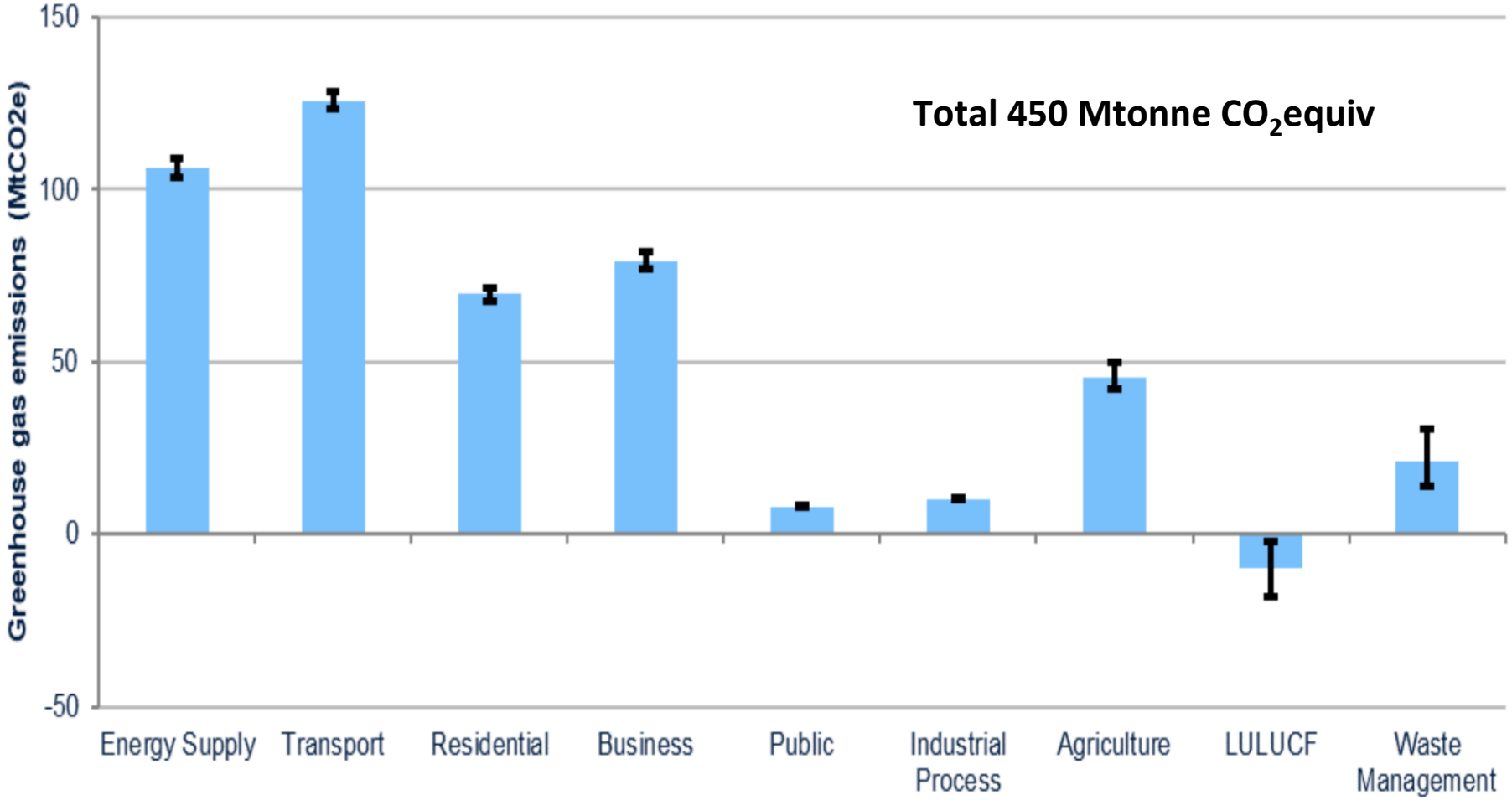
Over-selling Hydrogen in the UK

Tom Baxter



UK CO_2 Emissions 2018

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875522/Annex_1990-2018_UK_GHG_Emissions__final_figures_by_end_user_sector__by_fuel_and_uncertainties_estimates.pdf

1. A more ‘circular’ energy system, with energy efficiency at its core.

2. A greater direct electrification of end-use sectors (heat pumps for space heating or low-temperature industrial processes, electric vehicles for transport, or electric furnaces in certain industries).

3. Use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible.

EU Strategy

https://ec.europa.eu/energy/sites/ener/files/energy_system_integration_strategy_.pdf

The most common element in the universe.

It can be produced from electricity and water.

Can be stored and used to produce heat and electricity.

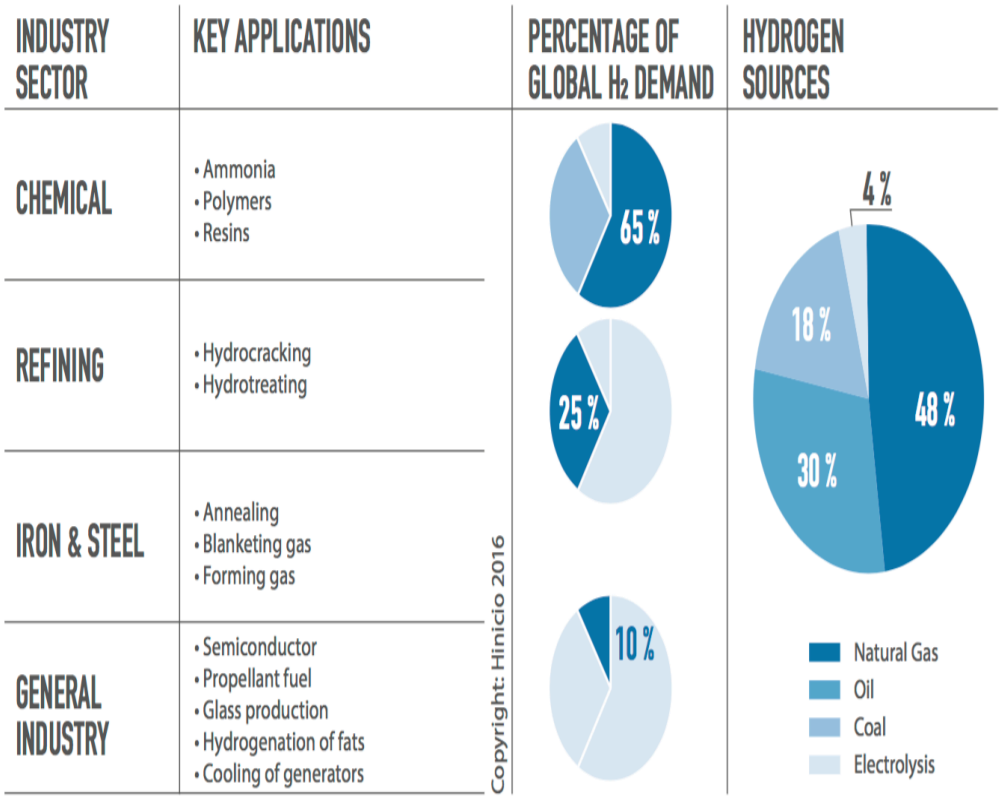
When liquefied the energy per unit weight is superior to fossil fuels.

It can deliver power at 60% efficiency via a fuel cell which can also run in reverse.

Can be transported using existing gas grid.

Combusts at a similar temperature to natural gas.

Hydrogen – what's not to like?



Source: IRENA based on FCH JU (2016).[3]

70 million MtH2 /yr. Almost entirely supplied from fossil fuels, with 6% of global natural gas and 2% of global coal going to hydrogen production.

