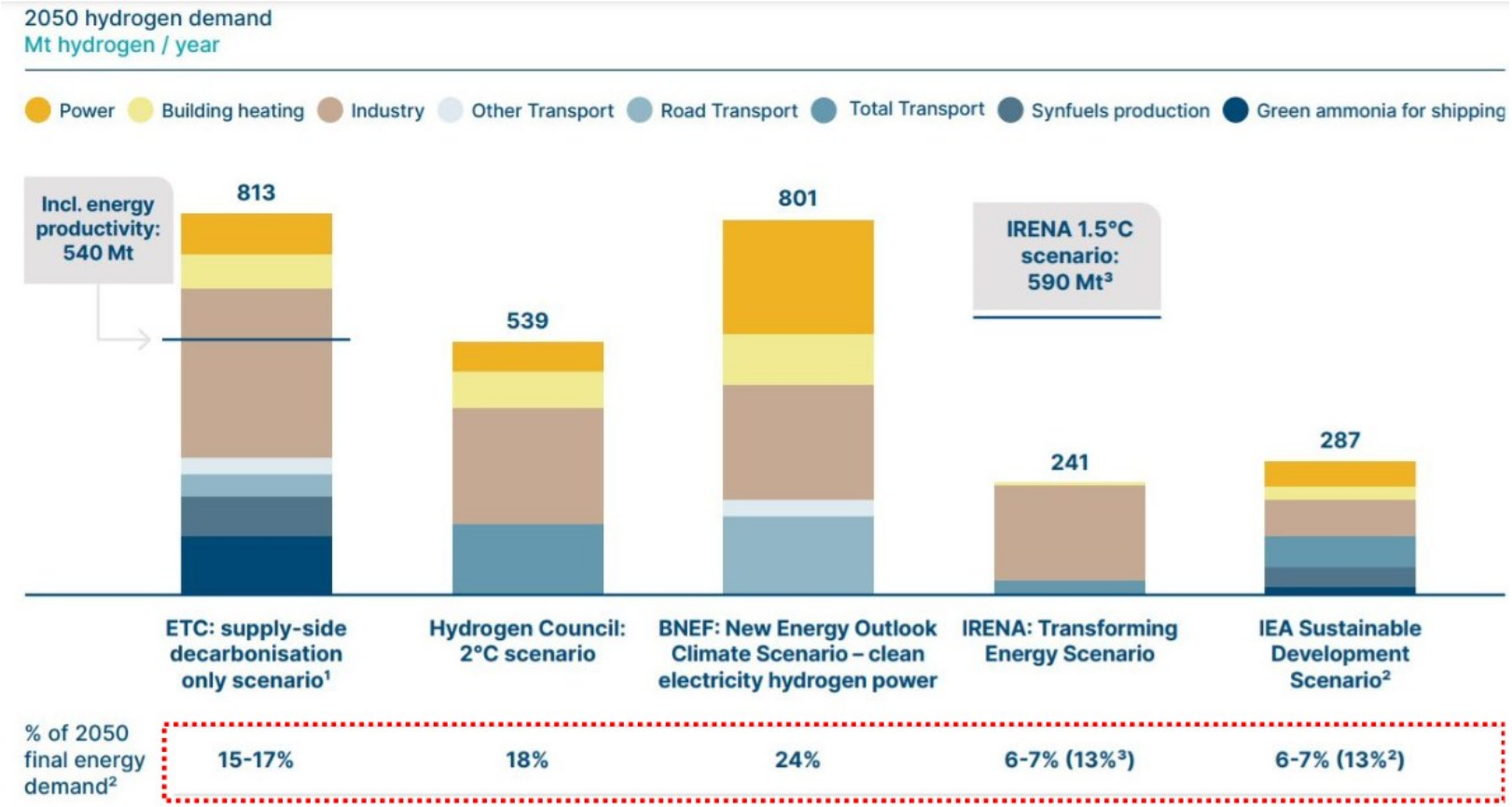


- 1,572 hydrogen projects announced globally
- USD 680 billion direct investments in hydrogen projects announced through 2030 (+20%)
- Companies have announced 48 Mt p. a. of clean hydrogen production capacity globally through 2030



Hydrogen Council (2024)

