Green Hydrogen

Hydrogen's role in a decarbonized economy

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RENEWABLE ENERGIES, ENERGY EFFICIENCY and CLIMATE CHANGE

SPECIAL FOCUS ON EURO-MEDITERRANEAN-AFRICAN INTEGRATION

Introduction

- Why are we talking about hydrogen at a renewable energy seminar?

  Electric energy will be produced, in the immediate future, from renewable sources but, for the moment, there are no non-polluting solutions that can replace fossil fuels as fuel for industry and heavy transport.

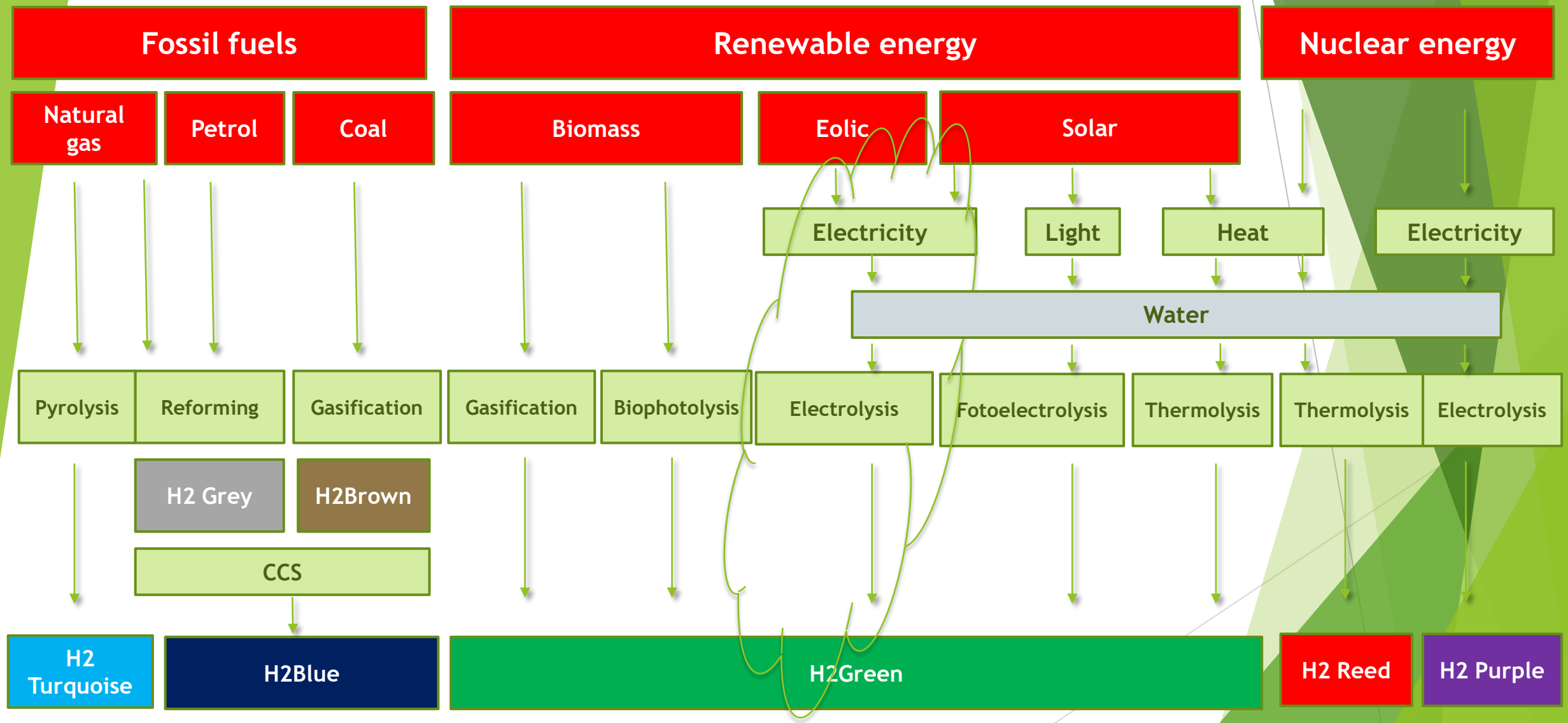
  Industry consumes 37% of final energy and heavy transport 20%. An alternative solution to fossil fuels, which does not yet exist, must be sought for these sectors, which constitute 57% of the final energy consumed.

  It seems that hydrogen could become that solution….

Hydrogen

- Hydrogen is the most abundant chemical element in the universe but, unfortunately, it's not possible to find it free in our planet.
- To obtain hydrogen it's necessary to split a molecule that contains it. Methane (CH_4) and water (H_2O) are the most common molecules used to make it.
- Hydrogen is the element that has the highest calorific value by unit mass (142 MJ/kg) and it's the lightest (0,0899 kg/m^3 under normal conditions)
- Hydrogen has 3,5 more energy by mass unit that petrol and natural gas.
- Hydrogen is not a fuel, it is an energy carrier. Energy is needed to produce it and it returns energy when it oxidizes.
- Hydrogen can be used: in fuel cells to produce electricity, oxidized in conventional burners or used, reacting with carbon monoxide, to produce synthetic fuels.

Types of hydrogen

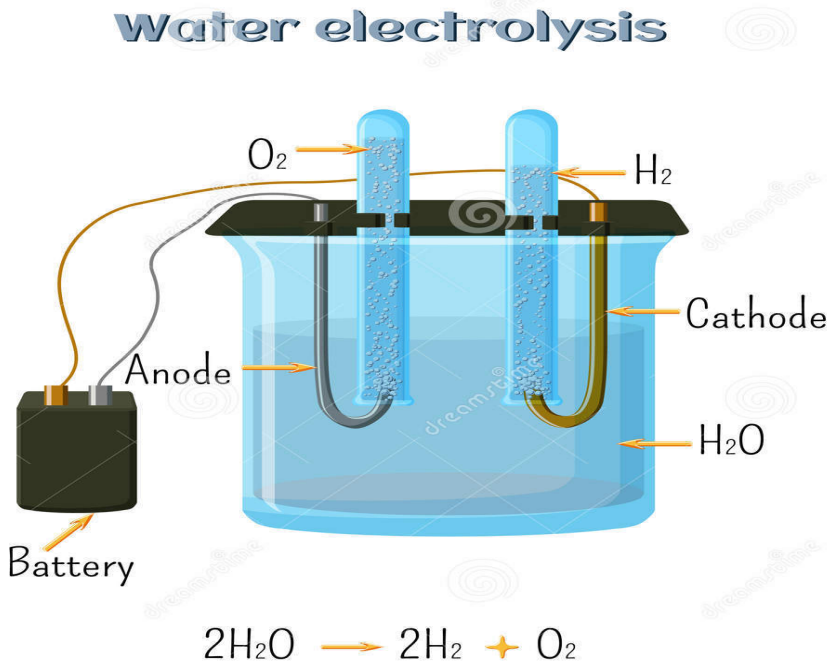


Types of hydrogen

There are different types of hydrogen, depending on the sources and their production methods.

