Hydrogen – a sustainable option for energy?

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Hydrogen production: grey, blue & green

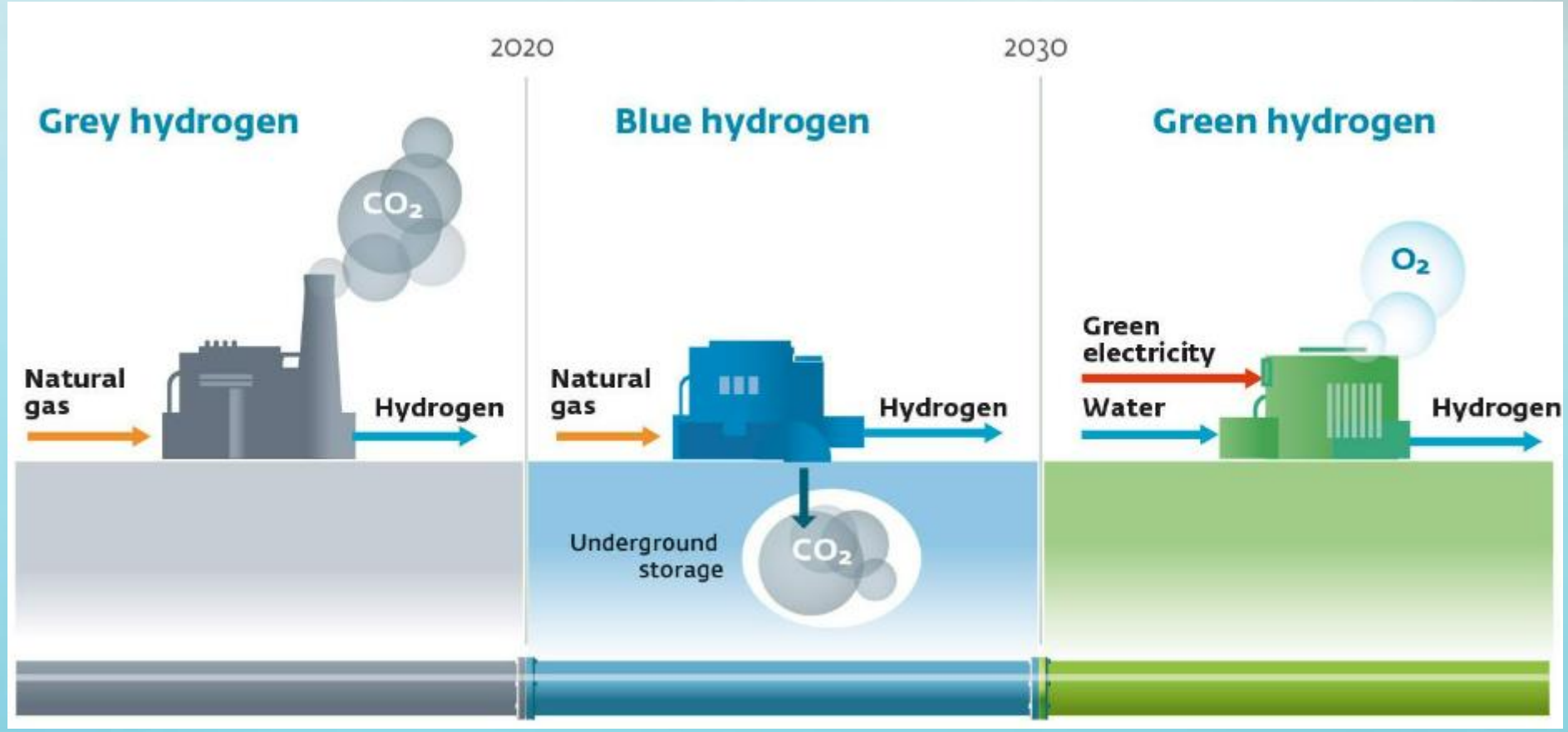
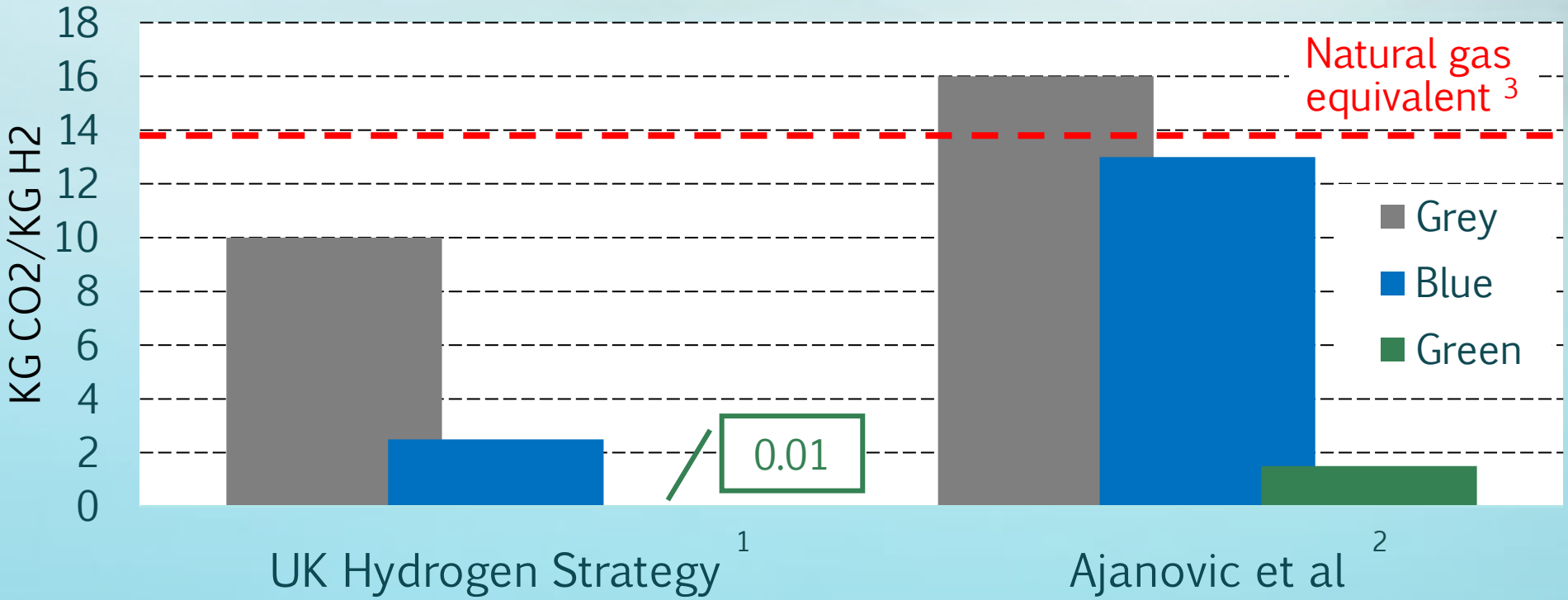