Hydrogen momentum

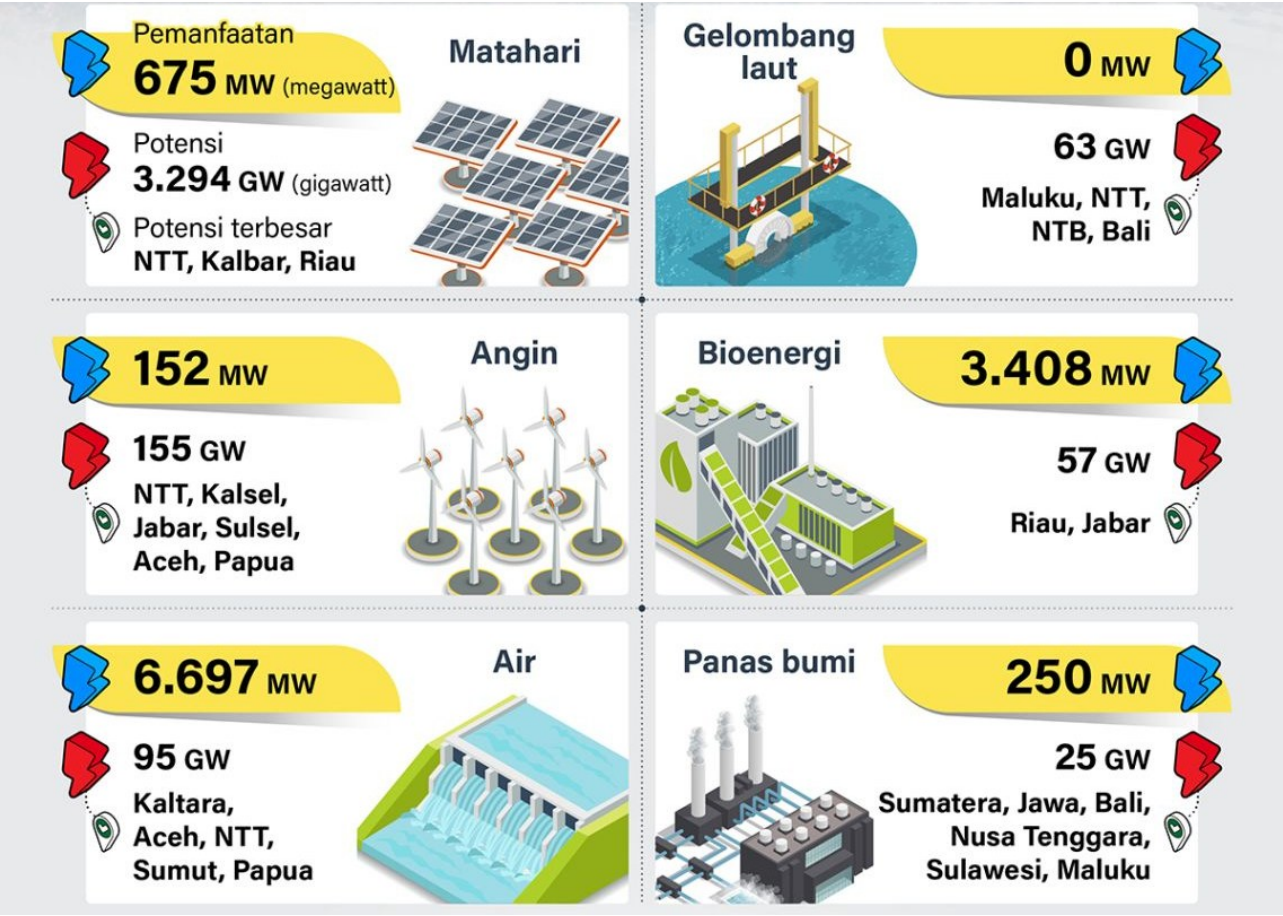


Hydrogen will play a key role in decarbonizing hard-to-abate sectors

All major decarbonization studies and reports project a massive **increase in the amount of hydrogen required** and in new industrial applications

Source: Energy Transitions Commission (2021)

Opportunities for Indonesia



Indonesia possesses vast renewable energy resources, including solar, wind, and hydro, yet their utilization remains significantly underdeveloped

(AntaraNews, 2024)

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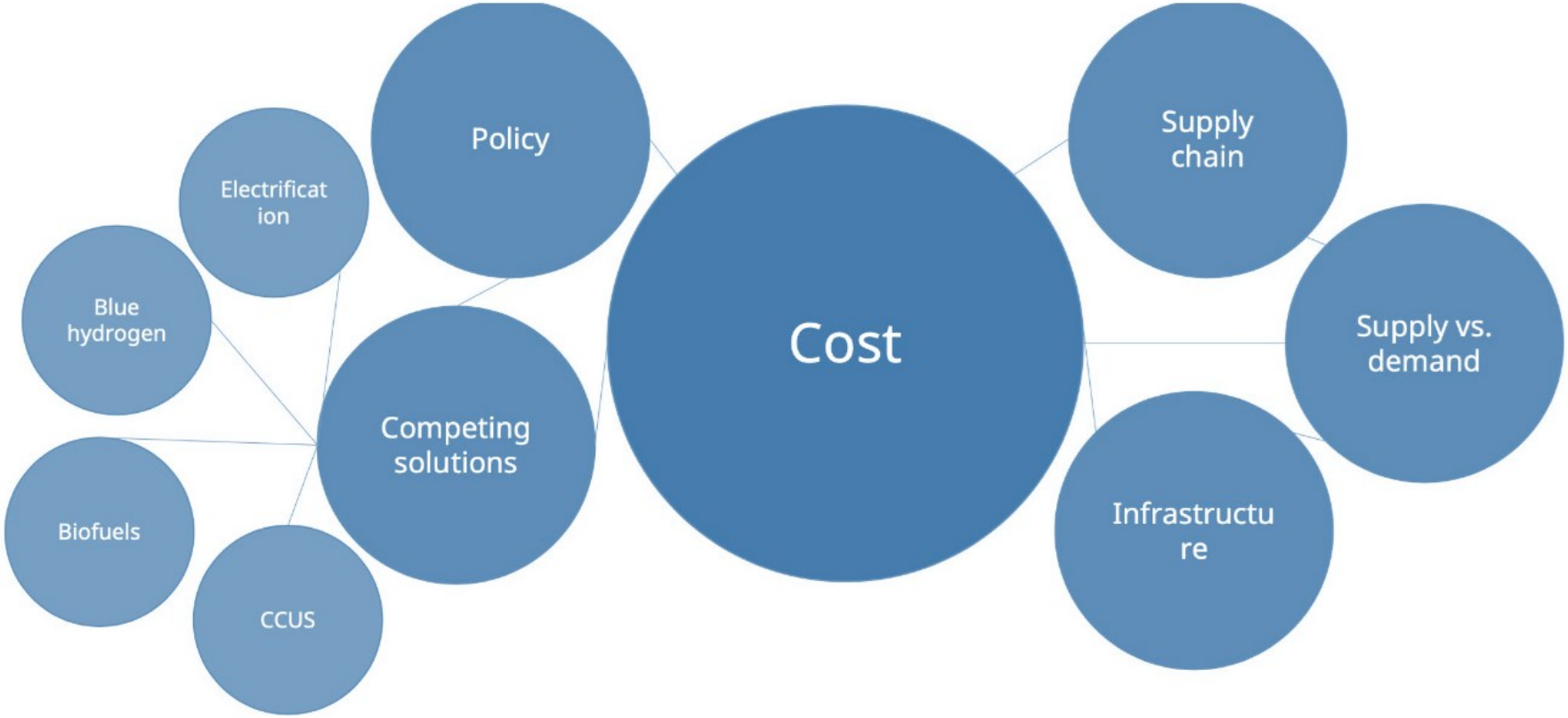
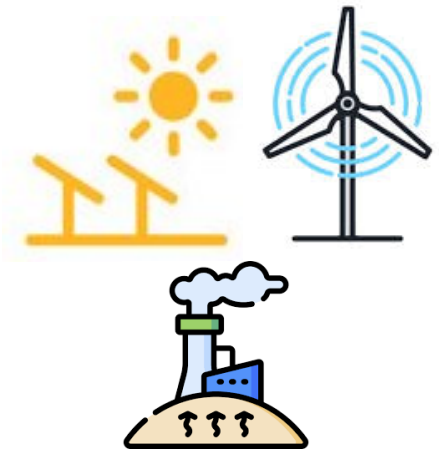
Challenges

Why isn’t green hydrogen fully commercialised and globalized today?