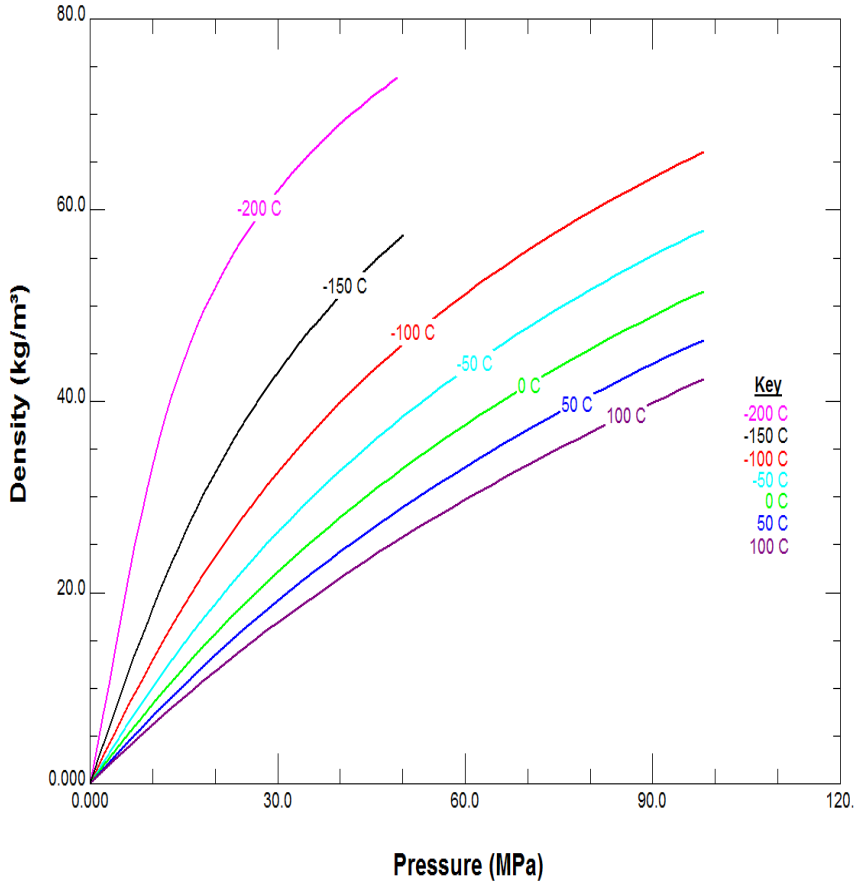
Hydrogen is responsible for carbon dioxide (CO2) emissions of around 830 MtCO2 /yr.

Equivalent to the CO2 emissions of Indonesia and the United Kingdom combined.

Total annual hydrogen demand worldwide is around 330 Mtoe, larger than the primary energy supply of Germany.

Hydrogen today – immediate abatement focus

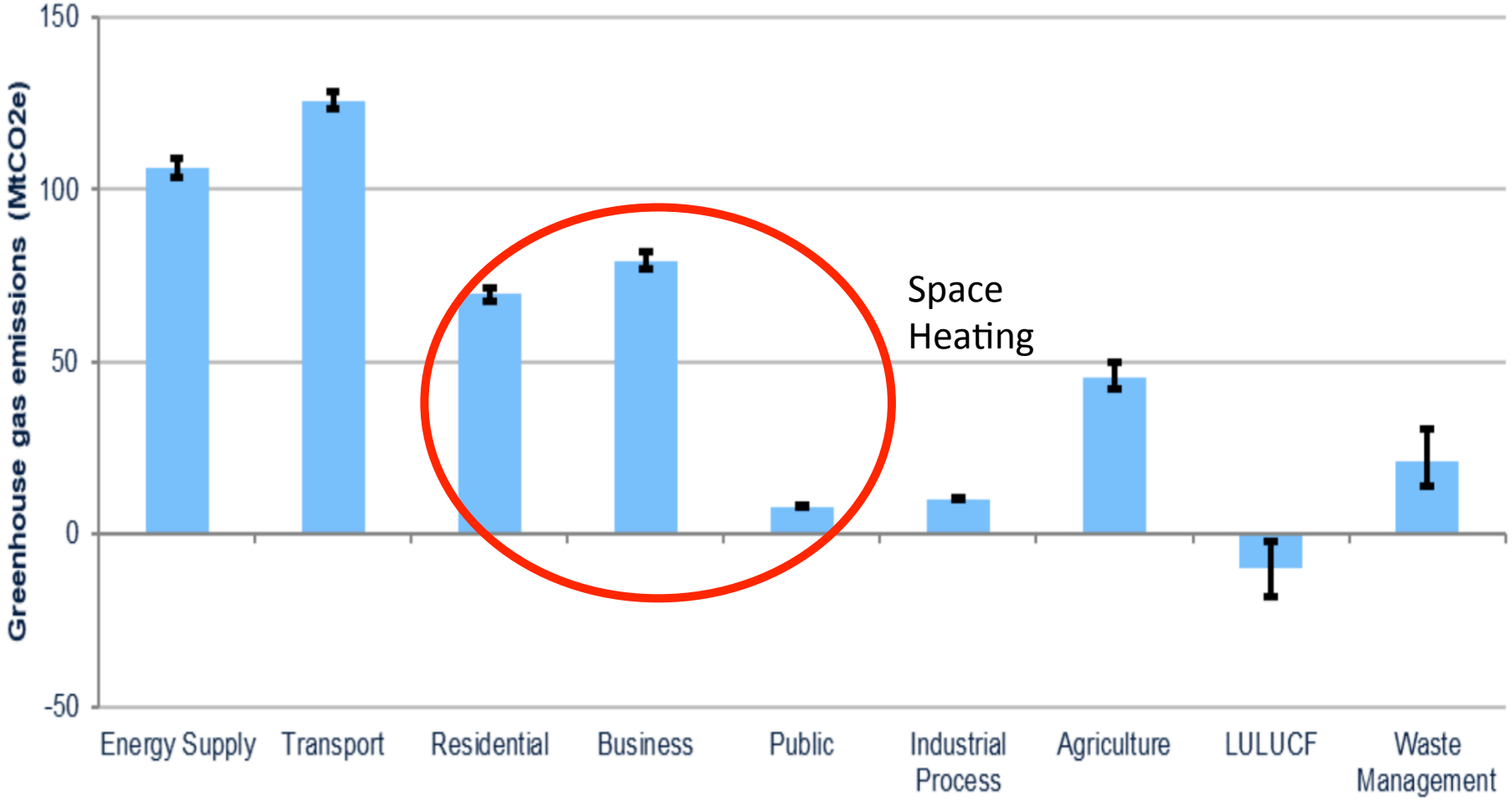
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_Hydrogen_from_renewable_power_2018.pdf



Lower Heating Value

Hydrogen	120 MJ/kg
	10.8 MJ/Sm³
Methane	50 MJ/kg
	35.8 MJ/Sm³
Liquid Hydrogen	4000-5000 MJ/m³
Kerosene	43 MJ/kg
	35300 MJ/m³