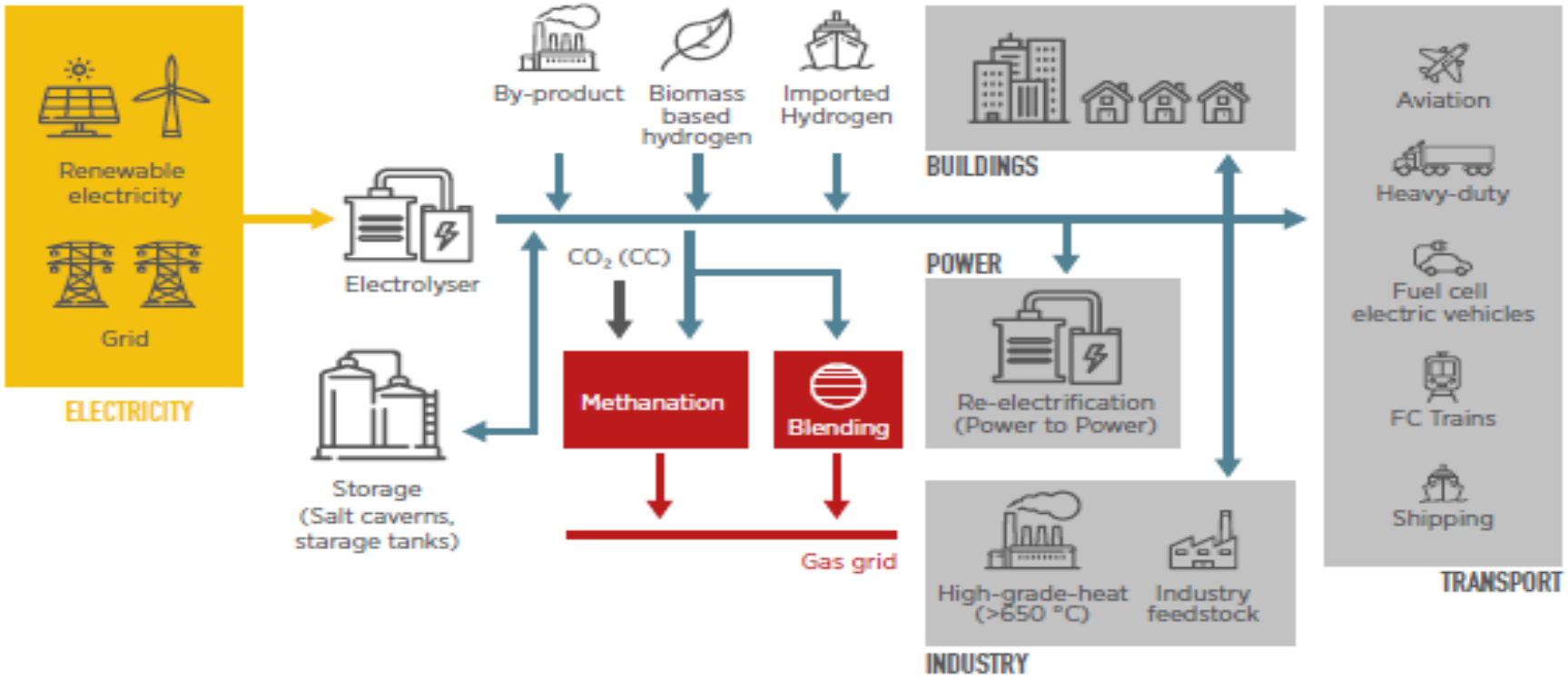
Grey hydrogen	***Blue hydrogen***	***Green hydrogen***
Split natural gas into CO_2 and hydrogen	Split natural gas into CO_2 and hydrogen Residual gasses also in H-vision scope	Split water into hydrogen by electrolysis powered by wind and sun
CO_2 emitted in the atmosphere	*CO_2 stored or re-used*	*No CO_2 emitted*