CEC Euroean Managers (2022)



Green Hydrogen Storage

PEM Electrolysis (TRL 9)
Efficiency 83%
1100 USD/kW

Physical Storage
500 USD/kg

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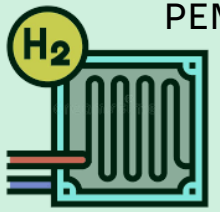
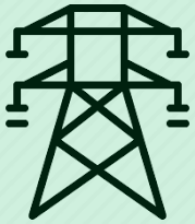
PEM Fuel Cell (TRL 9)
Efficiency 40-60%
58470 USD/25 kW





Thermal power plant
(PLTG,PLTU,PLTMG)
Est efficiency 34%

Li-ion Battery, duration 6 hr
10 MW
Efficiency 95%
390 USD/kWh

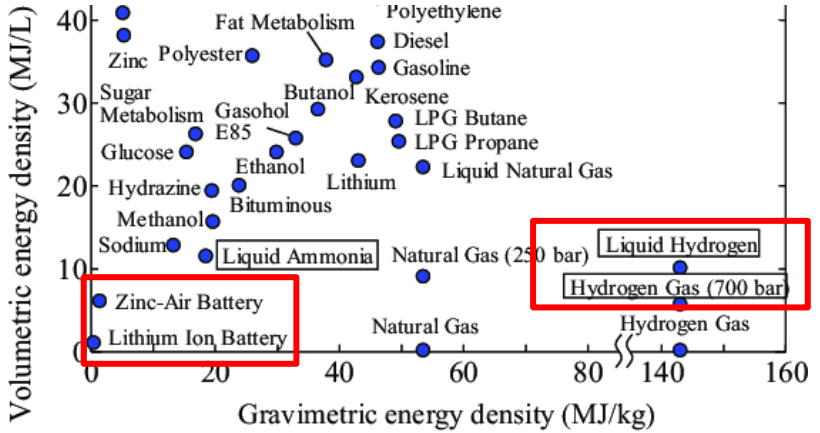
Battery storage

Energy Storage

(Pusat Studi Energi, 2024)

Performance of Hydrogen energy storage considering:

- Lifetime
- Duration
- Space/Area
- Cost



Cost-development of green hydrogen in Indonesia

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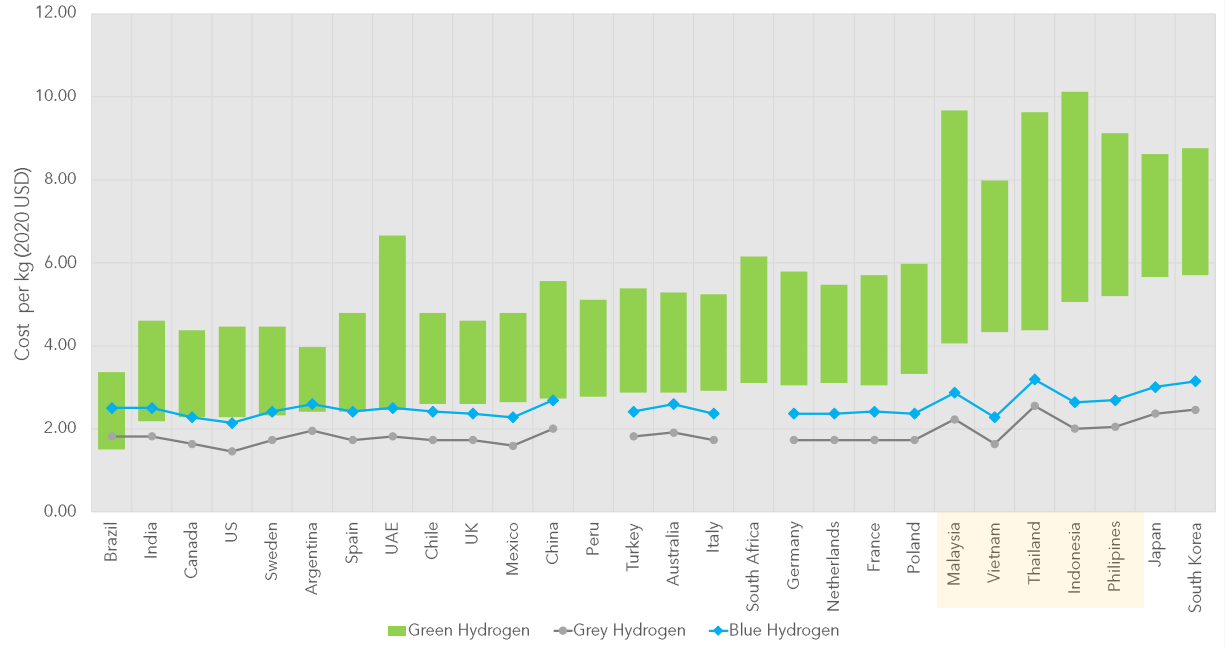
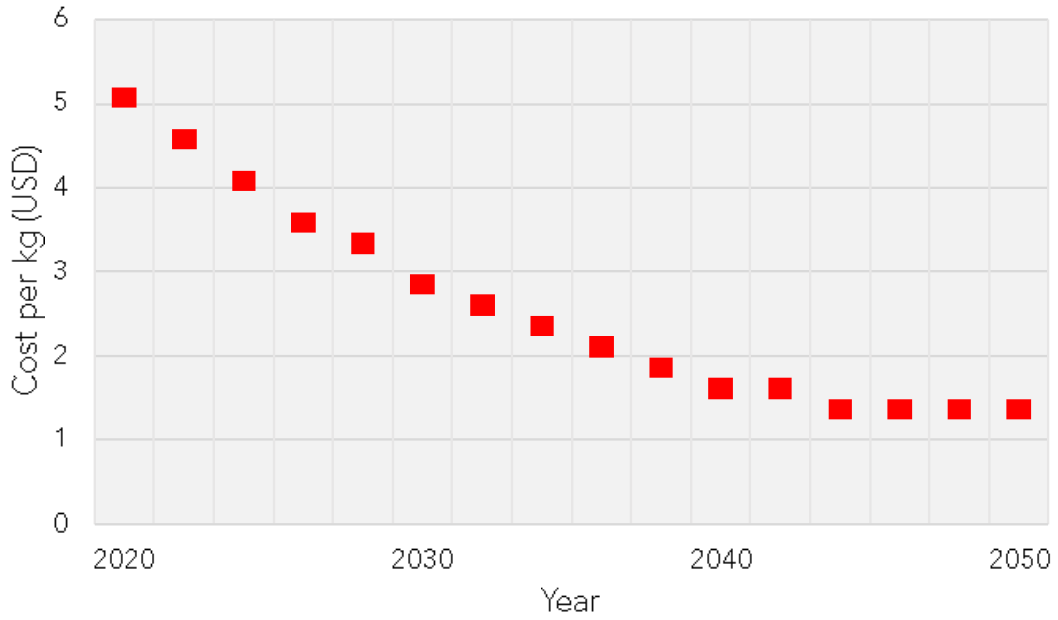
In the range in the range of $5 - $10 per kg based on Bloomberg's estimates



