# Green Hydrogen

Hydrogen's role in a decarbonized economy

October 13, 2020

**Ecowas Centre for Renewable Energy and Energy Efficiency**

# Introduction

- 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 could produce its electricity, in 2050, with renewable technologies but will be difficult to substitute the 742 Mtoe/year dedicated to mobility and the fraction of the 472 Mtoe/year (natural gas) used by industry.
- The consumption of electricity in Europe was around 2.500 TWh in 2019. To produce this electricity with renewables energy, and without storage devices, will be necessary to install, as least, 2,5 TW of green power.
- This generation park will produce 3.350 TWh/year of surpluses. **What to do with this energy?**
- It would be possible to produce "**green hydrogen**" with this excess of electricity. Hydrogen is, like electricity, a **energetic vector**.

# Europe needs hydrogen

- **Germany plans to promote ‘green’ hydrogen with €7 billion**

**The German government adopted its national hydrogen strategy (10 June), with plans to ramp up production capacity to 5 GW by 2030 and 10 GW by 2040. To achieve this, €7 billion will be invested in new businesses and research.**

Hydrogen will be used first where processes cannot be electrified – for example, in heavy goods transport, steel production, the chemical industry and aviation.
Companies in these sectors will receive financial aid if they invest in electrolysis plants to transform their production processes. To this end, a pilot programme for so-called Carbon Contracts for Difference (CfD) will be launched, which is aimed at the steel and chemical industries.
Hydrogen will also be used in the transport sector, an idea that was originally rejected by the environment ministry. And to support the production of renewable energies, infrastructure for hydrogen refuelling, among other things, will be established.
In addition, the German government wants to examine whether a 20% quota for renewable energies in aviation can be implemented by 2030.

# Hydrogen

- Hydrogen is the most abundant chemical element in the universe but, unfortunately, it's not possible to find free hydrogen 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 (0,071 $g/dm^3$ under normal conditions)
- Hydrogen has 3,5 more energy by mass unit that petrol and natural gas.
- Green hydrogen can be used, mixed with $CO_2$, to produce renewable synthetics fuels

# Types of hydrogen

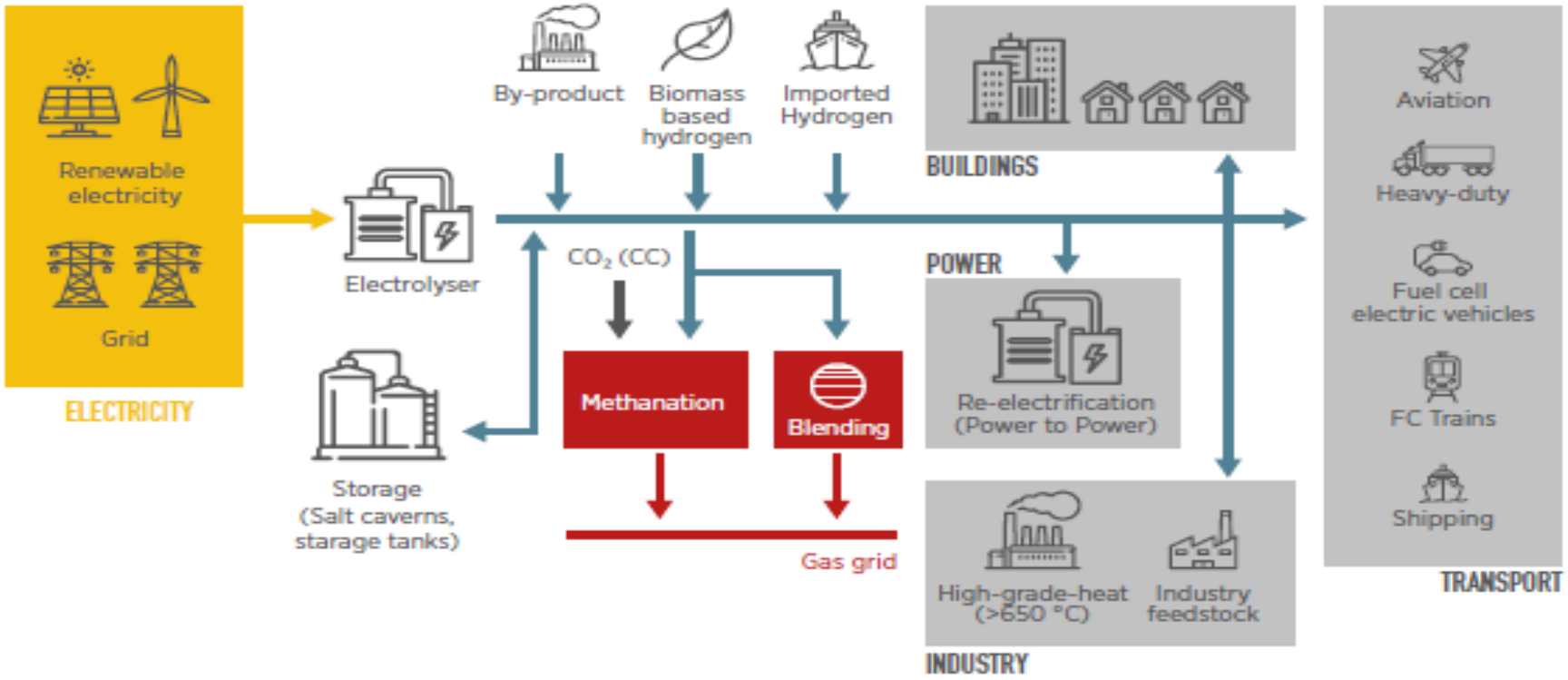
There are different types of hydrogen, depending on the sources and their production methods.

| ***Grey hydrogen*** | ***Blue hydrogen*** | ***Green hydrogen*** |
| --- | --- | --- |
| Split natural gas into $CO_2$ and hydrogen | Split natural gas into $CO_2$ and hydrogen<br>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* |