Green hydrogen production

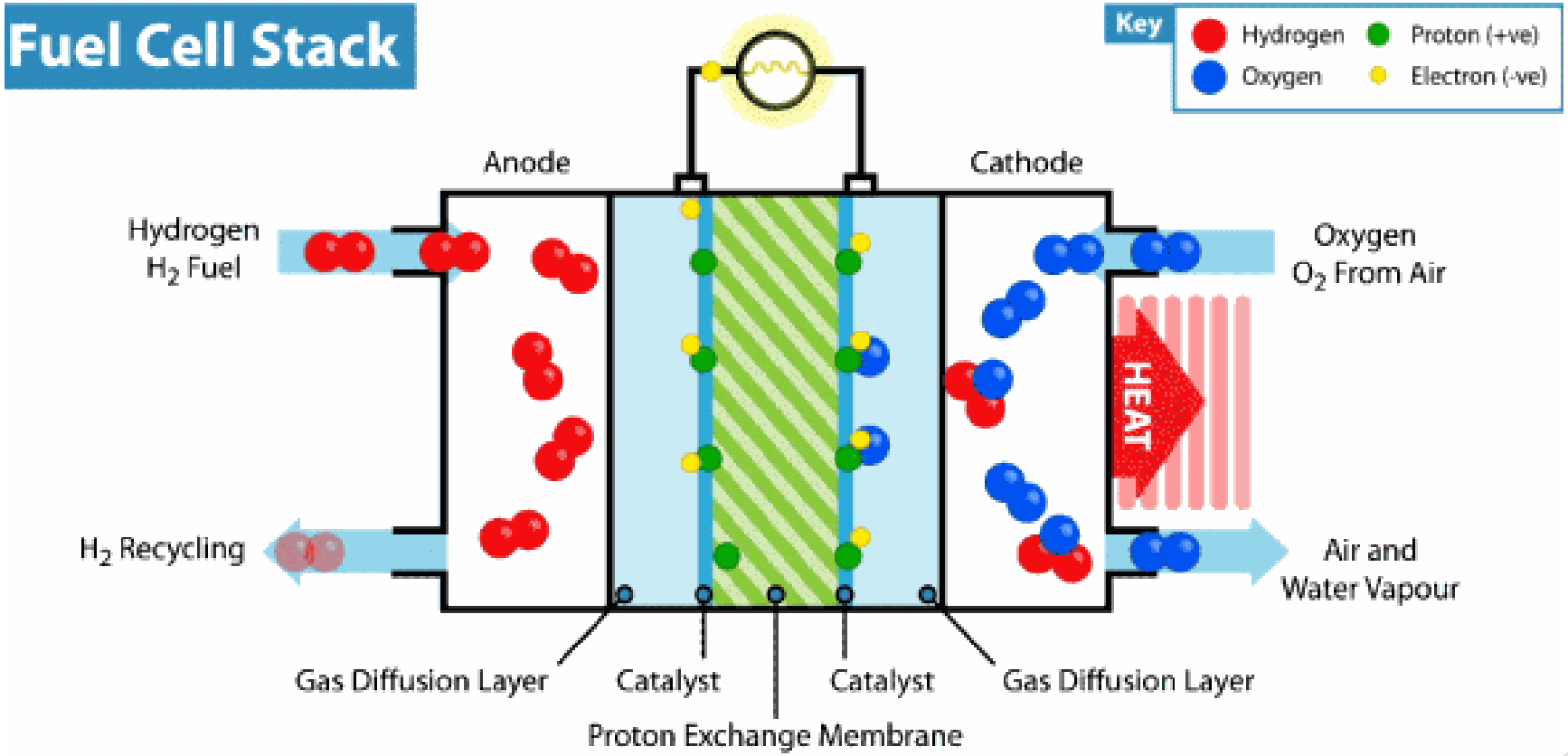


To produce 1 kg of H_2 of green hydrogen it's necessary to use 45 kWh of electricity (the process efficiency is about 85%)

What can be done with green hydrogen?

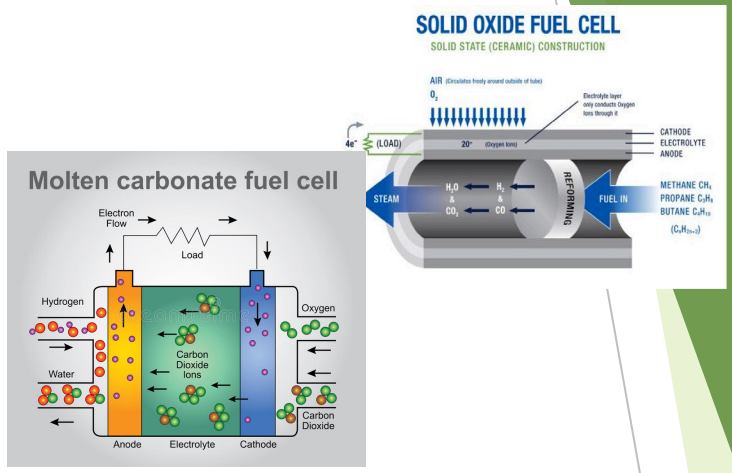


Fuel cell principle



The efficiency of a fuel cell depends on the technology used and can range between 40 and 70%