Hydrogen Properties



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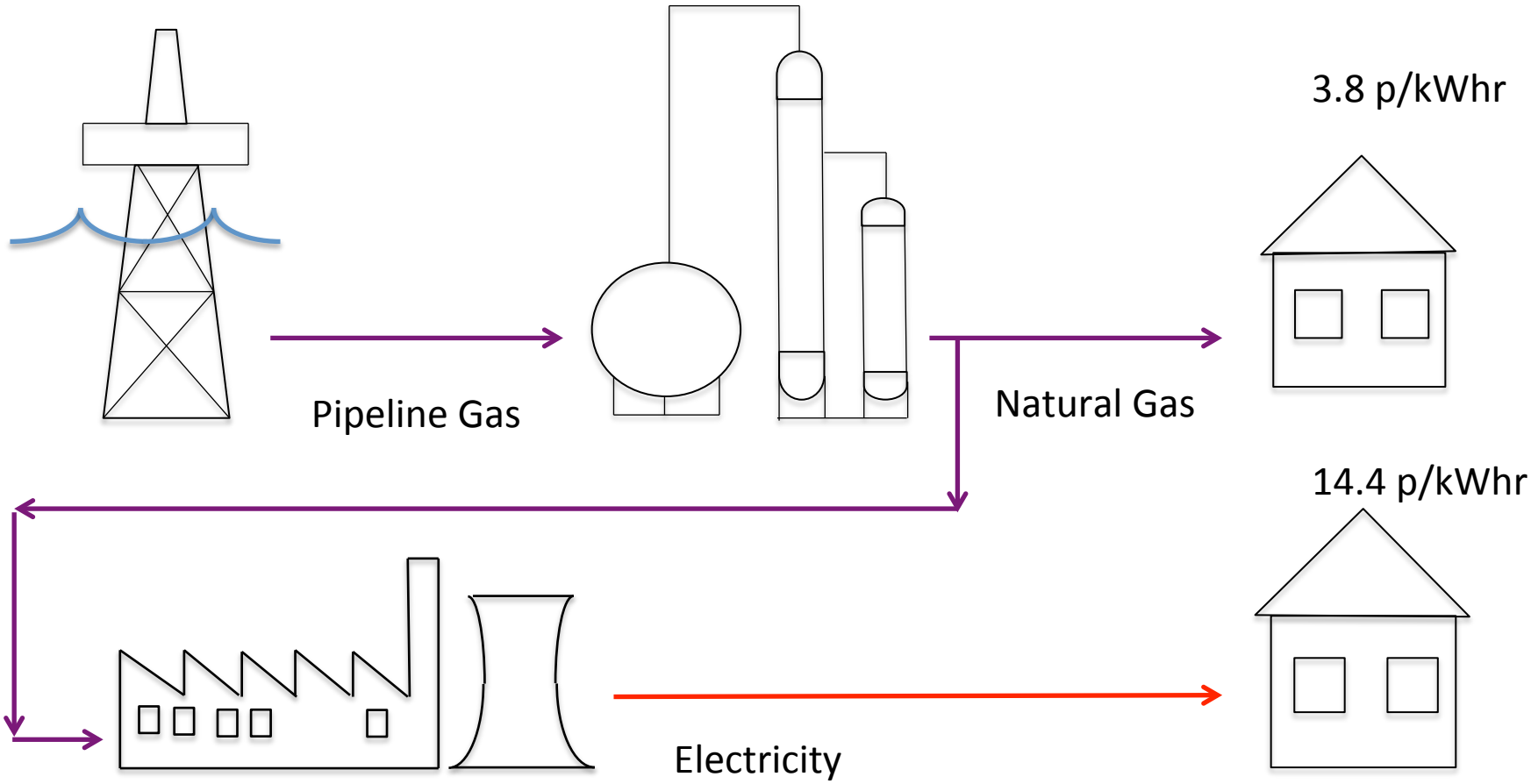
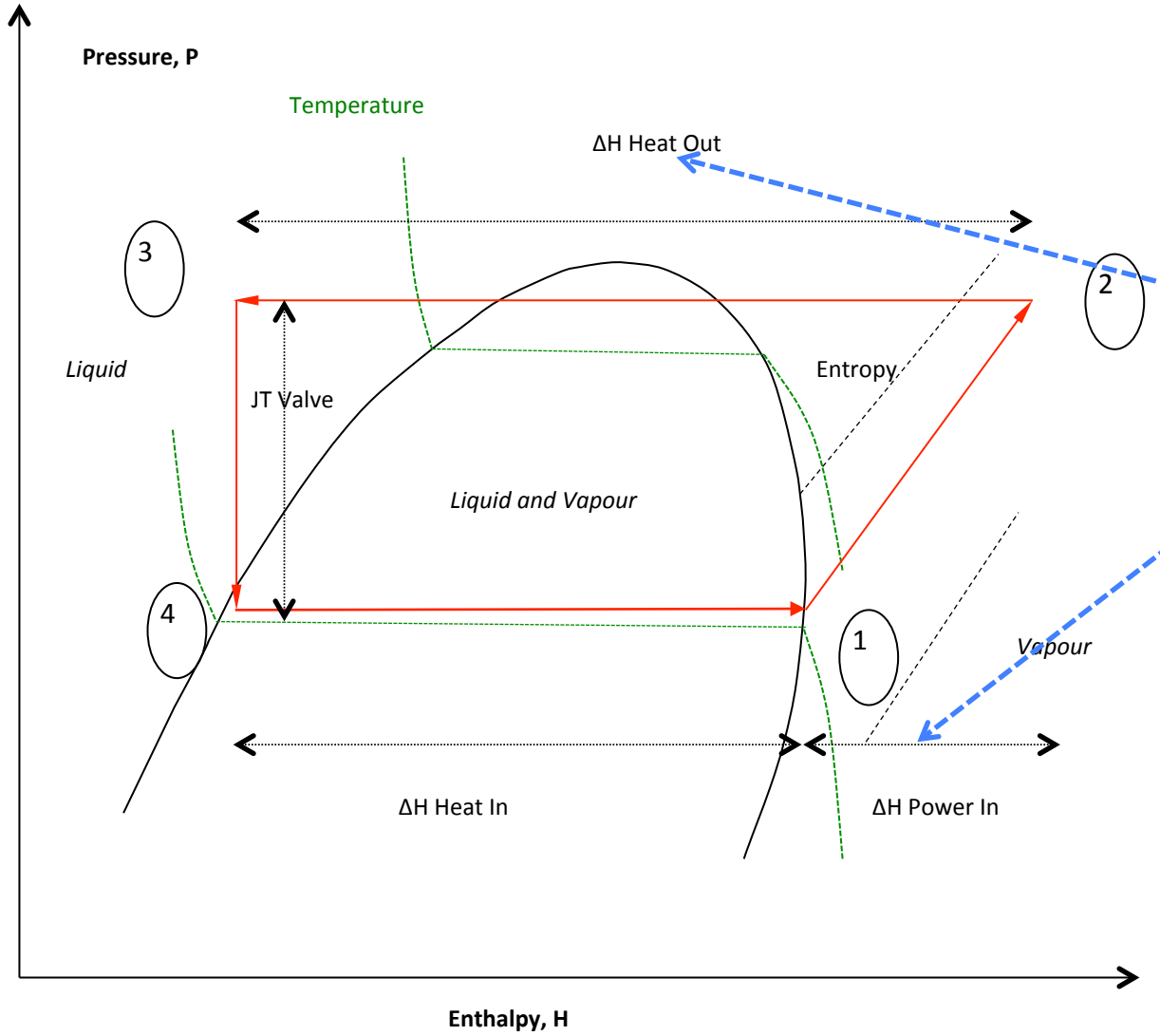