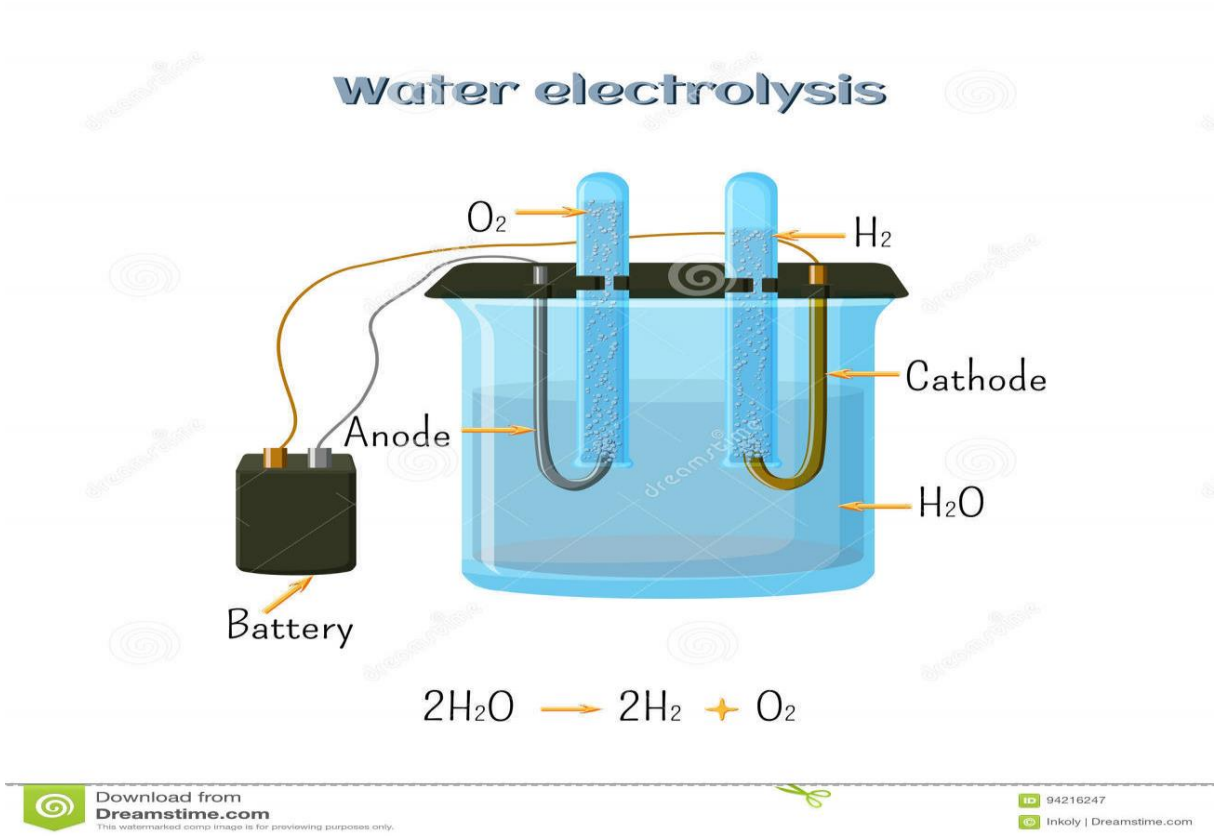
# Green Hydrogen production

- To produce a kg of $H_2$ of green hydrogen it's necessary to use about 50 kWh of electricity. With 3.350 TWh/year (expected electricity surpluses in Europe in 2050) will be possible to produce 67 $MtH_2$/year.
- If Europe wants replace with hydrogen the 742 Mt of oil/year dedicated to the mobility and one half of the 472 Mtoe of natural gas, it would need about 300 $MtH_2$/year.
- The question is **where can this hydrogen be produced?**

# What can be done with hydrogen?



# Green hydrogen production

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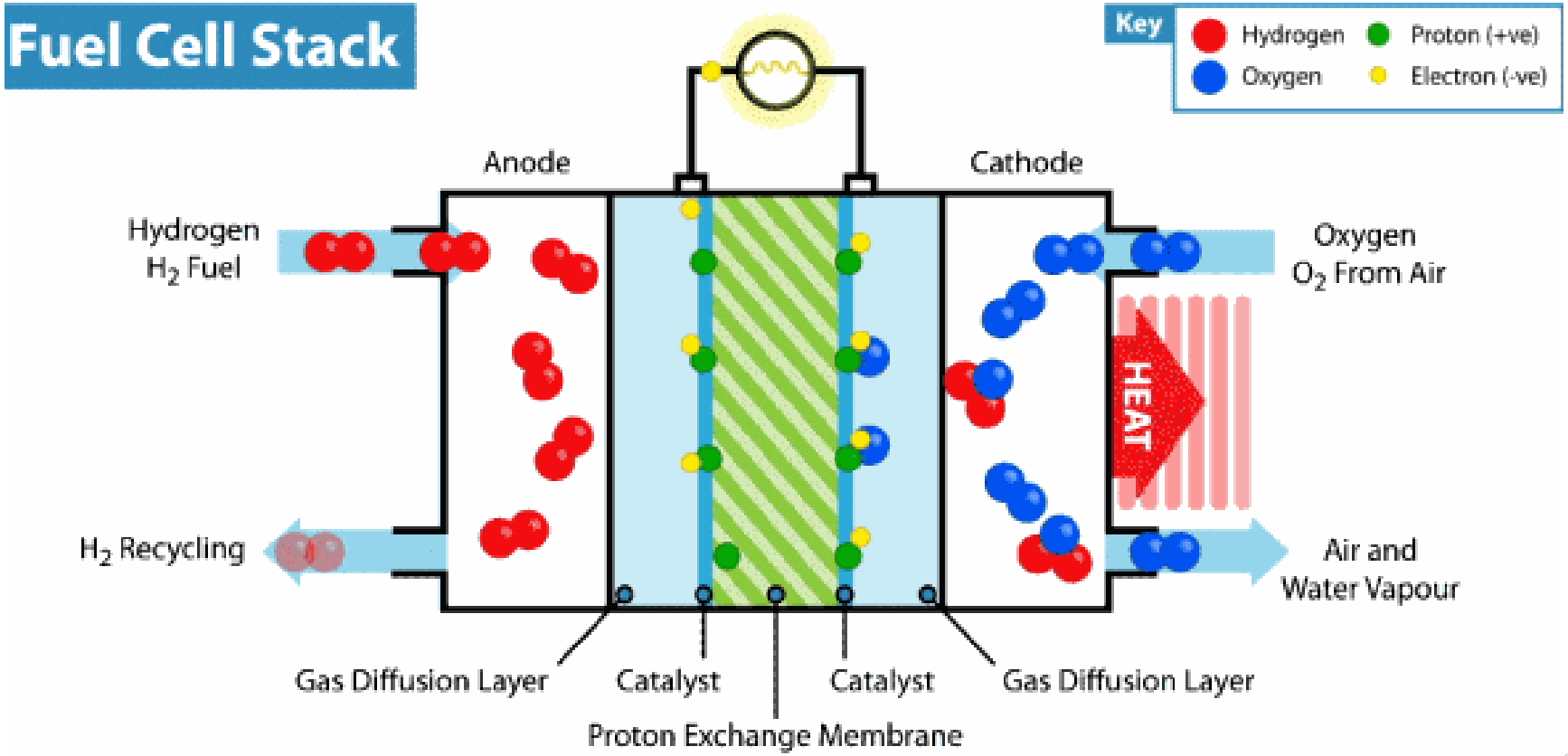
# Fuel cell principle