Types of fuel cells



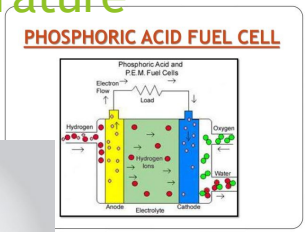
Efficiency

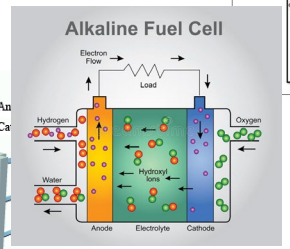
0,6

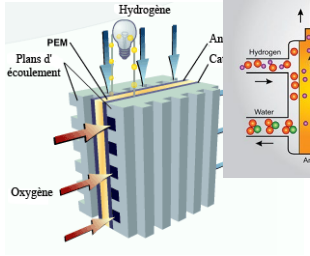
0,5

0,4

Low temperature



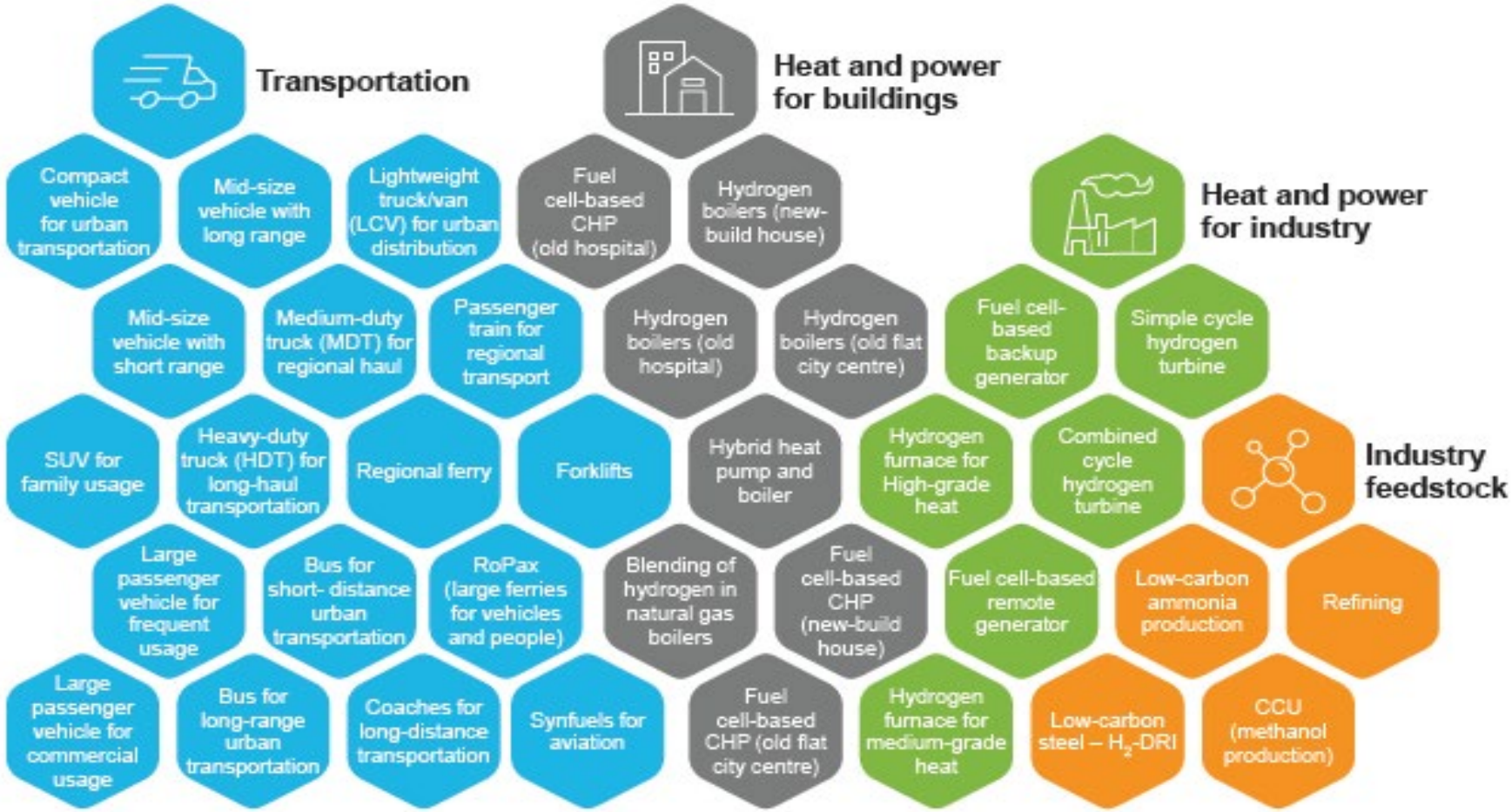