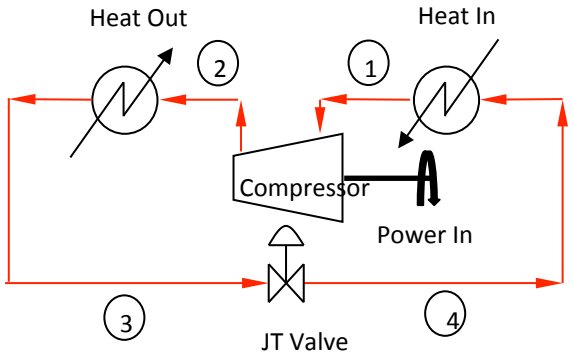
Today's energy supply

https://www.ukpower.co.uk/home_energy/tariffs-per-unit-kwh

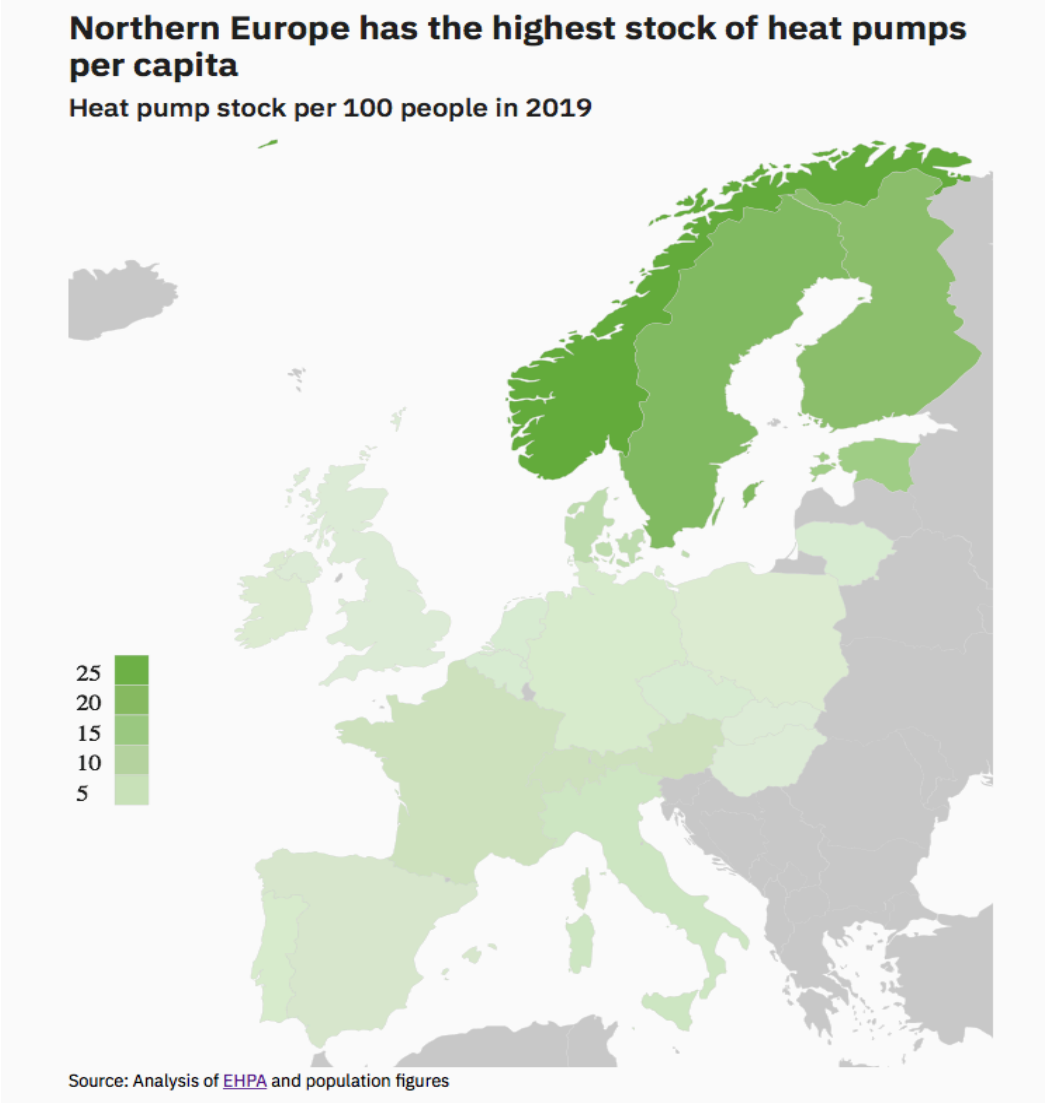


Coefficient of performance COP

$$\frac{\Delta H \text{ Heat Out}}{\Delta H \text{ Power In}}$$

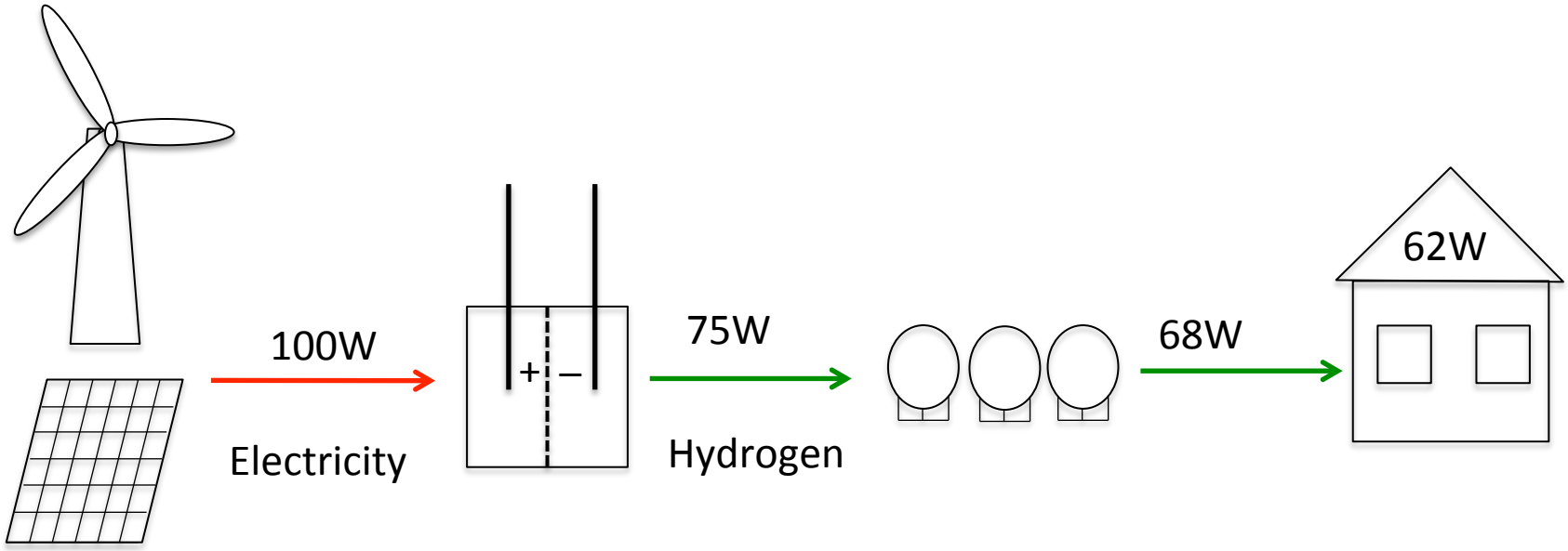


Heat Pump



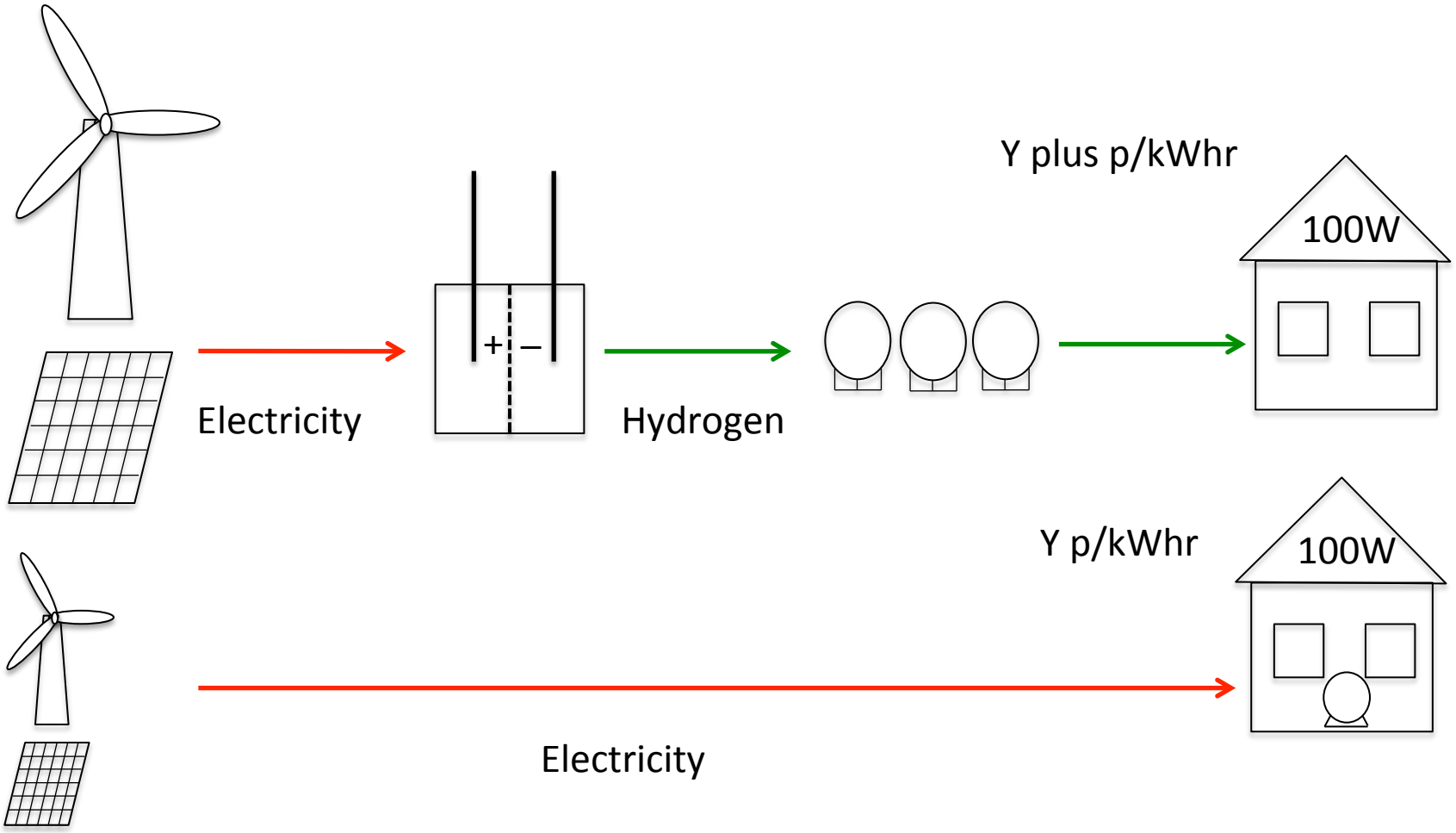
European heat pump uptake

https://energymonitor.ai/sector/heating-cooling/heat-pumps-are-on-the-rise-in-europe



Space Heating – Green Hydrogen

Space Heating – Heat Pump



Space Heating – Comparison

“London’s carbon targets cannot be met unless there is a rapid transition toward low carbon solutions such as heat pumps and district heating. “

Tariff basis
Natural gas – 3.2 p/kWhr
Electricity – 15.2p/kWhr

Move forward to green hydrogen - must cost more than the electricity it was derived from further supporting HP case.