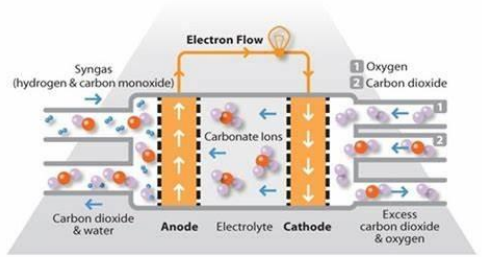
# Types of fuel cells

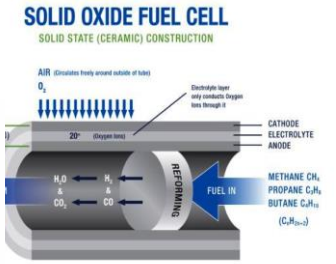
Efficiency

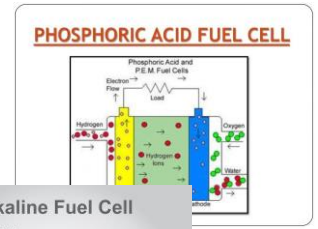
0,6

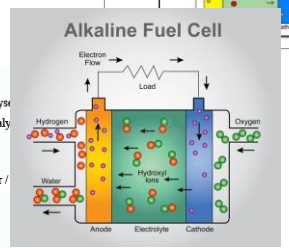
0,5

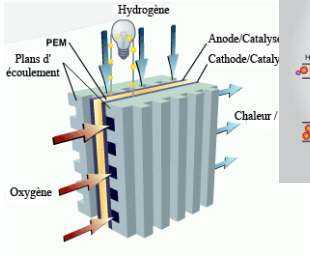
0,4



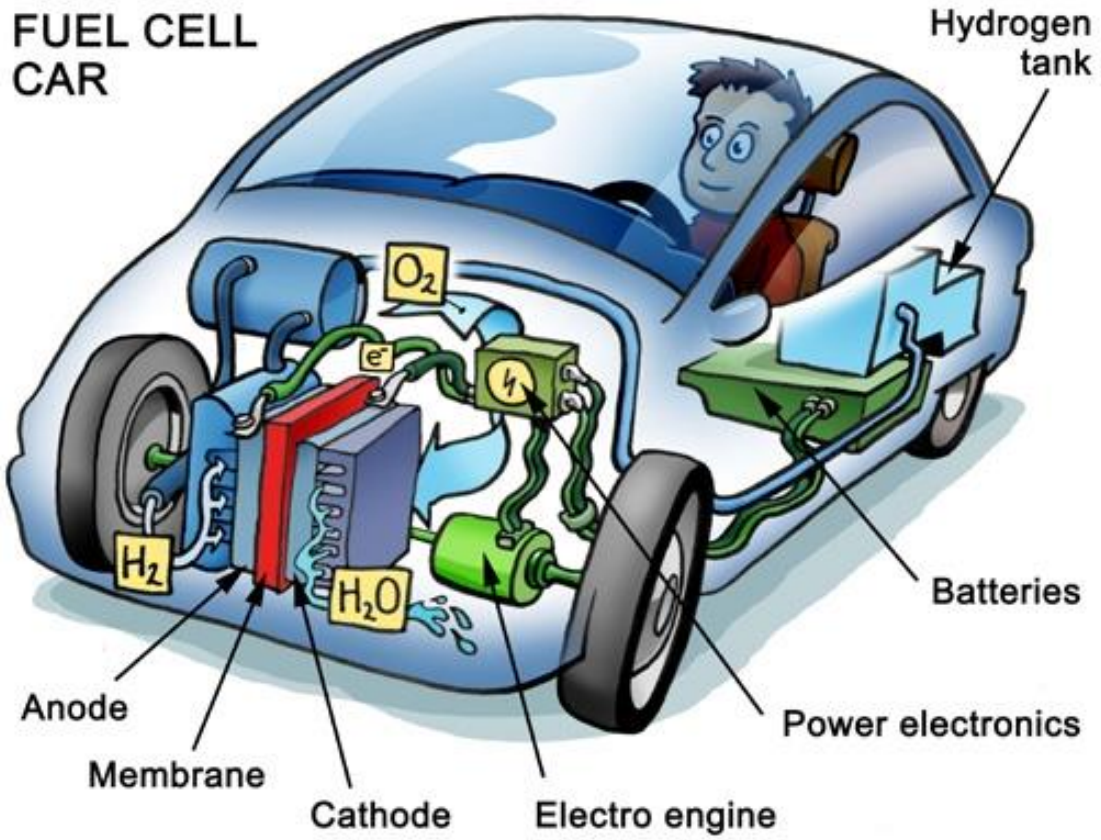