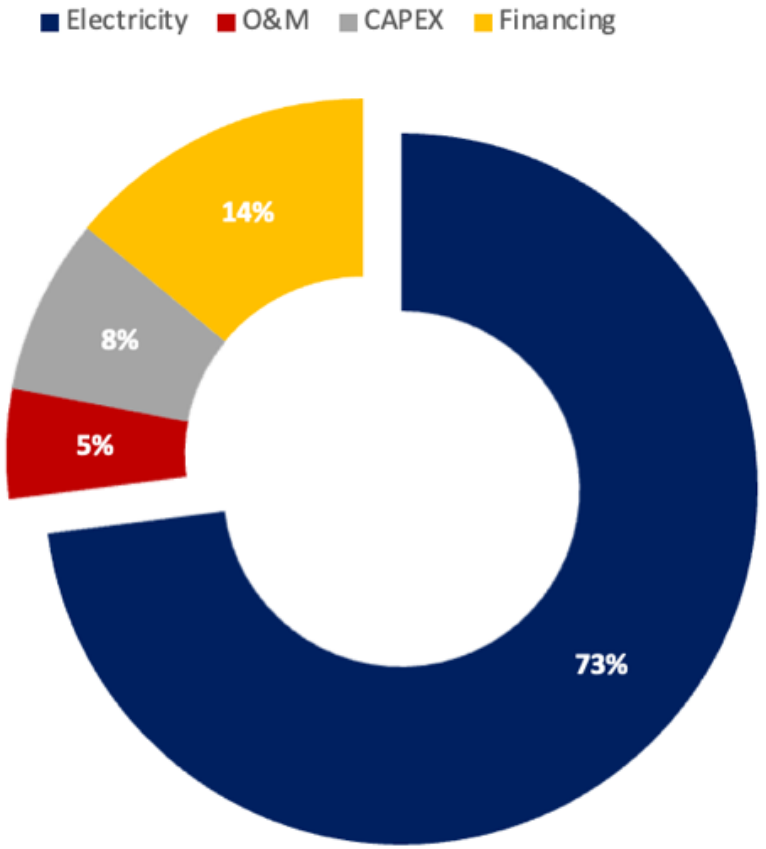
Analyzed based on PWC estimates



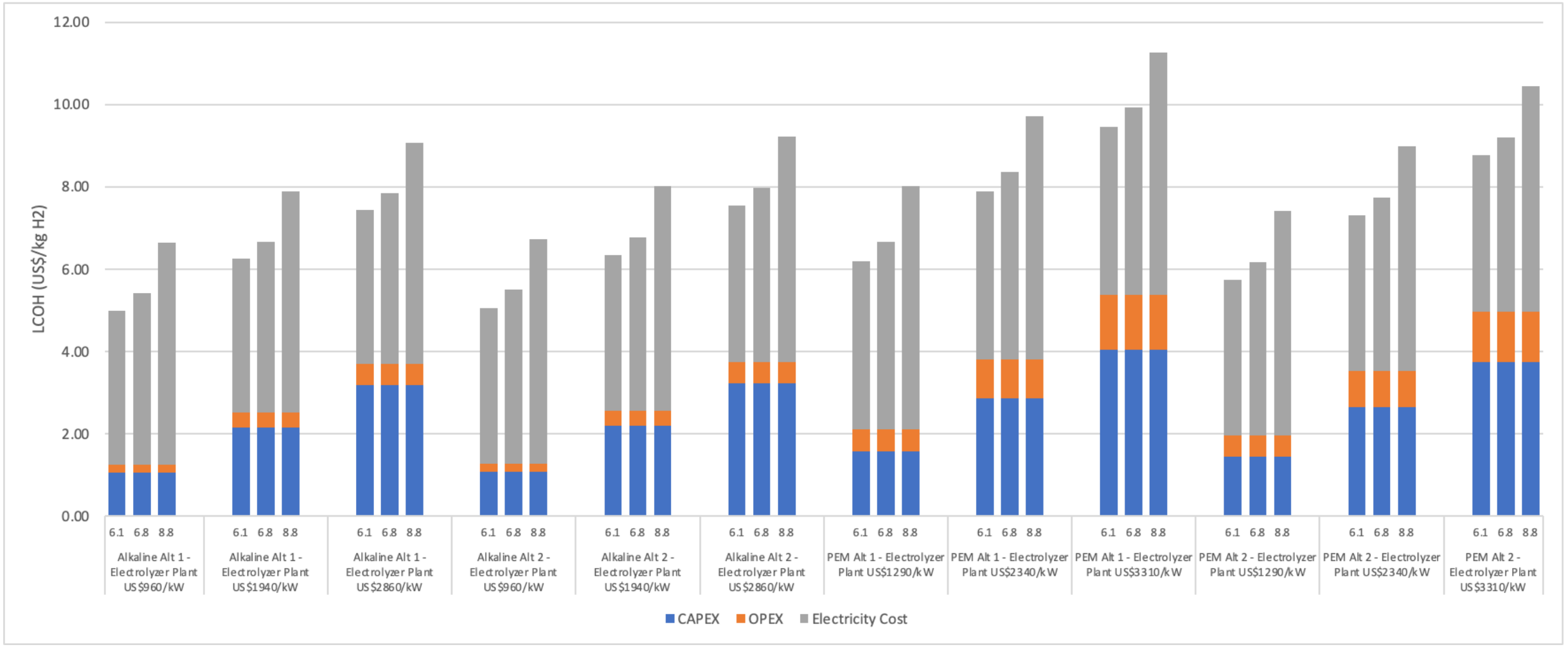
Component cost

The main components of hydrogen production costs consist of **electricity prices**, O&M, CAPEX, and financing costs (OIES, 2022).