Heat Pumps in London

https://prod-drupal-files.storage.googleapis.com/documents/resource/public/Heat-pump-retrofit-in-London-v2.pdf

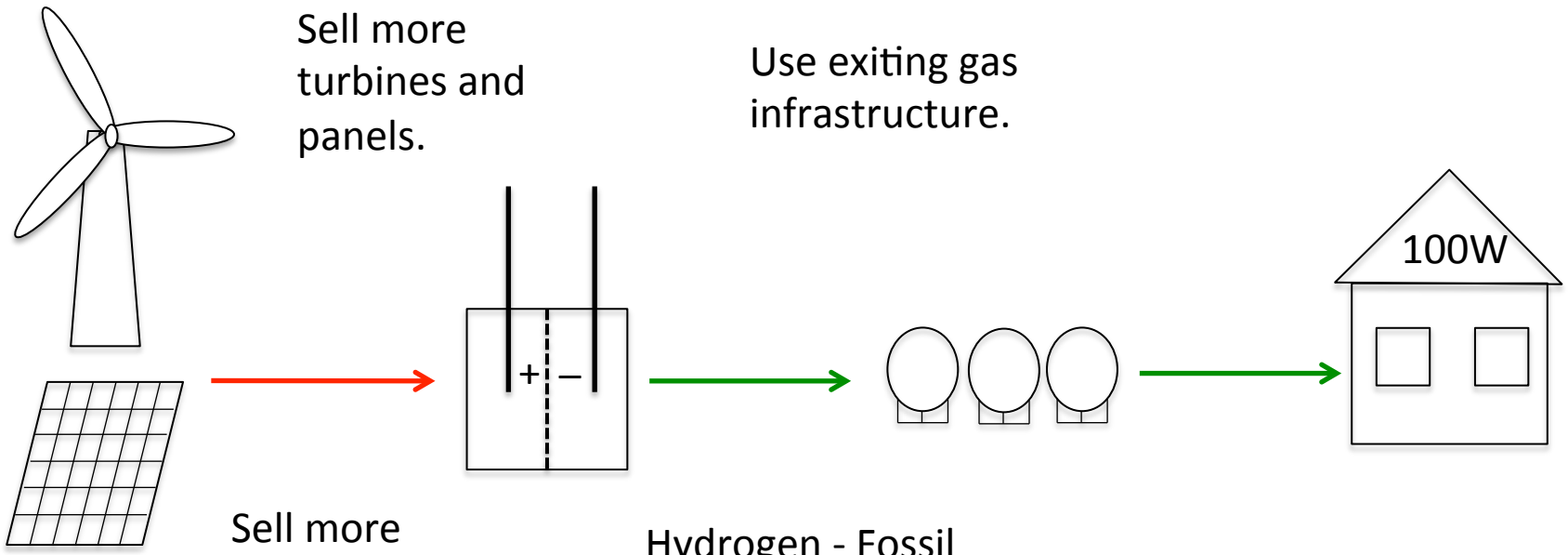
The hydrogen revolution is a marvellous chance for Britain, if it does not throw away the prize

Big Finance is sizing up the opportunities that the gas can offer with Britain in pole position to benefit

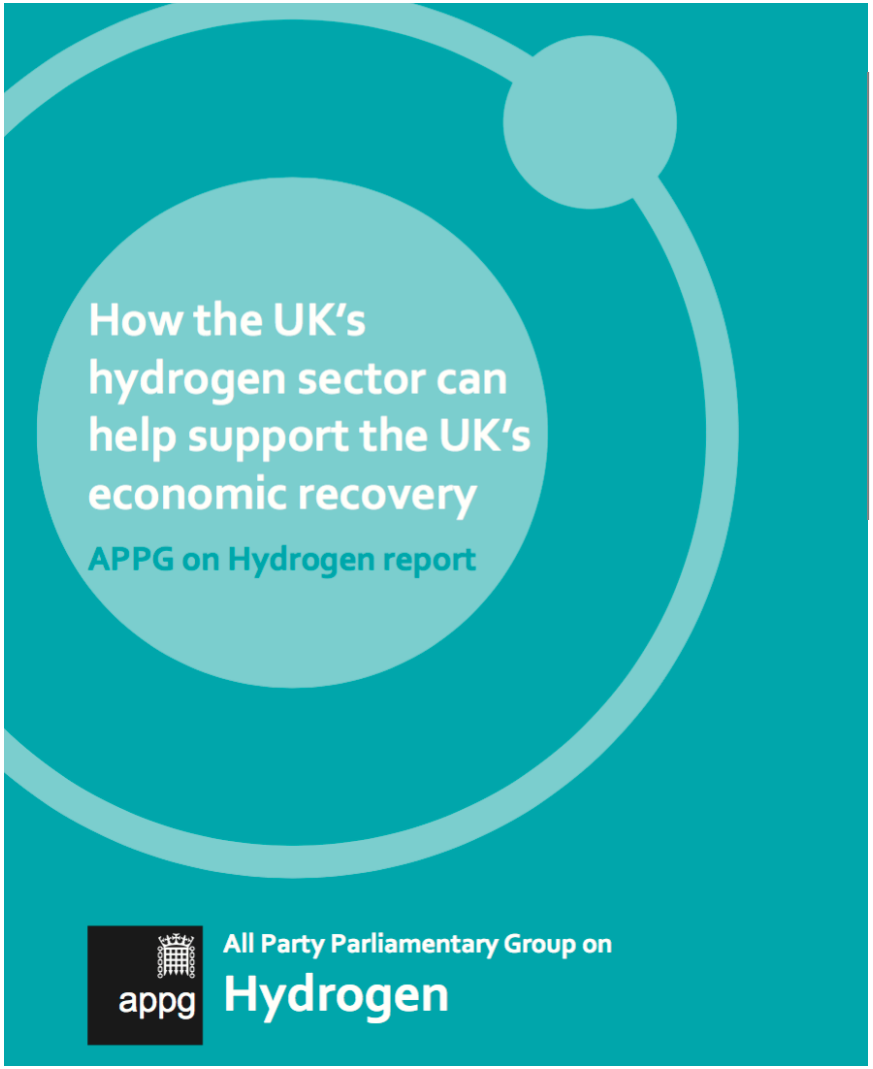
AMBROSE EVANS-PRITCHARD

15 July 2020 • 8:59pm

Are Big Finance and the UK Consumer aligned?



Hydrogen is good for Big Business



The APPG on Hydrogen is sponsored by:

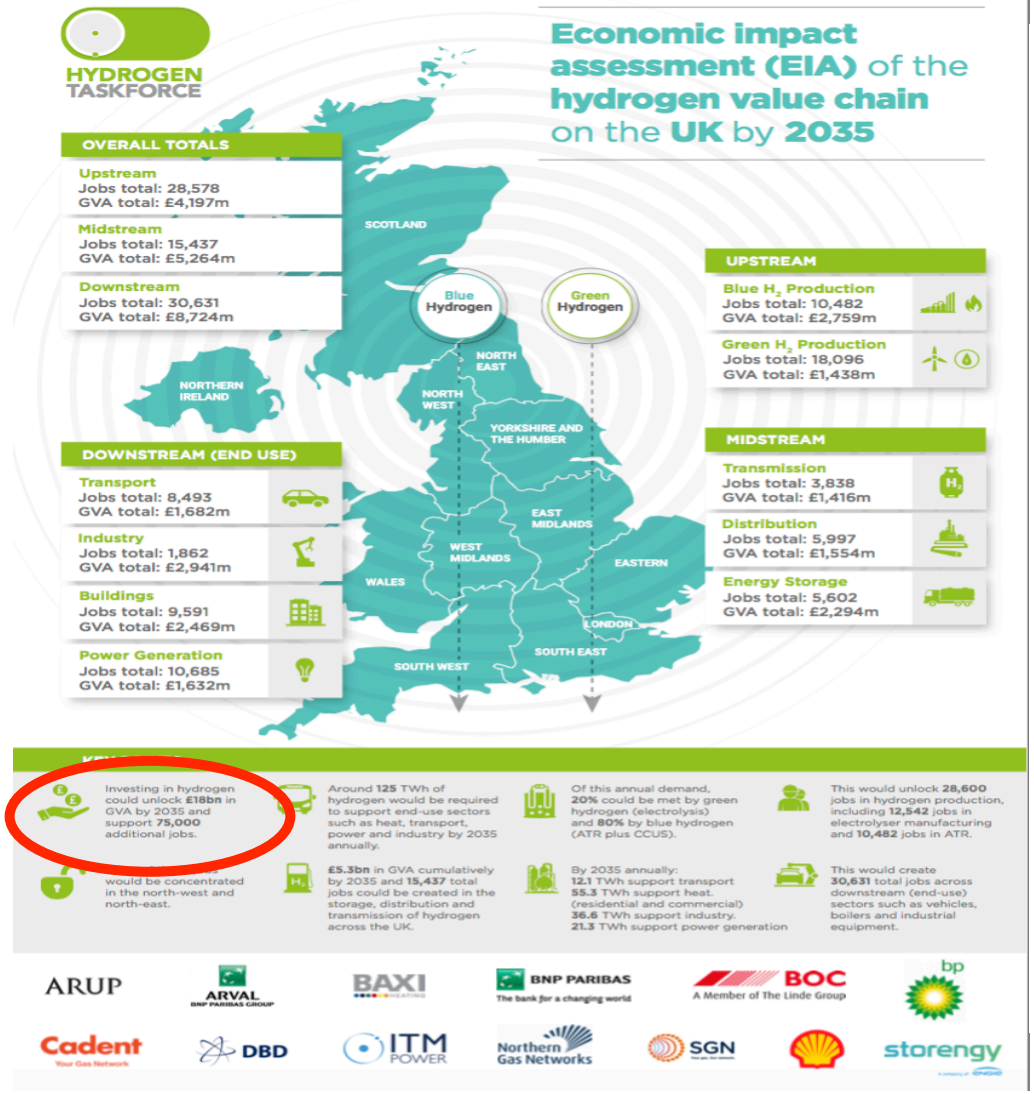
BAXI BOSCH Cadent Your Gas Network equinor EUA energy&utilities alliance

nationalgrid Northern Gas Networks SGN Your gas. Our network.