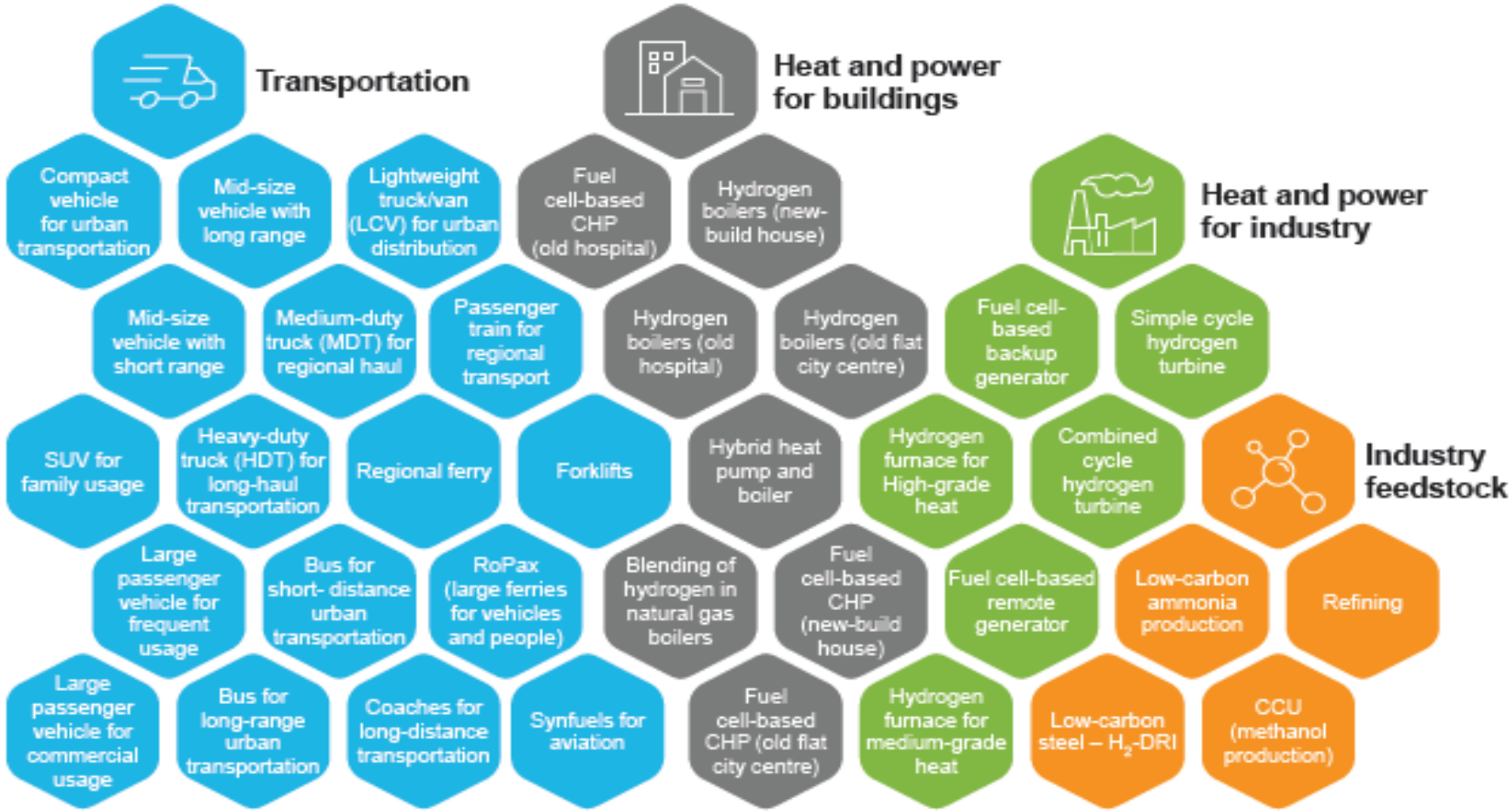

°C

100 200 300 400 500 600

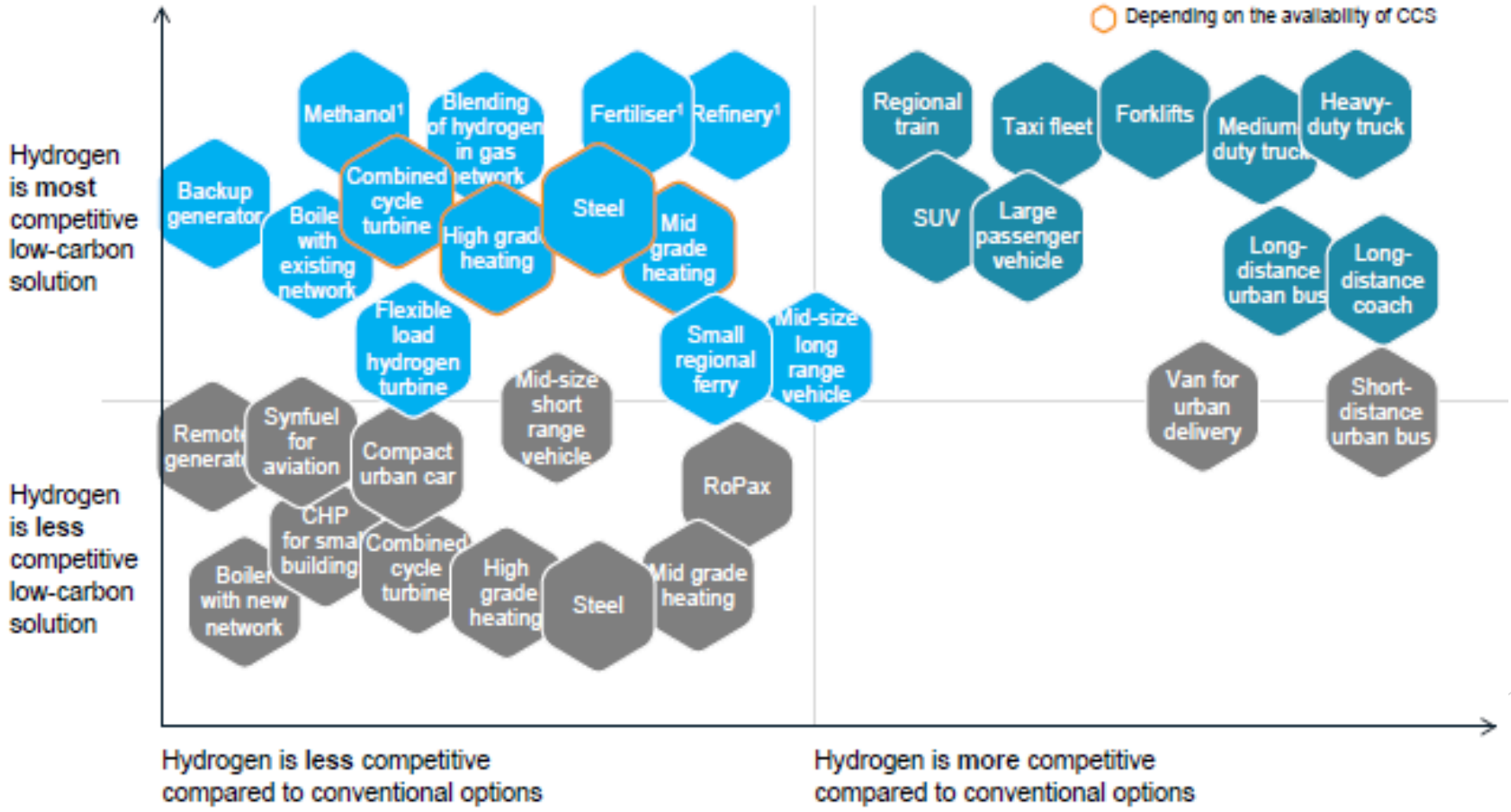
# Possible use of fuel cells



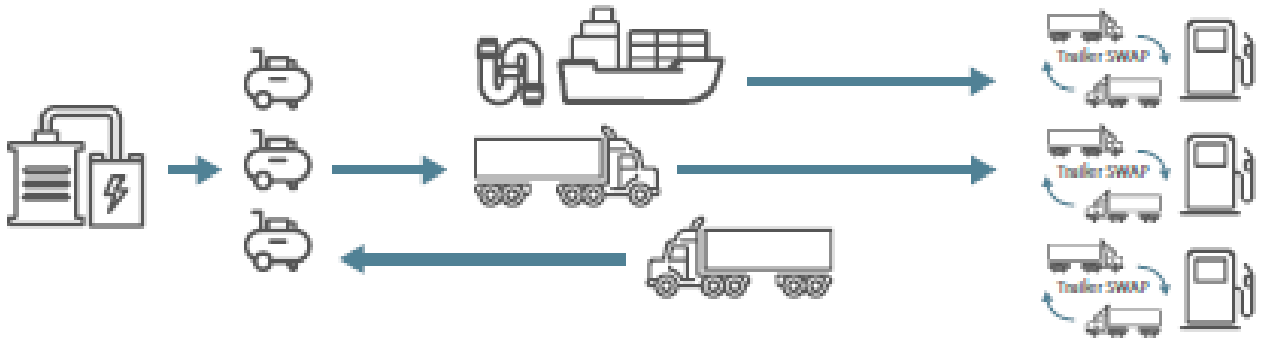
# Overview hydrogen applications

# Competitiveness of green hydrogen vs low carbon and conventional alternatives