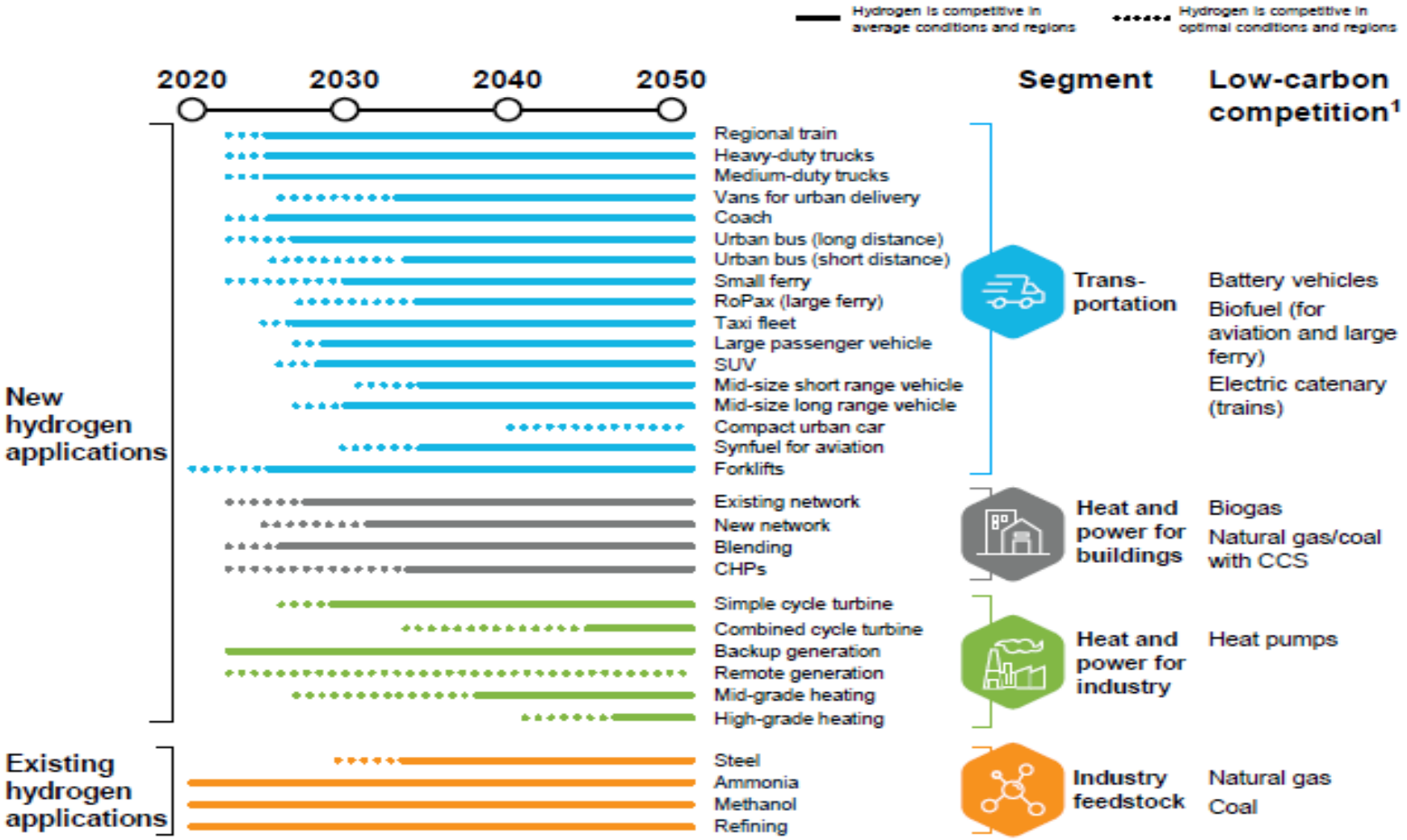
High temperature

100 200 300 400 500 600 700 800 °C

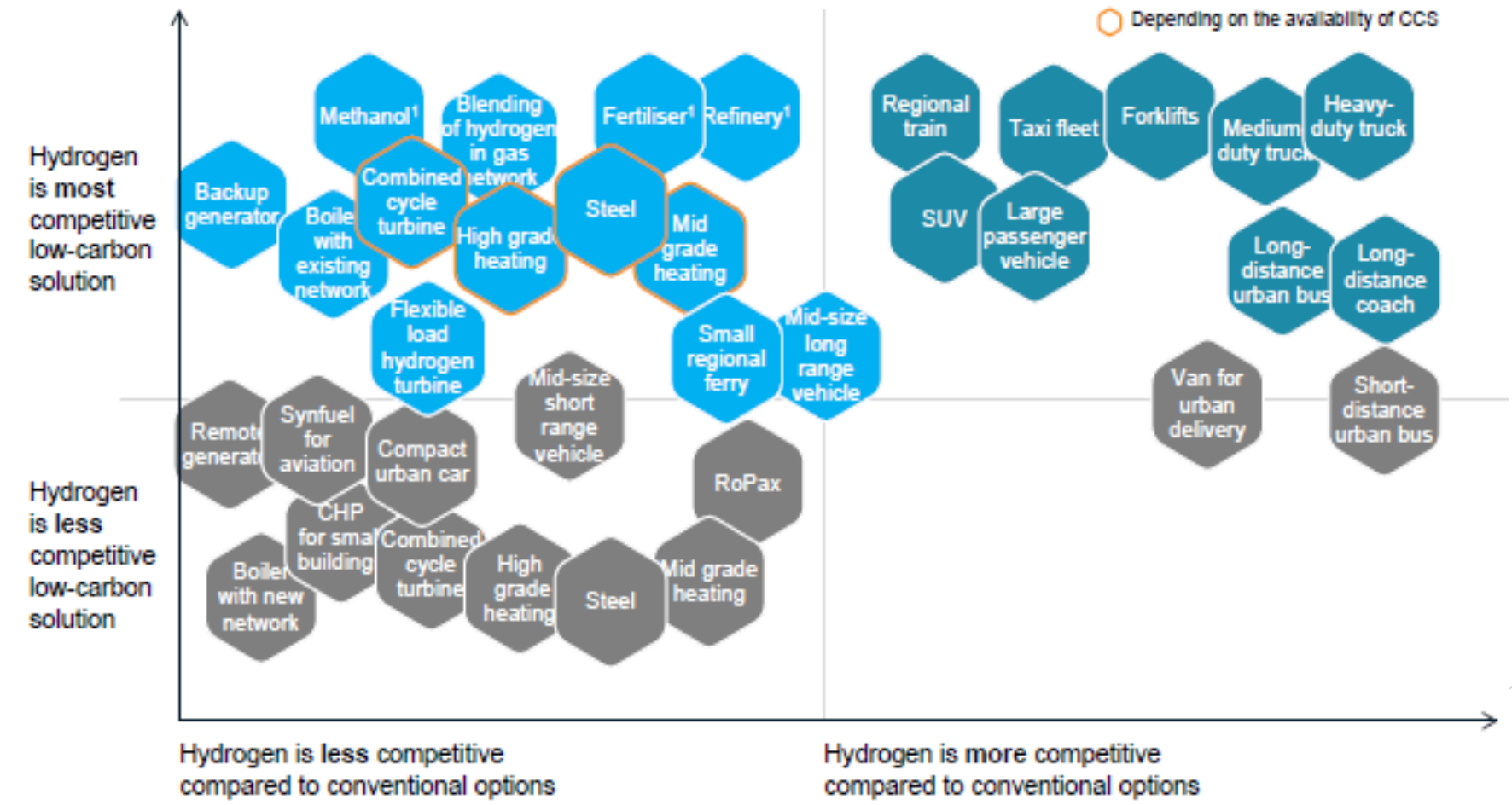
Overview hydrogen applications



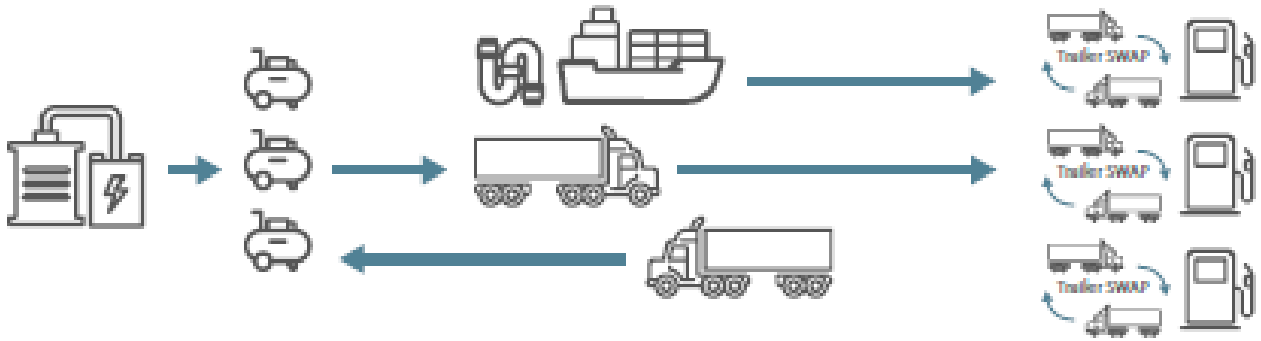
Cost competitiveness trajectories in hydrogen applications