Sponsors all have business models that favour hydrogen. Not surprising the APPG report presents a very positive view on hydrogen.

All Parties Parliamentary Group

https://connectpa.co.uk/appg-hydrogen/



Install 5 million heat pumps by 2035 at £10,000 each.

Headline

Heat Pumps worth £50bn to UK economy and lowers heating bills.

£18bn GVA to UK

https://www.hydrogentaskforce.co.uk/wp-content/uploads/2020/08/6-EIA-report.pdf

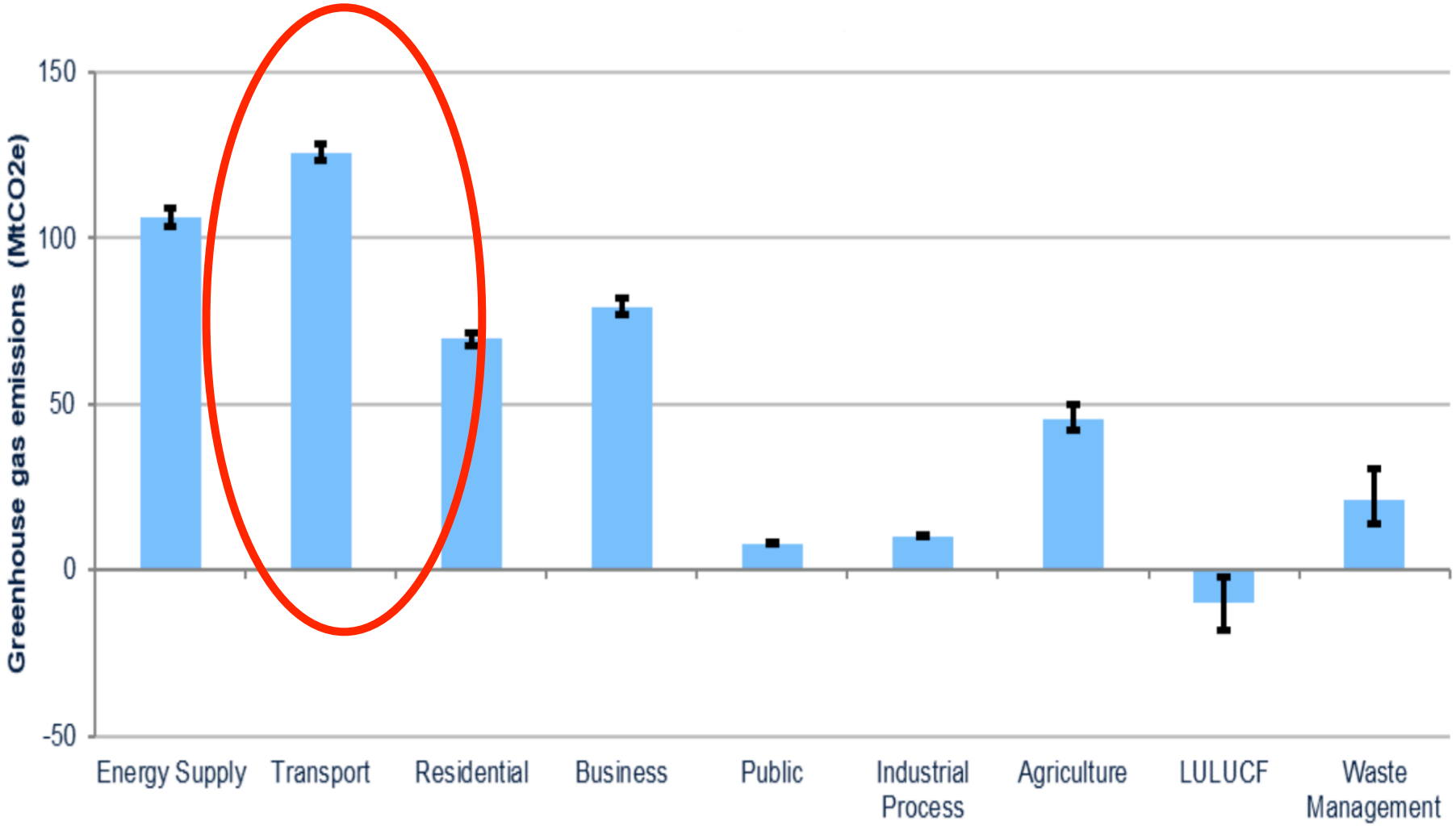


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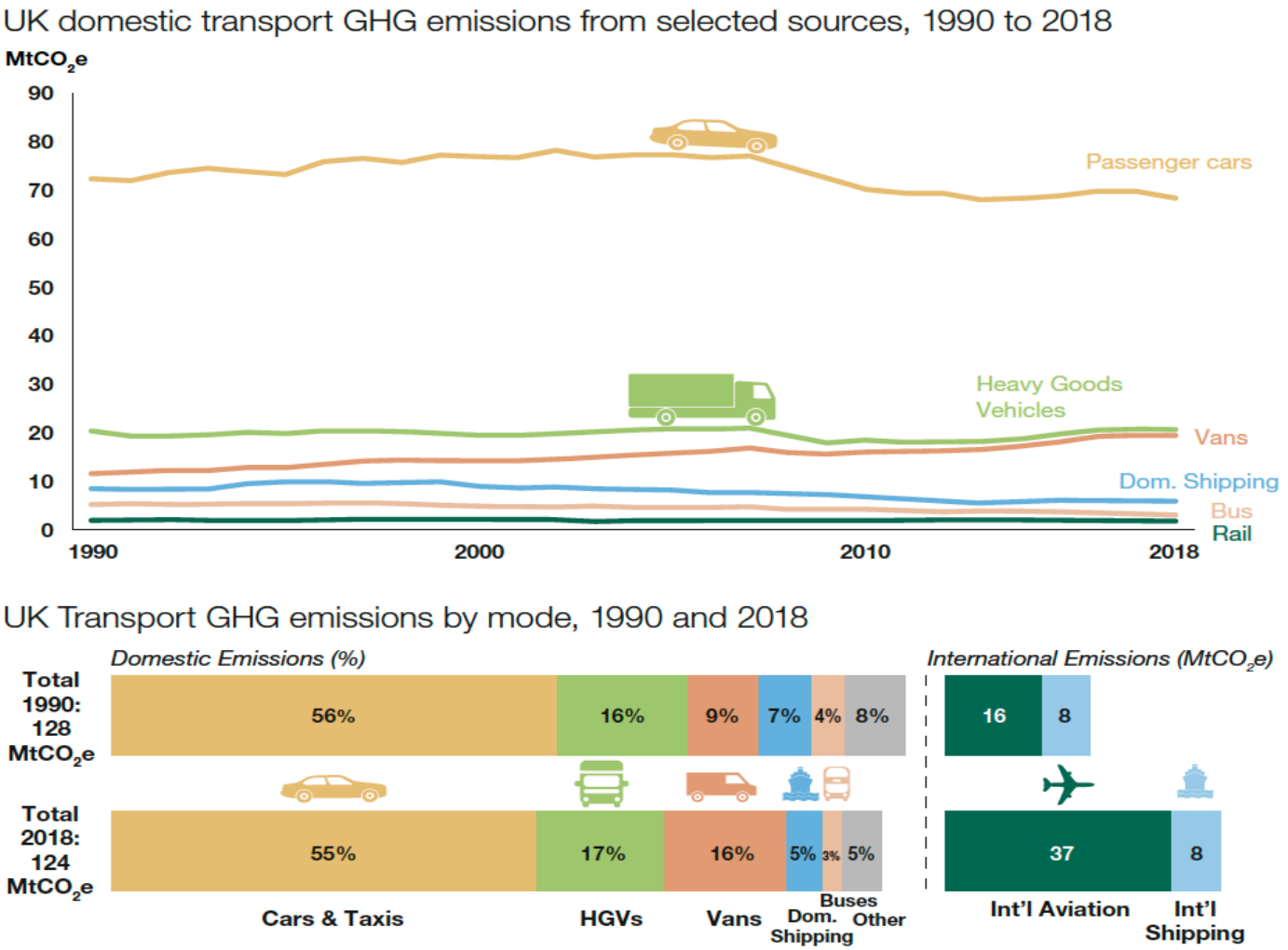
Figure 3: UK domestic and international GHG emissions, 2018