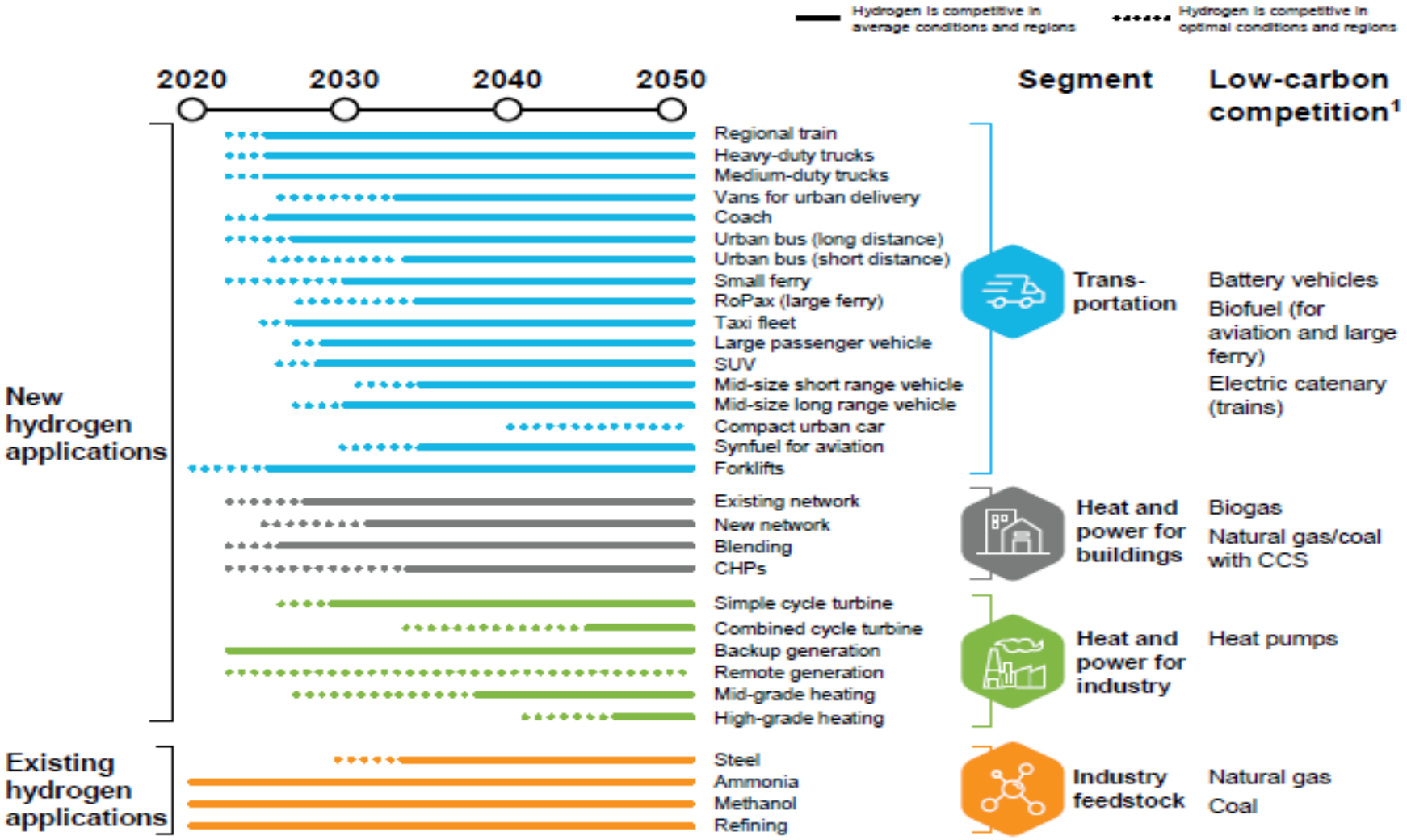


# Evolution of the cost of green hydrogen




| | $H_2$ 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 |

# Cost competitiveness trajectories in hydrogen applications



# 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.

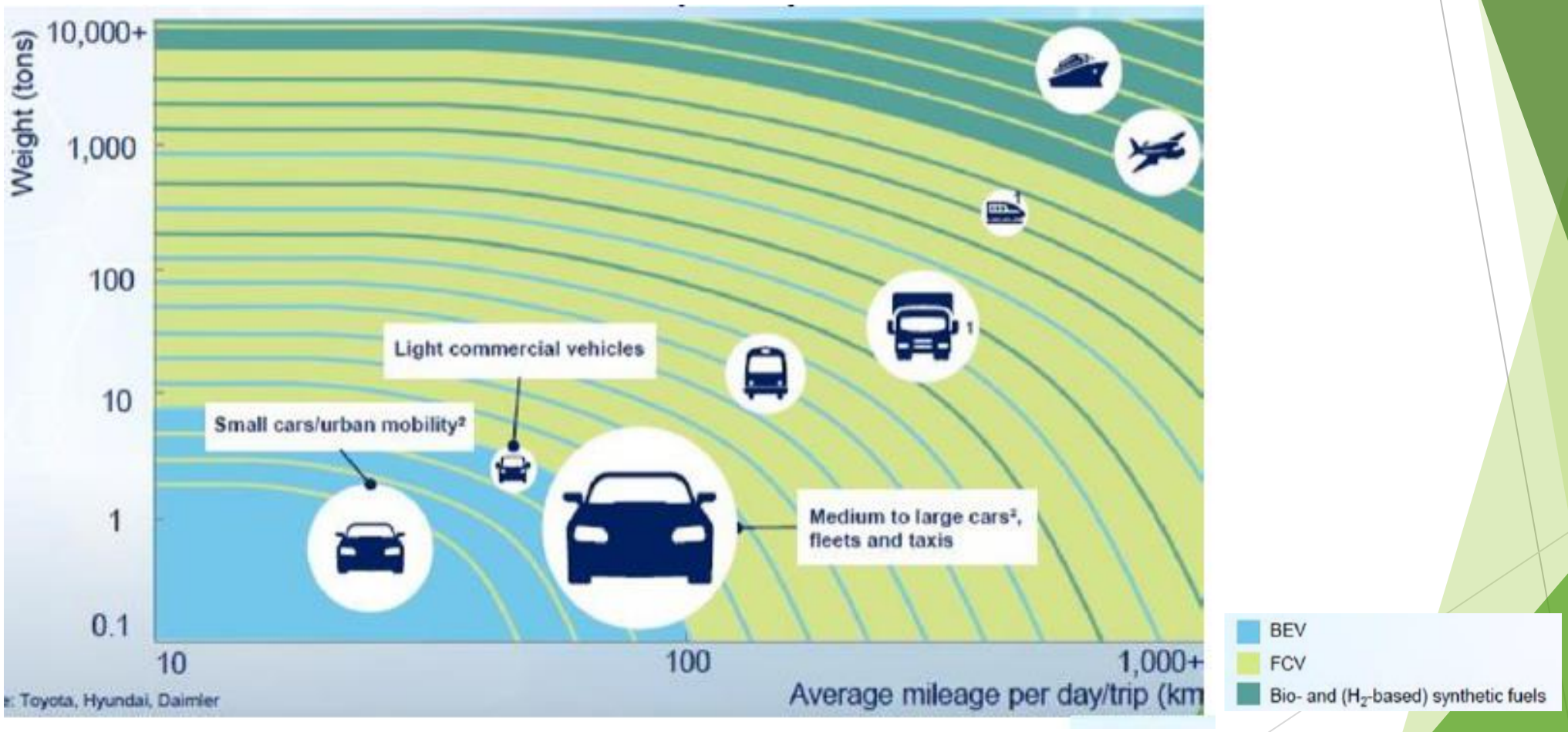

Two Coradia iLint engines will replace diesel trains on the 100-kilometer (62-mile) route linking the towns of Cuxhaven and Buxtehude, with 14 other hydrogen trains set to be introduced across the state by 2021. The new-type engines are produced by the French company Alstom.