Competitiveness of green hydrogen vs low carbon and conventional alternatives

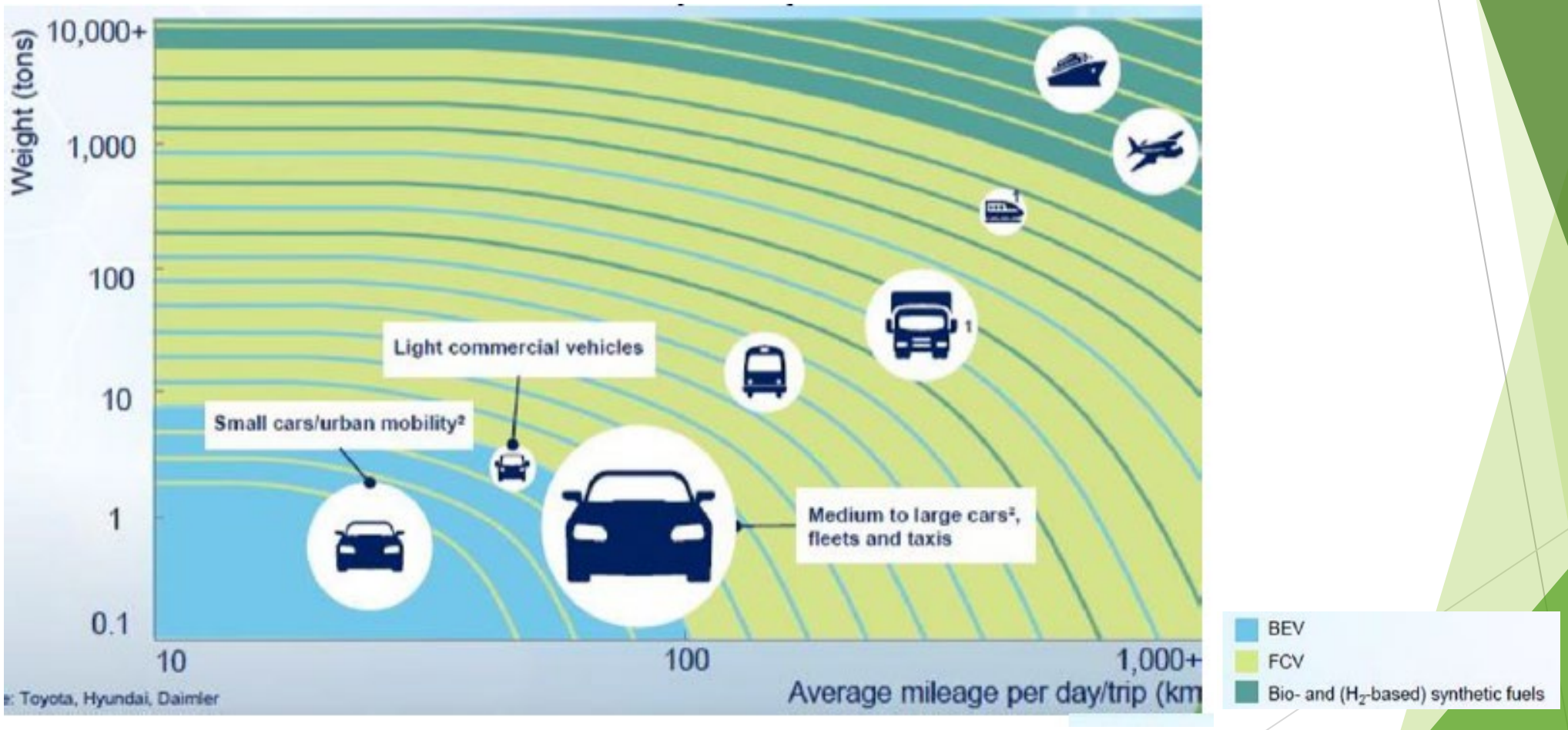


Evolution of the cost of green hydrogen

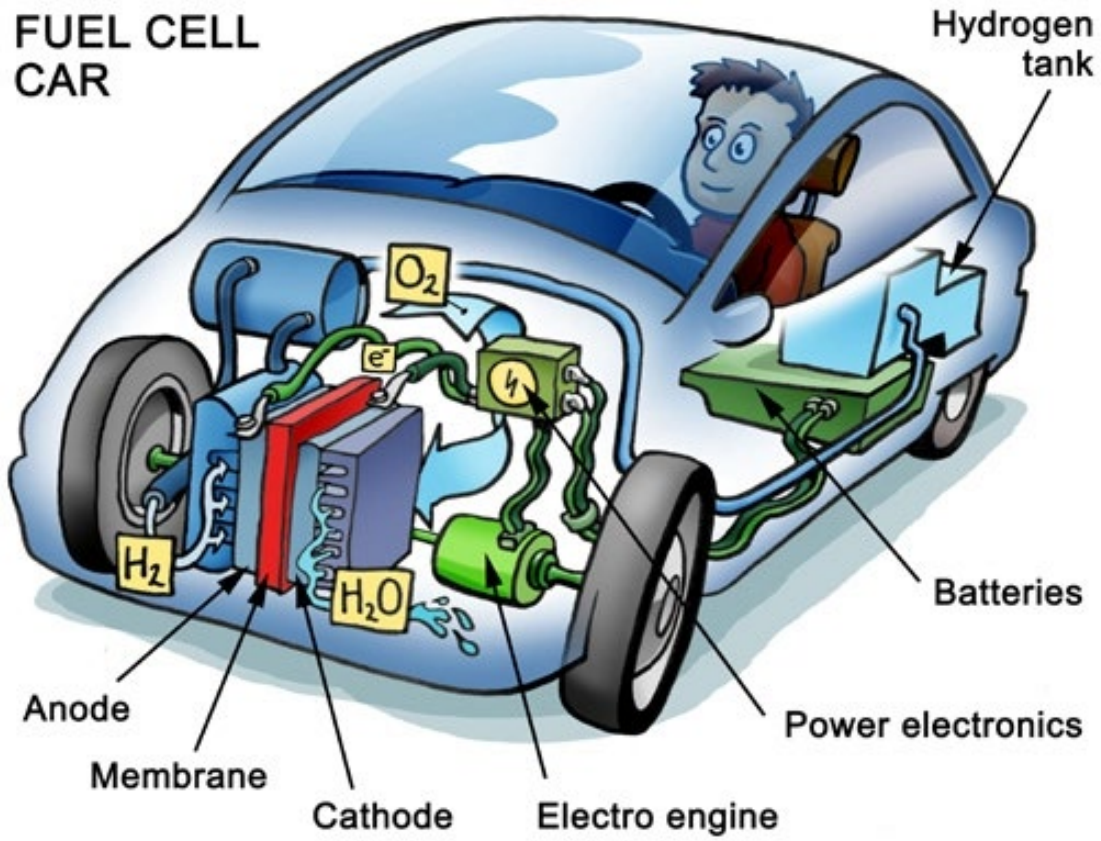


	H_2 production	H_2 compression	H_2 logistics	H_2 distribution
Cumulated supply chain cost – current estimate	5–6 $/kg	$$	$$	13–16 $/kg
Cumulated supply chain costs – targets (Europe)	1–3 $/kg	$	$	3–7 $/kg

The future of mobility



Possible use of fuel cells



Fuel cell trucks

Hyundai's h2 xcient fuel-cell truck

Kenworth T680 Day Cab Drayage Truck powered by Ballard FCveloCity(R)-HD module

World's first hydrogen train rolls out in Germany

Commuters in Germany now have a chance to ride the world's first hydrogen train as the country moves to replace old diesel-powered engines. Instead of exhaust fumes, hydrogen trains produce only water.

Two Coradia iLint engines will replace diesel trains on the 100-kilometer (62-mile) route linking the towns of Cuxhaven and Buxtehude, with 14 other hydrogen trains set to be introduced across the state by 2021. The new-type engines are produced by the French company Alstom.