Passenger car is main transport carbon emitter

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932122/decarbonising-transport-setting-the-challenge.pdf

Cathode

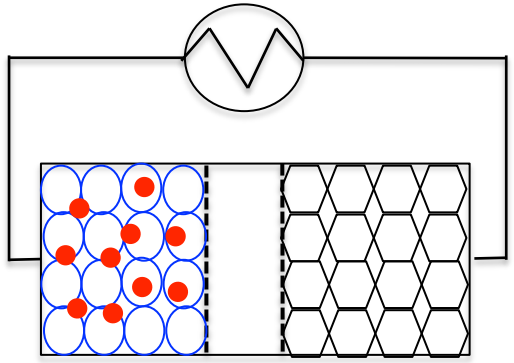
$CoO_2 + Li^+ + e^- \longrightarrow LiCoO_2$

Anode

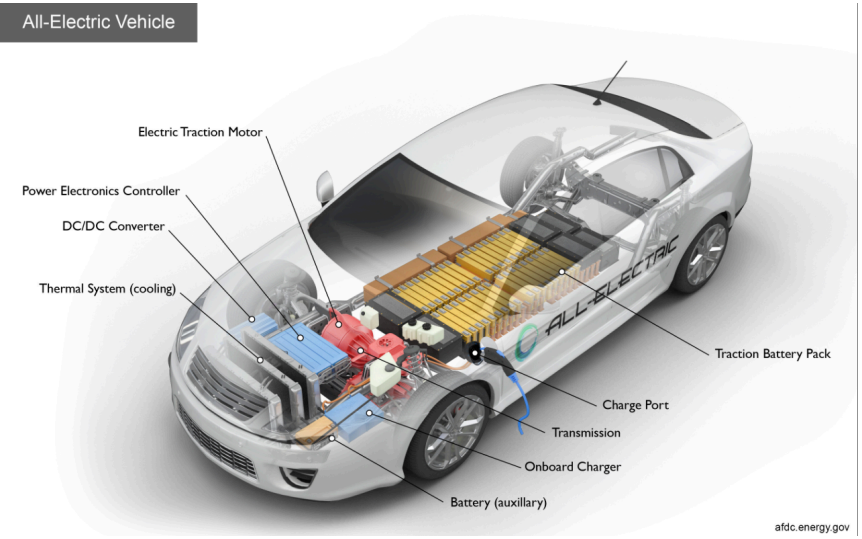
$LiC_6 \longrightarrow C_6 + Li^+ + e^-$