Image: Gasunie

Hydrogen emissions: grey, blue & green



- Assumptions used vary emissions significantly – in particular whether fugitive emissions from methane production are properly accounted for
- SMR is an energy intensive process and so fugitive emissions are critical

References: 1 – UK Hydrogen Strategy, UK Govt, 2021. 2 – Ajanovic et al, 2022, International Journal of Hydrogen Energy. 3 – BEIS emissions factors used to calculate emissions from natural gas compared with hydrogen on a per kWh basis.

Hydrogen cost in 2020: grey, blue & green

- Grey and blue prices are close to equivalent with natural gas
- Green prices are higher, and with a significant range of uncertainty, due to uncertainty in cost reductions with scale and potential efficiency improvements.

References: as per previous slide, and 3 – Ofgem wholesale market price from Sept 21 for comparison with H2 numbers, compared with hydrogen on a per kWh basis.

Achieving net zero heating – hydrogen or heat pumps?

	Hydrogen in the gas grid	Electrification + heat pumps
Infrastructure cost [1]	£150 bn additional cost by 2050 (large uncertainty due to safety requirements)	£250 bn additional cost by 2050
Carbon footprint	Potential to reach net zero, dependent on hydrogen production	Potential to reach net zero, dependent on electricity generation mix & energy storage
Environmental impacts of infrastructure	• Polyethylene pipes needed • Impacts of digging up roads	• Large amounts of copper required with mining impacts • Reinforcing overhead lines
Notes	Gas grid provides large energy store Safety?	Significant need for energy storage or baseload power – nuclear? Mature technology

References: 1 – National Infrastructure Commission report on cost analysis of future infrastructure options, 2018.

Achieving net zero transport – hydrogen fuel cell or battery/overhead wires?

	Hydrogen fuel cell vehicles		Battery electric vehicles
Cars		Limited uptake to date Longer range May be cheaper to reach 100% market penetration?	Uptake well under way Recharging high numbers will need rapid chargers on main routes
Buses		Suitable for full range of duty cycles Total cost of ownership equivalent to battery vehicles	Uptake is underway for short distance routes
Trains		Cheaper than electrification with overhead lines? Germany is deploying FC trains	Very high power requirements need large batteries or overhead lines
HGVs		FC well suited to high power requirements and flexible operations Number of manufacturers are developing products	Needs overhead lines on trunk roads for long haul, with smaller batteries for final 10-20 miles?

Final thoughts…

- Strong case for green hydrogen in industry
- For heating, electrification is likely to be cheaper on a total cost basis (& more efficient), but energy storage or baseload power is a significant challenge
- In transport EVs win out for passenger cars, but energy storage requirements for mass rapid charging are significant
- In heavy duty transport a mixture of electrification and hydrogen seems likely depending on use case
- To reach net zero we will need both hydrogen and electrification. Infrastructure needs to be designed along circular economy principles, and sustainability analysis must be done!