Wind Farm cost effectiveness

- Wind Farm Power 100 MW
- Investment 140 M$
- Energy Production 250 GWh/year
- Energy Sold 200 GWh/year
- Energy Lost 50 GWh/year
- Income 12 M$/year
- Pay-back 11,67 years

Data:
Unitary cost Wind Farm 1400 $/kW
Wind Farm productivity 2500 h/year
Energy sales ratio 80%
Energy sale price 60 $/MWh

Wind Farm+H2 Production cost effectiveness

- Wind Farm Power 100 MW
- Electrolyser Power 20 MW
- Investment 140 M$ + 10 M$ = 150 M$
- Energy Production 250 GWh/year
- Energy Sold 200 GWh/year
- Energy for H2 50 GWh/year
- H2 Production 1,11 t/year
- Annual Income 12 M$+ 3,33M$ = 15,33 M$
- Pay-back 9,78 years

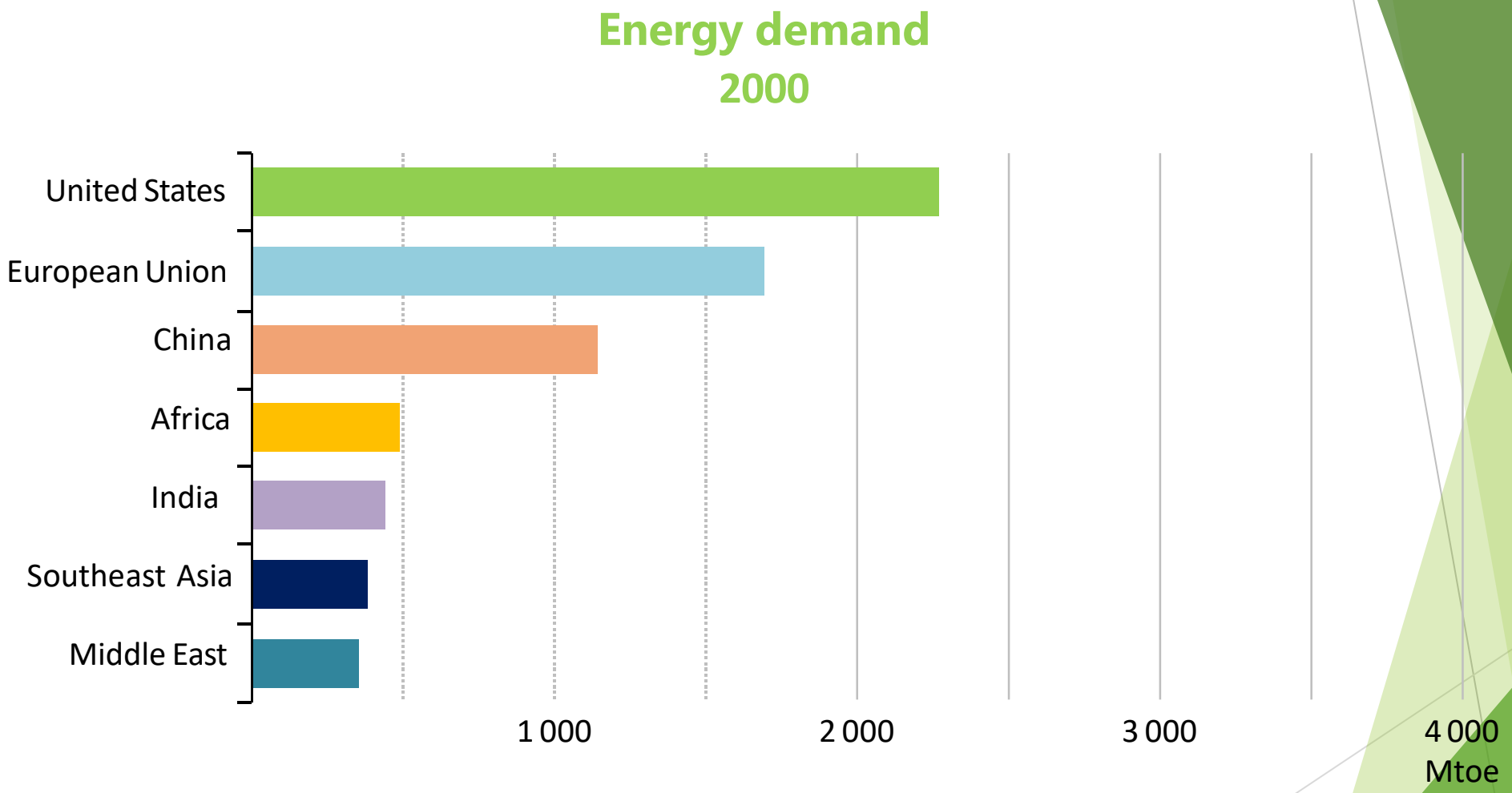
Data:
Unitary cost Wind Farm 1400 $/kW
Wind Farm productivity 2500 h/year
Energy sales ratio 80%
Energy sale price 60 $/MWh
Unitary electrolyser's price 500 $/kW
Sales Hydrogen price 3 $/kg

Photovoltaic plant dedicated to H2 Production cost effectiveness

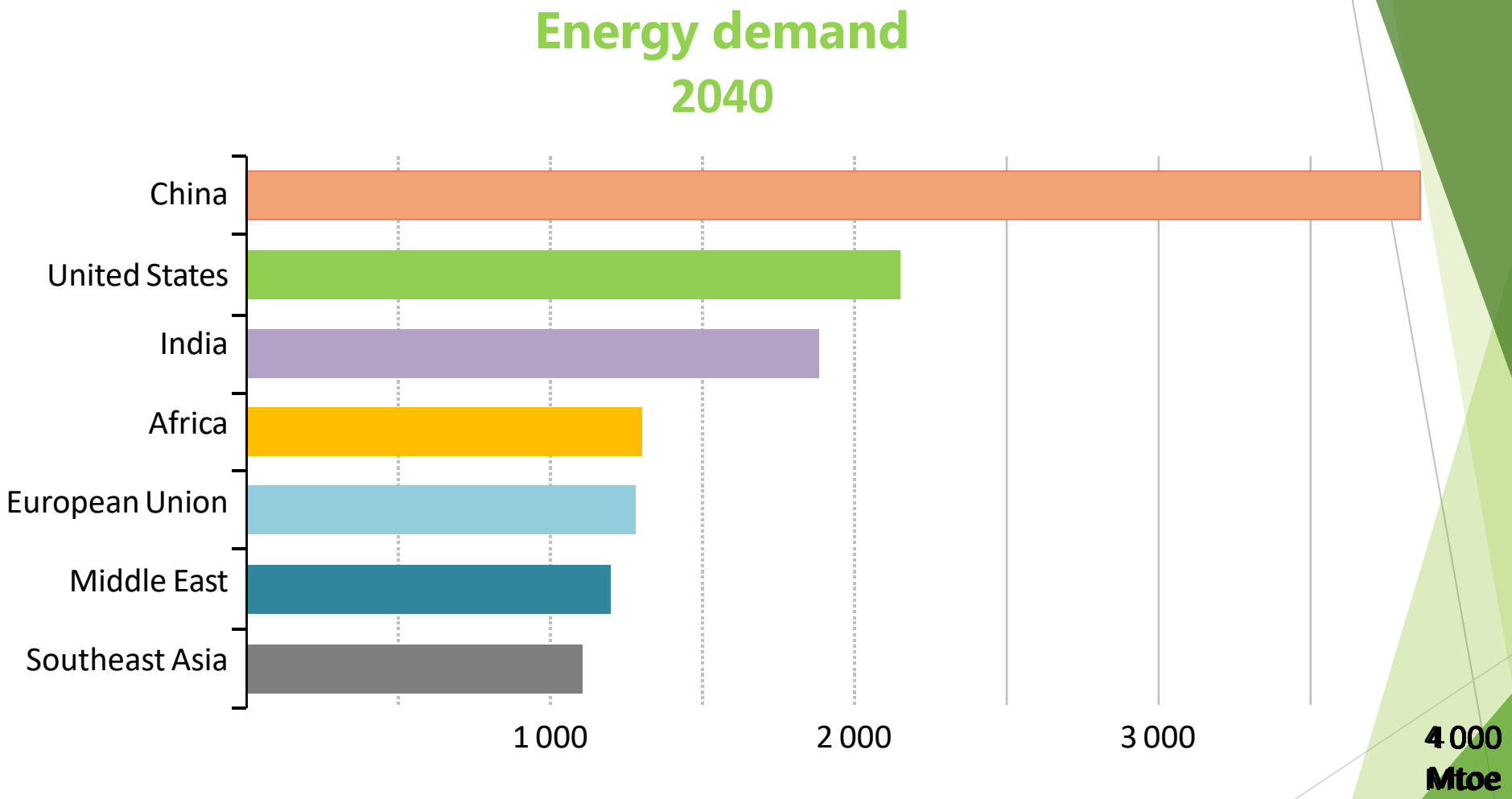
- PHP Power 50 MW
- Electrolyser Power 40 MW
- Investment 30 M$ + 20M$ = 50 M$
- Energy Production 90 GWh/year
- Energy for H2 81 GWh/year
- H2 Production 1,8 t/year
- Annual Income 6 M$
- Pay-back 8,33 years

