H_2 Generation Technology
The past, the present and the future

TRILEMA Workshop

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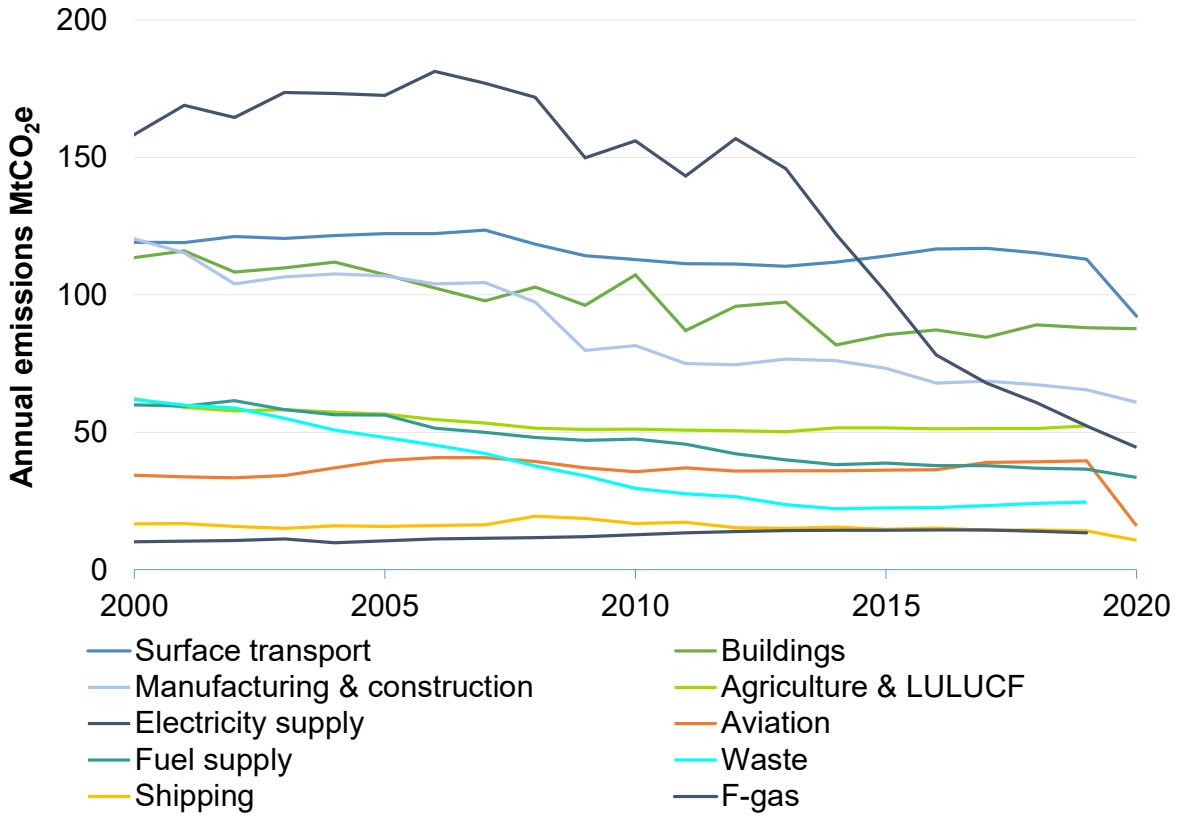
CO_2e emissions in the UK



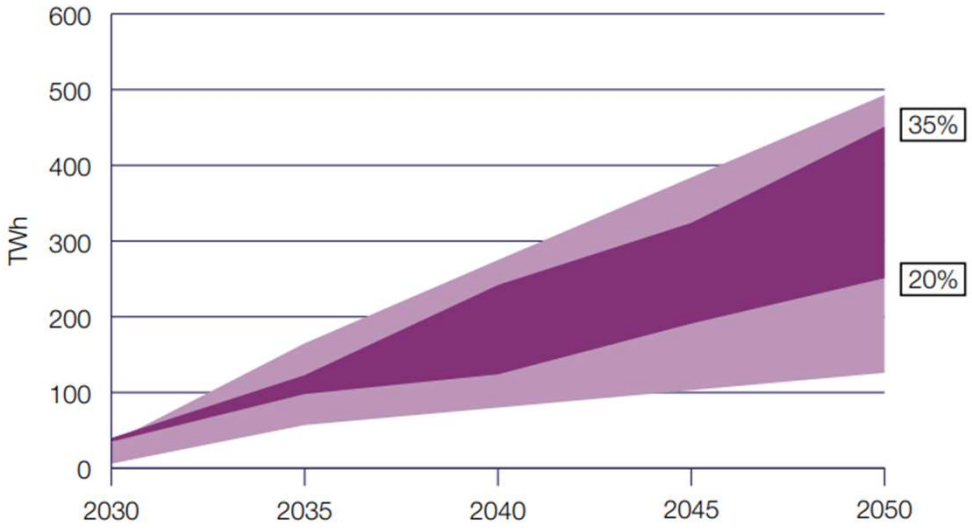
H_2 *can* decarbonise nearly all of these