Discharged

Cathode +

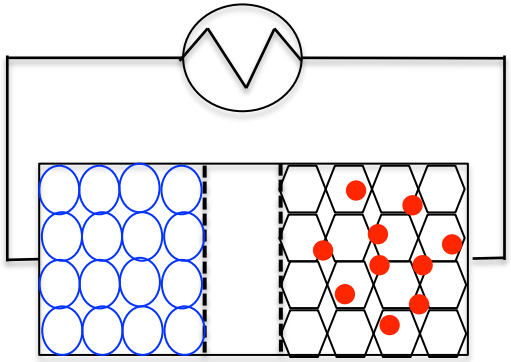


Anode -



Charged

Cathode +



Anode -

Lithium Ion Battery

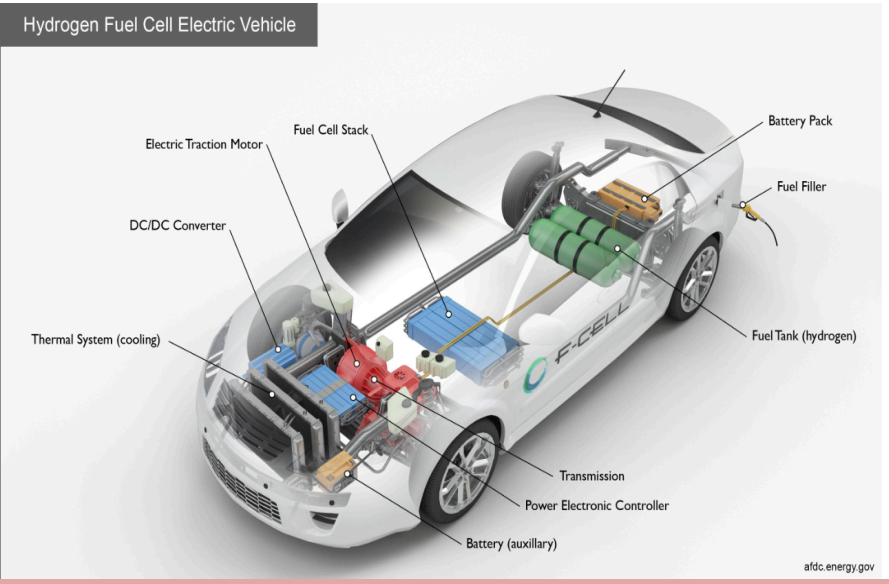
Cathode

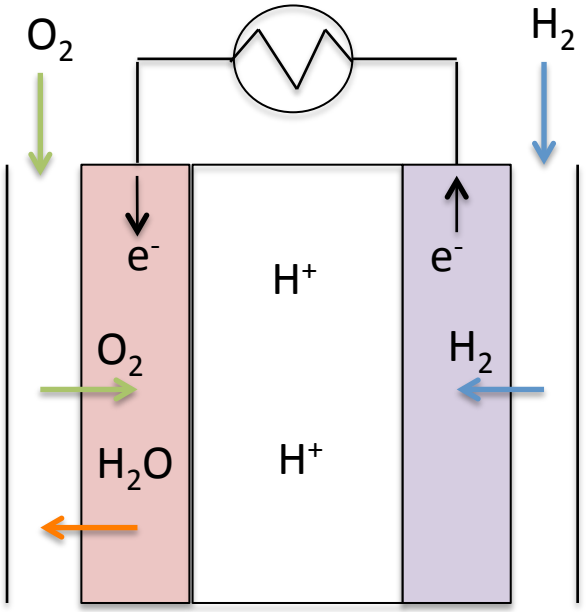
$1/2O_2+2H^++2e^- \longrightarrow H_2O$

Anode

$H_2 \longrightarrow 2H^++2e^-$

Platinum catalyst

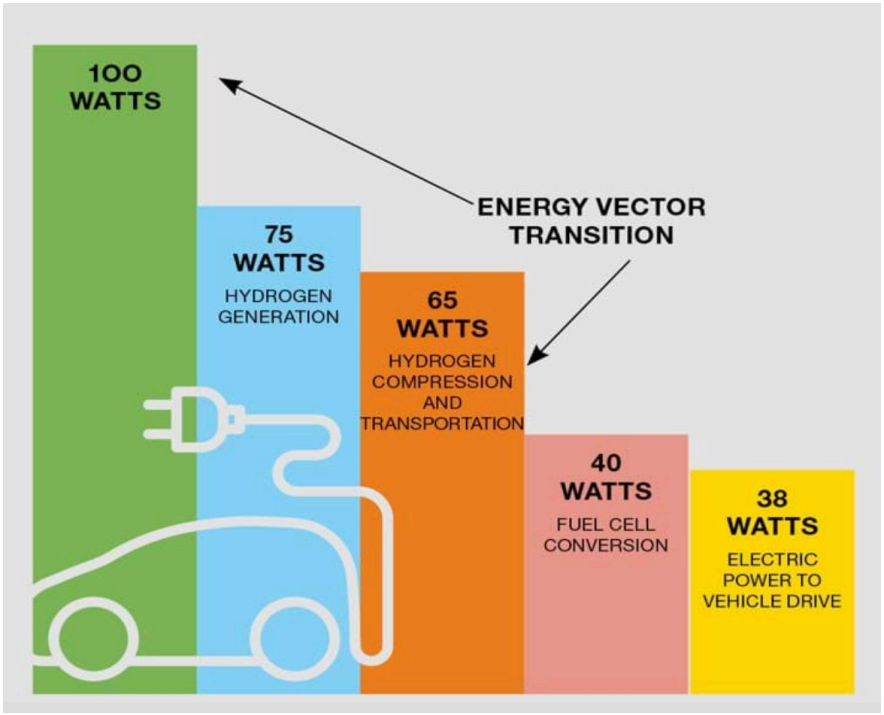




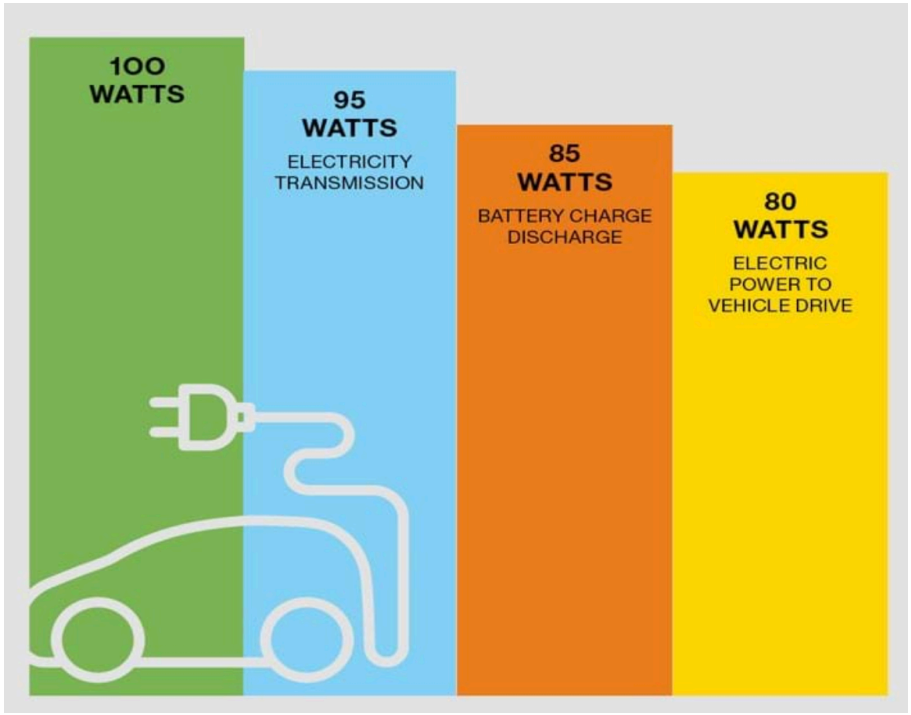
Cathode + Anode -

Hydrogen Fuel Cell

HFCEV



BEV



BMW – "The overall efficiency in the power to vehicle drive energy chain is therefore only half the level of a BEV."

BEV twice as efficient as HFCEV

https://www.thechemicalengineer.com/features/maybe-you-can-drive-my-car/
https://www.bmw.com/en/innovation/how-hydrogen-fuel-cell-cars-work.html

VW

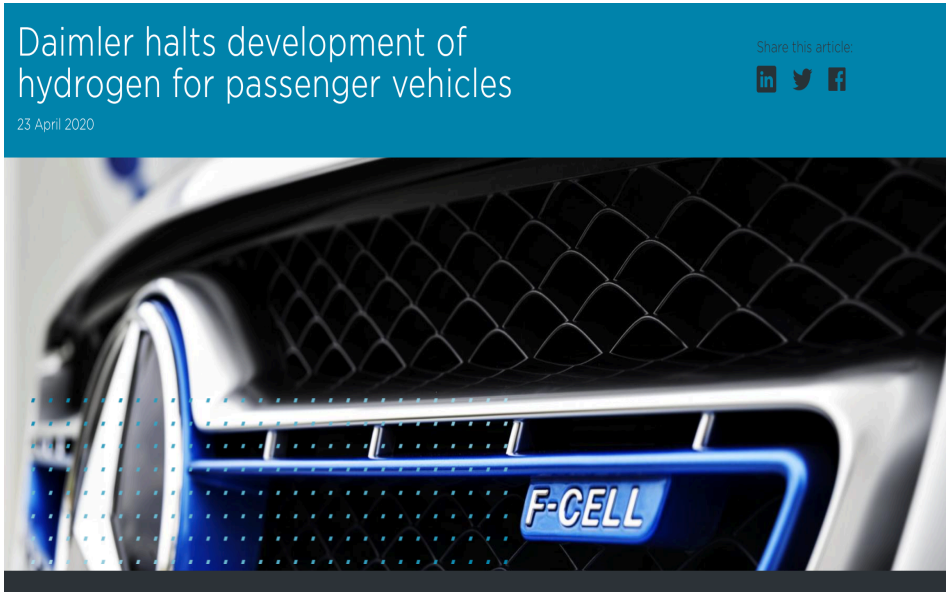
"The conclusion is clear: in the case of the passenger car, everything speaks in favour of the battery and practically nothing speaks in favour of hydrogen. "

GM

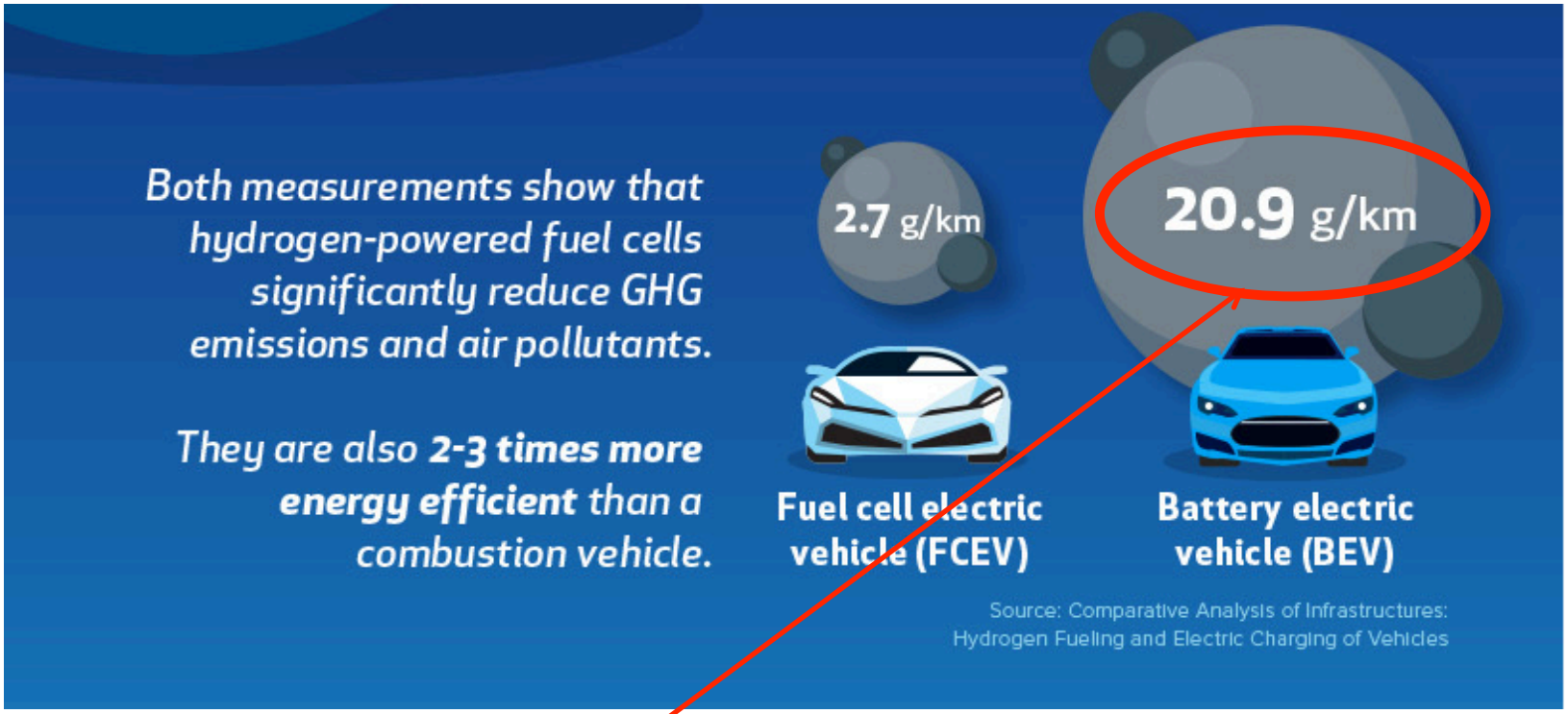
"We want to put everyone in an EV, and we believe we have what it takes to do it."

Bloomberg NEF

"Hydrogen can play a valuable role decarbonizing long-haul, heavy-payload trucks. But the bulk of the car, bus and light-truck market looks set to adopt battery electric drive trains, which are a cheaper solution than fuel cells."



Battery electric vehicles to dominate market



Assumes electricity is derived from burning fossil fuels – biased assumption.
Study funded by Hydrogen Mobility!

Hydrogen hype

https://juser.fz-juelich.de/record/842477/files/Energie_Umwelt_408_NEU.pdf