The LCOH will vary significantly depending on the price of renewable energy, the location of the green hydrogen project, and the production technology used.

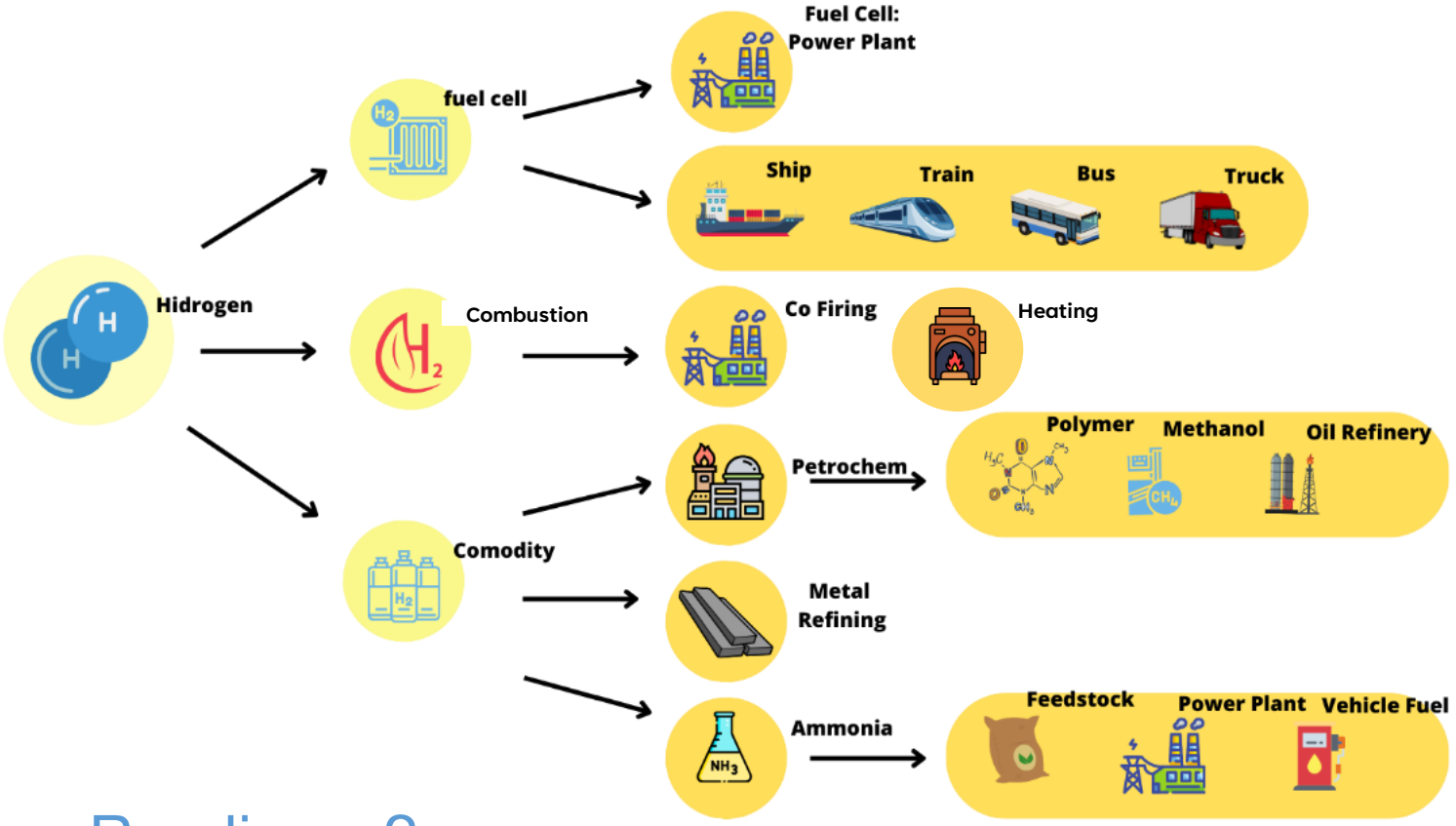


Cost Breakdown LCOH



(Pusat Studi Energi, 2024)