National Strategy

- 10 GW of H_2 by 2030 at least 50% green
- First cluster projects operational by 2030

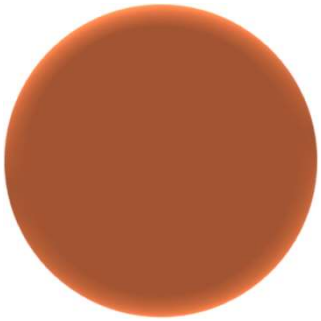
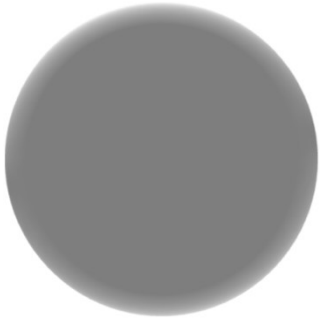
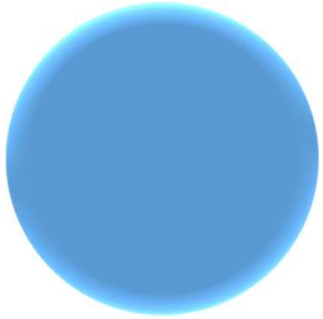
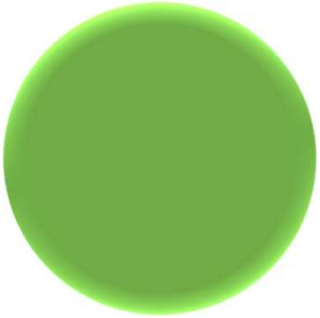
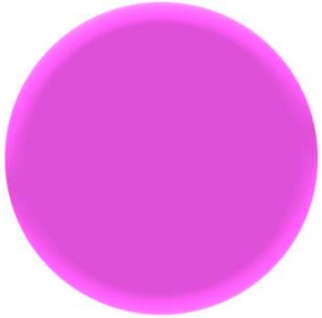
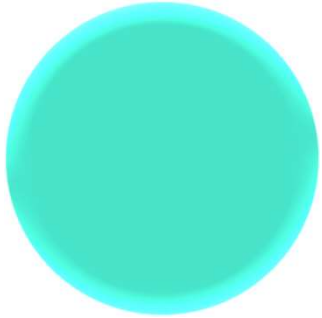
- This only represents ~1/3 of the H_2 needed by 2050
- H_2 will be used in multiple sectors including:
  - Aerospace + Maritime
  - Heavy transportation
  - Industry / hard to decarbonise activities
  - Peak load power supply

Figure 1.2: Hydrogen demand and proportion of final energy consumption in 2050



% = hydrogen as proportion of total energy consumption in 2050

How is it made? / What colour is H_2?