Data:
Unitary cost Wind Farm 600 $/kW
PH productivity 1800 h/year
Unitary electrolyser's price 500$/kW
Sales Hydrogen price 3$/kg

The *new* geography of energy



The *new* geography of energy



The current consumption of Africa is only of 812 Mtoe but the increment in the last 30 years has been of 110%. Increasing with this ratio, Africa will be the fourth energy **user and producer** in 2040.

European Green Deal

- Europe has decided to be a free CO_2 emissions area in 2050.
- Europe's primary energy consumption in 2019 was 2.050,7 Mtoe. The 74,2% of this energy were fossils fuels.
- Europe's gas natural consumption in tis year was 19,95 EJ (475 bcm). To substitute this natural gas by hydrogen will be necessary 247 MtH2/year and 6870 TWh/year of green electricity.
- If we want produce this electricity with wind farm (wind turbine of 5,8 MW in wind farm operating 2300 h/year) we will need 514.000 machines than would they occupy 358.000 km2, the 10% of the surface of the EU.
- It's clear than in their Green Deal, Europe will need partners and Africa meets the conditions to be that partner that would allow it to develop its renewable industry and complement it with the business of selling surpluses in the form of hydrogen

Cost of Green Hydrogen production

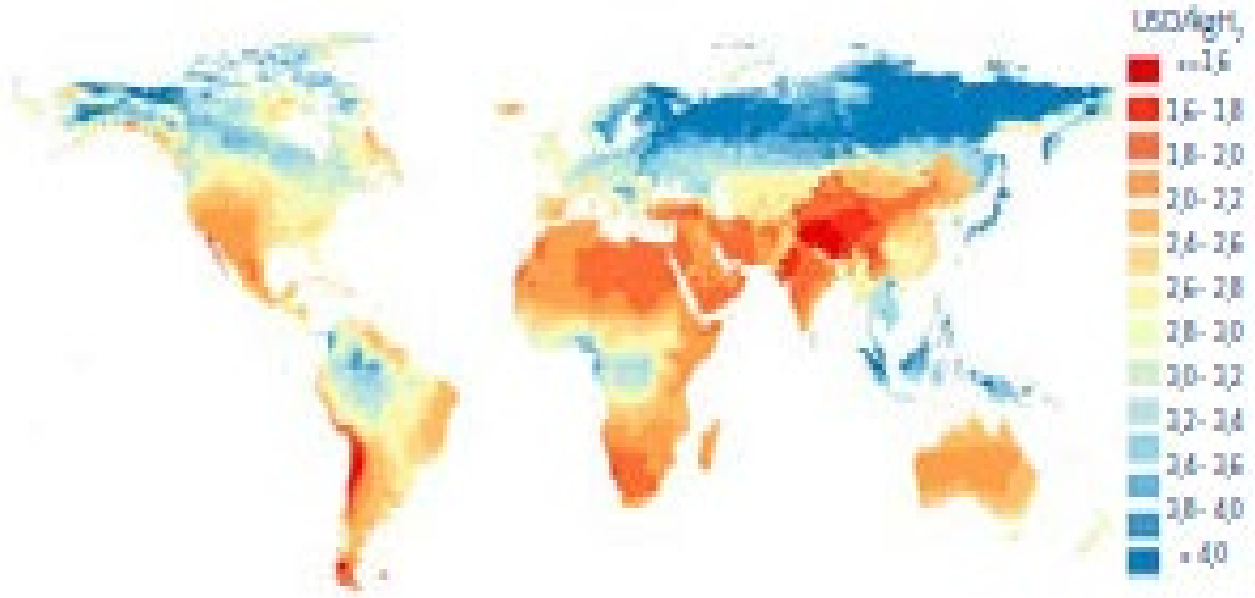


Figura 150.
Costes estimados para la producción futura de hidrógeno mediante electrólisis con electricidad renovable (fotovoltaica y eólica).

Fuente: Agencia Internacional de la Energía (IEA)[203]

Africa energy situation

- Africa has the best conditions to install green power (especially solar energy) because the insolation ratio is optimal.

> **Australia has potential like no other country in the world for hydrogen production and export – as long as we act upon the opportunity quickly. Imagine exporting West Australian sunshine and wind to the world in the form of hydrogen.**
> Jeff Connolly, Chairman and CEO of Siemens in Australia Pacific region

- I think that Africa has, as minimum, same potential that Australia and **I imagine Africa producing renewable energy for himself and supplying hydrogen for Europe.**

Bibliography & documentation

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Thanks for your kind attention