Hydrogen Utilization



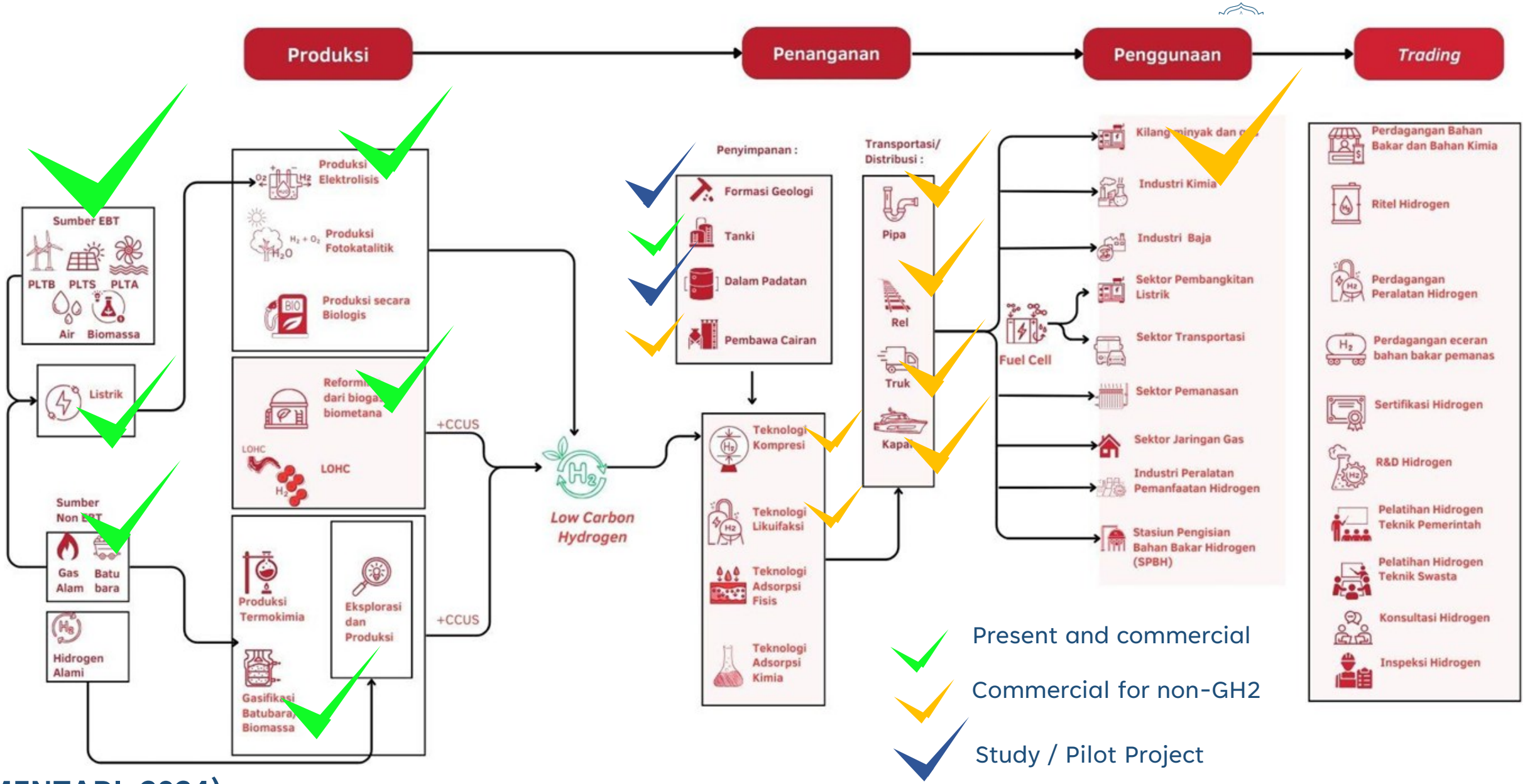
Readiness?

Infrastructure?

1. **(Energy) Fuel Cell:**
   - Producing environmentally friendly electricity.
   - Can substitute the fossil fuel combustion in marine vessels, rolling stocks, heavy duty land vehicles to reduce direct emissions.
2. **(Energy) Direct combustion:**
   - Power generation purpose to substitute fossil fuel and to reduce dependency of fossil fuel.
3. **Feedstock/Commodity:**
   - Metal refining to increase efficiency and to reduce emissions.
   - Green hydrogen-based ammonia potentially could be an energy storage for excess renewable energy generation, power plant fuel, and vehicle fuel in general. Ammonia is also a crucial feedstock for the fertilizer industry.
   - Hydrogen could change chemical production and fuel replacement in petrochemical sectors.
   - Hydrogen has a critical role in producing polymers
   - Could be used to produce methanol for a more sustainable pathway.
   - Could increase the fuel quality and reduce emission at the oil refinery.

(Pusat Studi Energi, 2024)

Green Hydrogen value chain in Indonesia



(MENTARI, 2024)

Supply chain alternatives (Green H_2)

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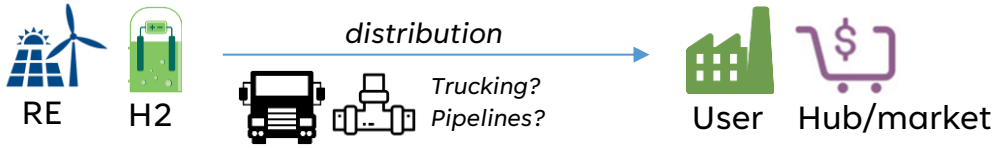
Existing ideas



H2 plant built near RE facilities. **H2 as output is distributed** to user through distribution channels such as trucking, pipelines.

Alt 1

H2 plant built in user facilities and produced using electricity generated by RE (**validated by green certificates**) which distributed using existing transmission.

Alt 2

H2 plant built in user facilities and produced using electricity generated by RE which distributed using dedicated transmission (must be developed if not exist yet). **Green certificate not required** for the alternative.

Alt 3

User facilities built close to RE and H2 plants. Require **relocation of factories** which may result in farther hub/market to distributed the user products.