# Fuel cell trucks

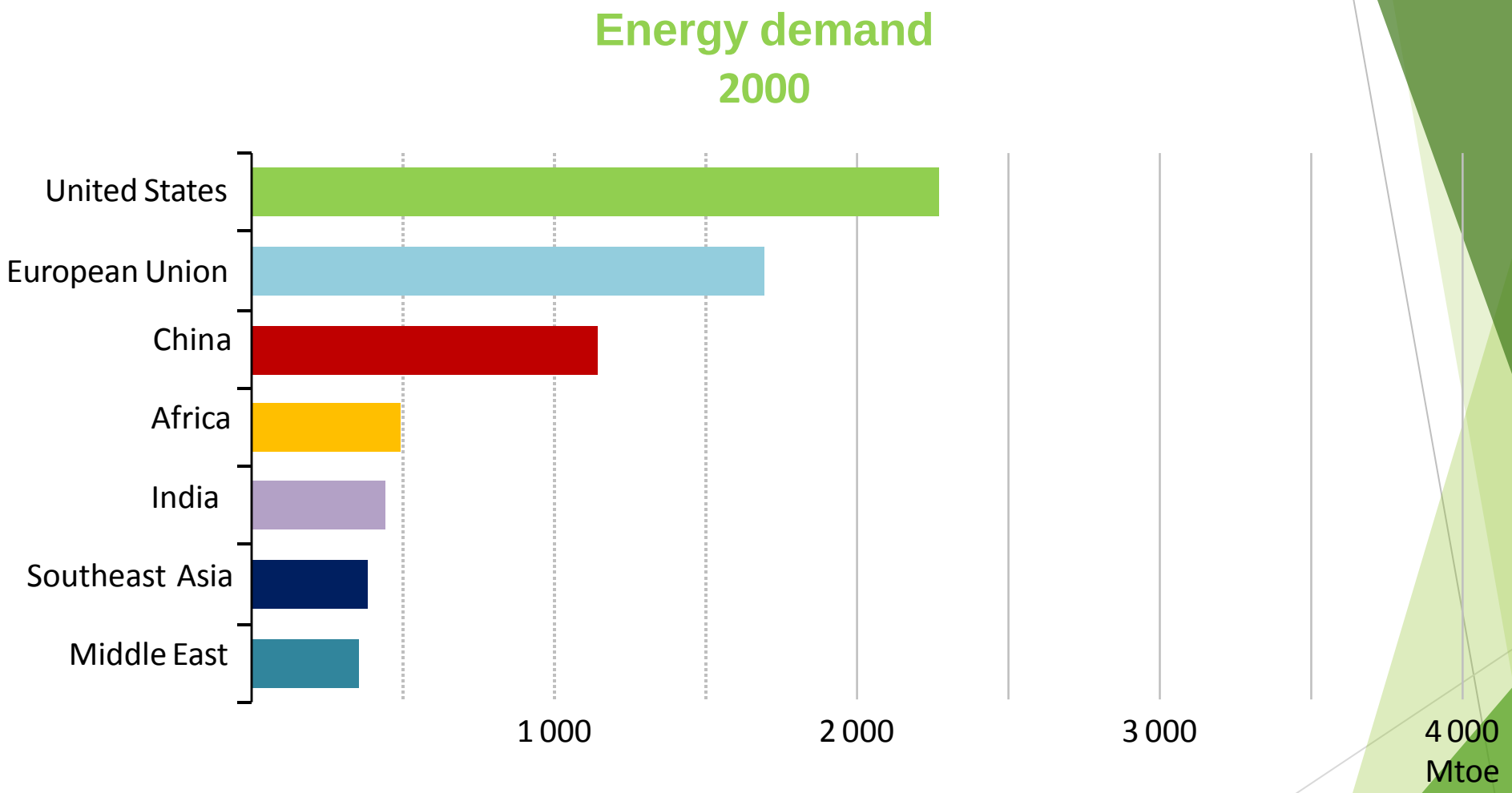

Hyundai's h2 xcient fuel-cell truck


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

# The future of mobility



# The *new* geography of energy



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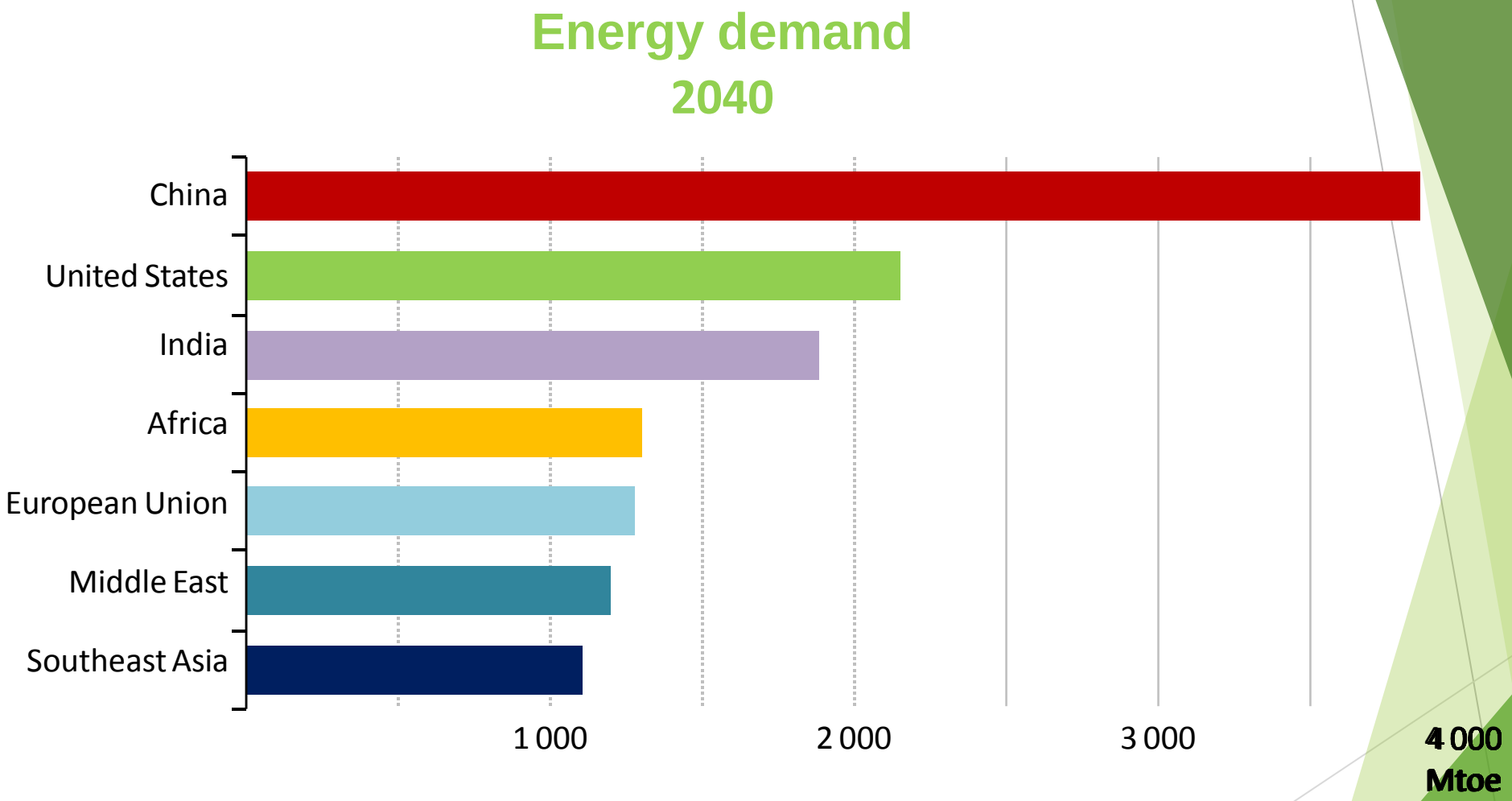
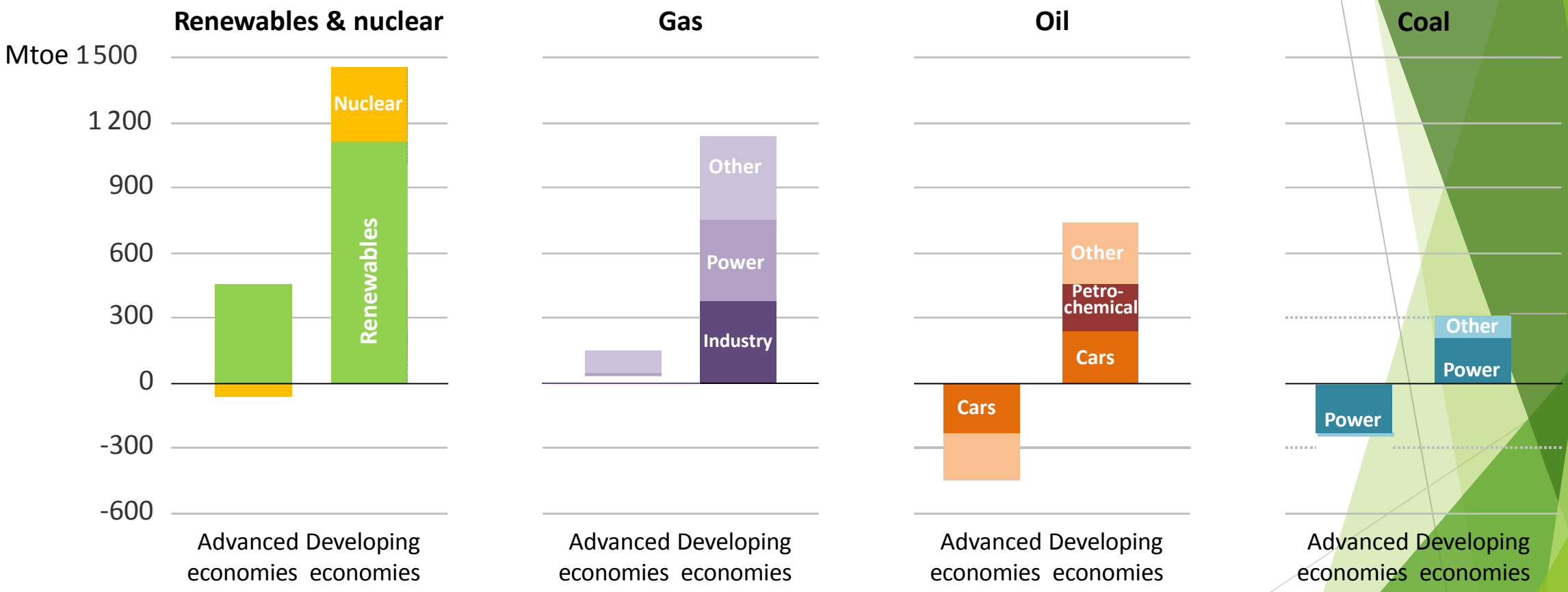


# Fuelling the demand for energy

## Change in global energy demand, 2017-2040



# Africa energy situation

- The consumption of primary energy in Europe is now 1.998 Mtoe with a 5% reduction since1990.
- 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.
- Africa has the best conditions to install green power (especially solar energy) because the insolation ratio is optimal.

> **New Renewable Hydrogen Project at Australia's Best Combined Solar and Wind Site Announced**
> Hydrogen Renewables Australia (HRA) has proposed the **Murchison Renewable Hydrogen Project** – a large scale (up to 5,000 MW) combined solar and wind farm to produce low-cost renewable hydrogen or 'green hydrogen' on Murchison House Station in Western Australia (WA). October,2019

> **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

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

# Bibliography & documentation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# Thanks for your kind attention