(Pusat Studi Energi, 2024)

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Strategies

Realizing the market potential of green hydrogen production

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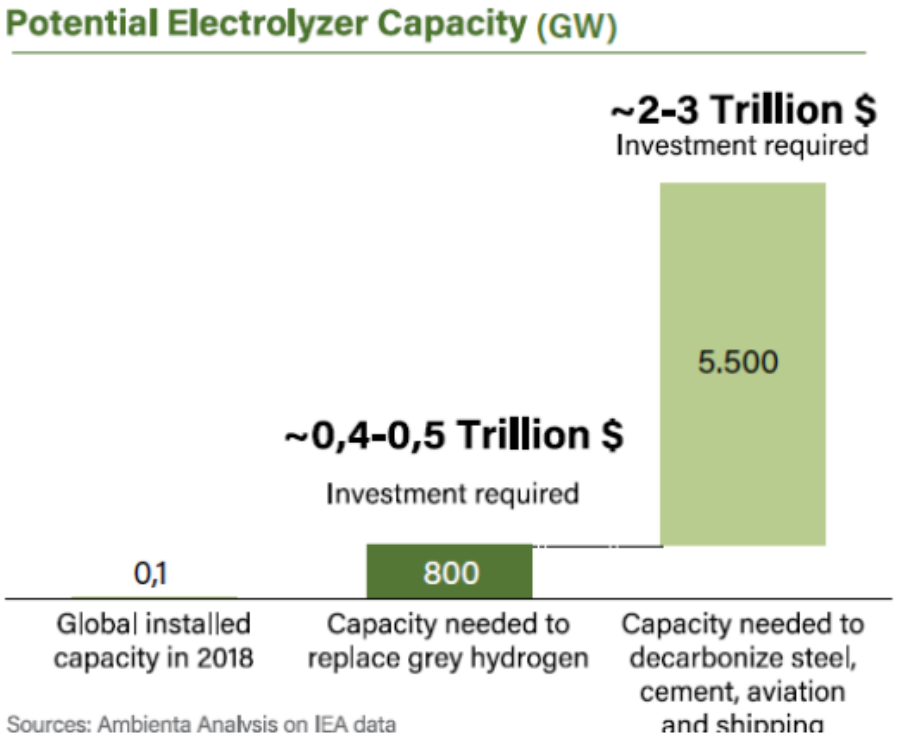

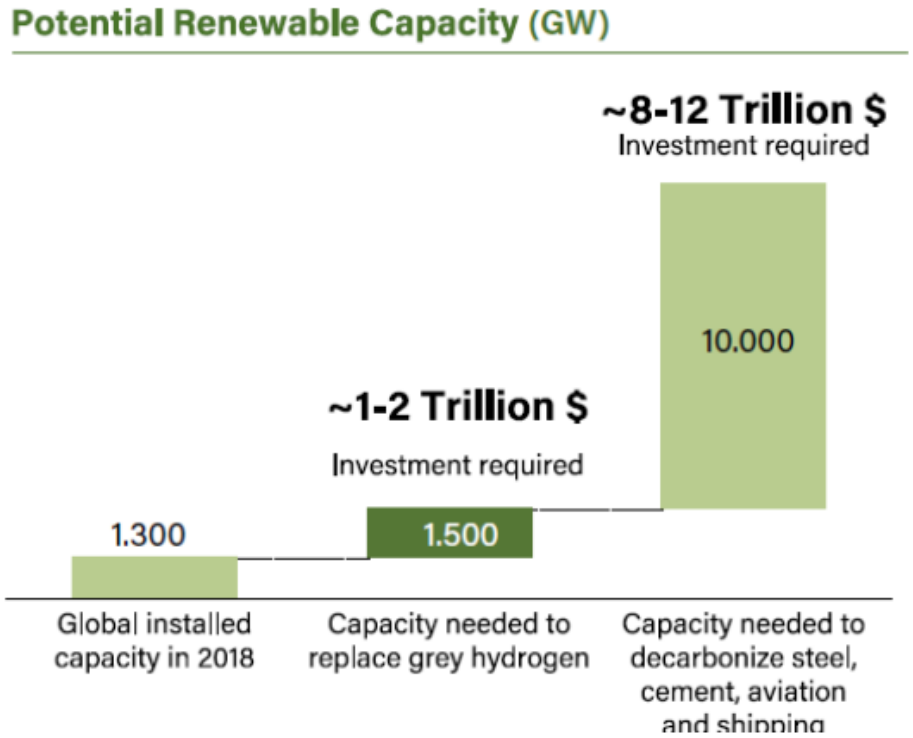

To replace grey with green hydrogen, we need **800 GW of electrolyzer capacity** and **3,500 TWh of electricity** (about 1,500 GW of additional renewable capacity installations).

CEC Euroean Managers (2022)

Reducing cost of green hydrogen

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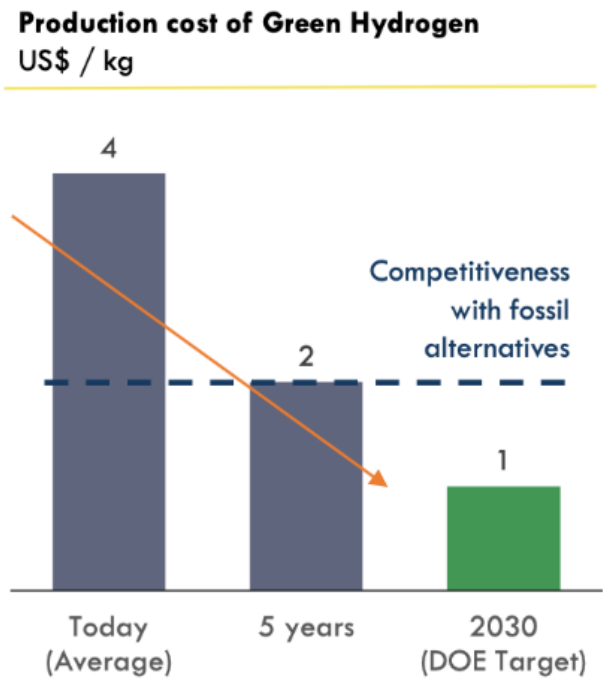

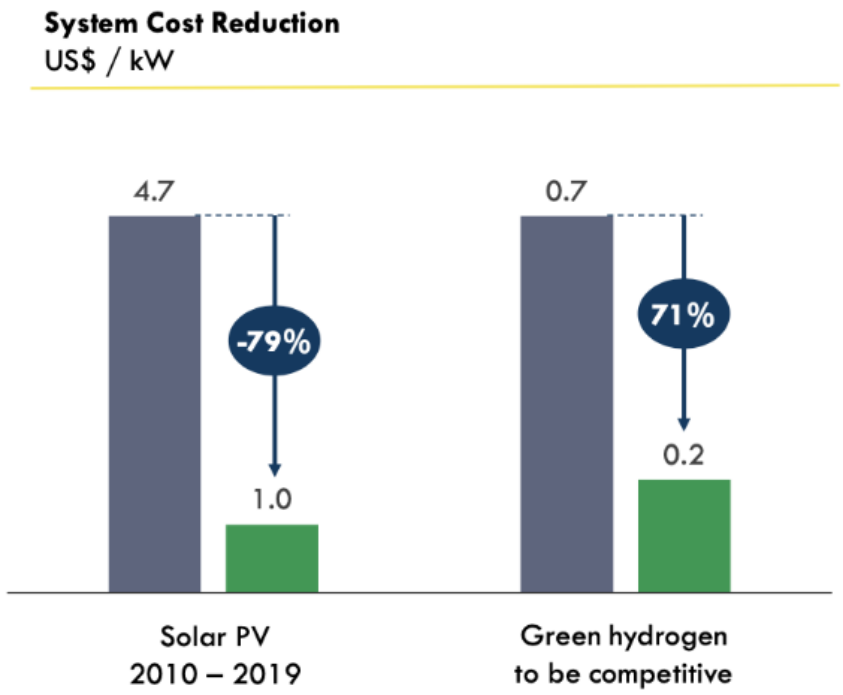

Need to reduce green hydrogen cost across the value chain

CEC Euroean Managers (2022)

Prioritizing Hydrogen Utilization

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	Recommended	Conflicting	Not Recommended
Agora Energiewende and Agora Industry (2024)	ammonia, steel, chemical, fertilizer, marine (long haul), aviation (long haul), back up energy, feedstock	heavy duty, train, high temp heat, aviation (short haul), marine (short haul)	light duty, building heating, low temp heat, 2 and 3 wheelers
Energy Innovation (2024)	ammonia, steel, chemical, refining, marine (long haul), aviation (long haul), back up energy	seasonal storage, aviation (short haul)	heavy duty, light duty, building heating, high temp heat, marine (short haul), day to day power generation
PSE' calculation	→ Cost-effectiveness Analysis (next)		

(Pusat Studi Energi, 2024)

Prioritizing Hydrogen Utilization

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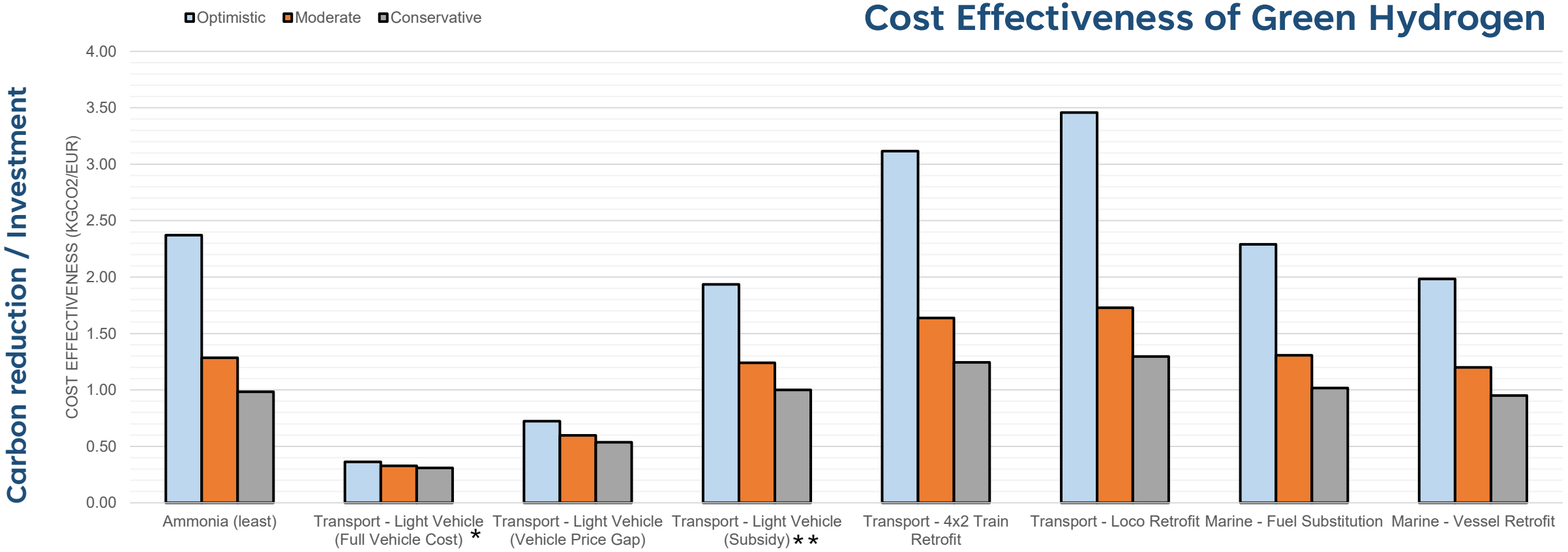
Cost Effectiveness of Green Hydrogen



*Fuel Cell Government Vehicles
** Fuel Cell vehicles receive EV subsidy

(Pusat Studi Energi, 2024)

Going forward

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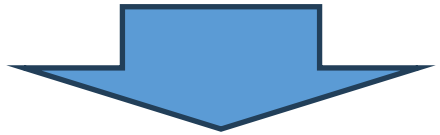
- Capture the momentum for green hydrogen
- Reducing green hydrogen cost to be competitive with grey hydrogen
  - Currently green hydrogen cost 3-5x grey hydrogen, more than half of the cost is due to electricity
- Prioritizing sectoral utilization of green hydrogen
  - Best for Industrial feedstock and heavy duty transport
- multiple scenarios for development of green hydrogen ecosystem and optimizing the pathway



Enabling regulatory framework

Create demand for green hydrogen

- Hydrogen taxonomy and standardization
- Upstream, midstream and downstream governance
- Incentives for green hydrogen
- Carbon cap and trade , carbon tax