H_2 production options

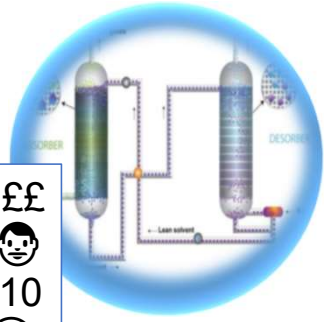
Coal

H_2 Cost = £
Age = 😷
Scale = 10
CO_2 = 😟

NG

H_2 Cost = £
Age = 😷
Scale = 10
CO_2 = 😟

NG + CCS



H_2 Cost = ££
Age = 🧑
Scale = 10
CO_2 = 🙂

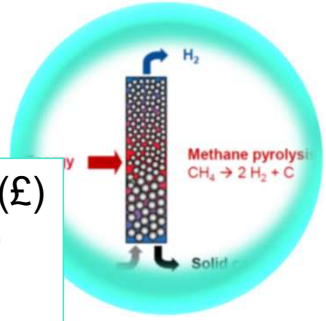
Electrolysis

H_2 Cost = £££(£)
Age = 🧔
Scale = 10
CO_2 = 😁

Nuclear

H_2 Cost = £££
Age = 🧒
Scale = 7
CO_2 = 😁

Others, including methane pyrolysis



H_2 Cost = ££(£)
Age = 👶
Scale = 4
CO_2 = 🙂

Blue hydrogen production by Sorption Enhanced Reforming

The HyPER Project

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May 2022

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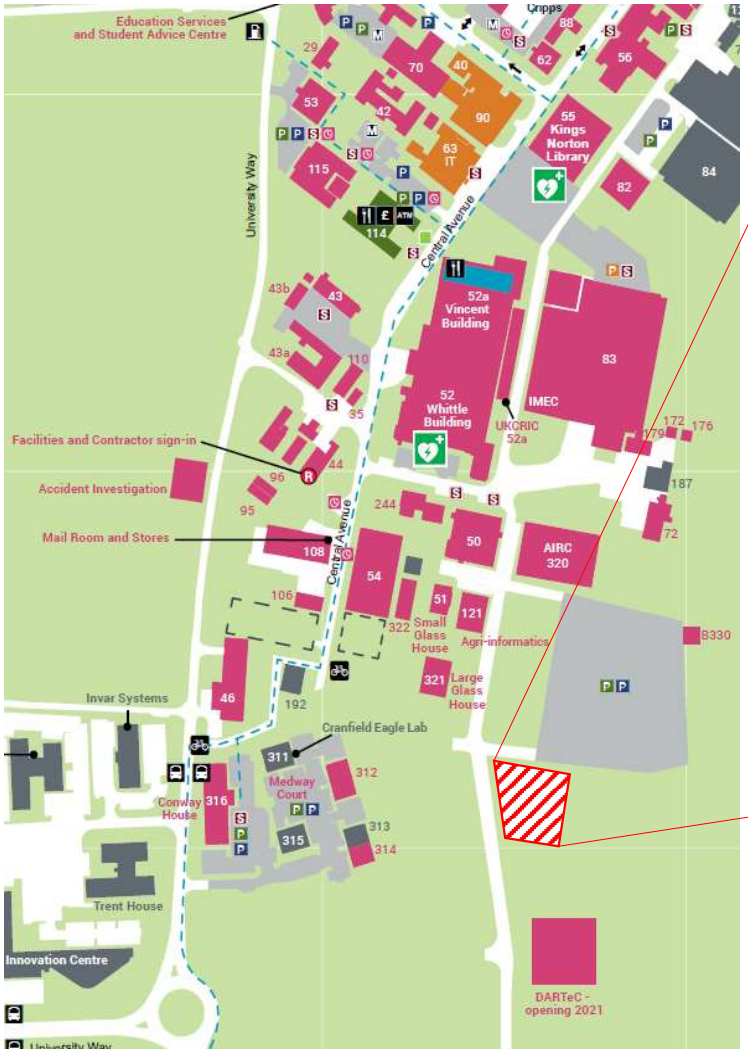
Introduction to HyPER

Bulk **Hy**drogen **P**roduction by Sorbent **E**nhanced Steam **R**eforming

Phase 1 – Feasibility	May – September 2019 (£0.5m)
Phase 2 – Demonstration	January 2020 – December 2022 (£7.4m)
Phase 3 – Extended Testing	April 2022 – December 2022 ($1m)

Current Consortium

Cranfield University	Project Lead and Technology Development
Doosan Babcock	Engineering Partner
Gas Technology Institute	Technology Owner and Techno-economics


Education Services and Student Advice Centre
University Way
Central Avenue
55 Kings Norton Library
52a Vincent Building
52 Whittle Building
IMEC
UKCRIC 52a
83
84
Facilities and Contractor sign-in
Accident Investigation
Mail Room and Stores
AIRC 320
Small Glass House
Agri-informatics
Large Glass House
8330
Invar Systems
Cranfield Eagle Lab
Medway Court
Conway House
Trent House
Innovation Centre
DARTeC - opening 2021

Cranfield University

HyPER

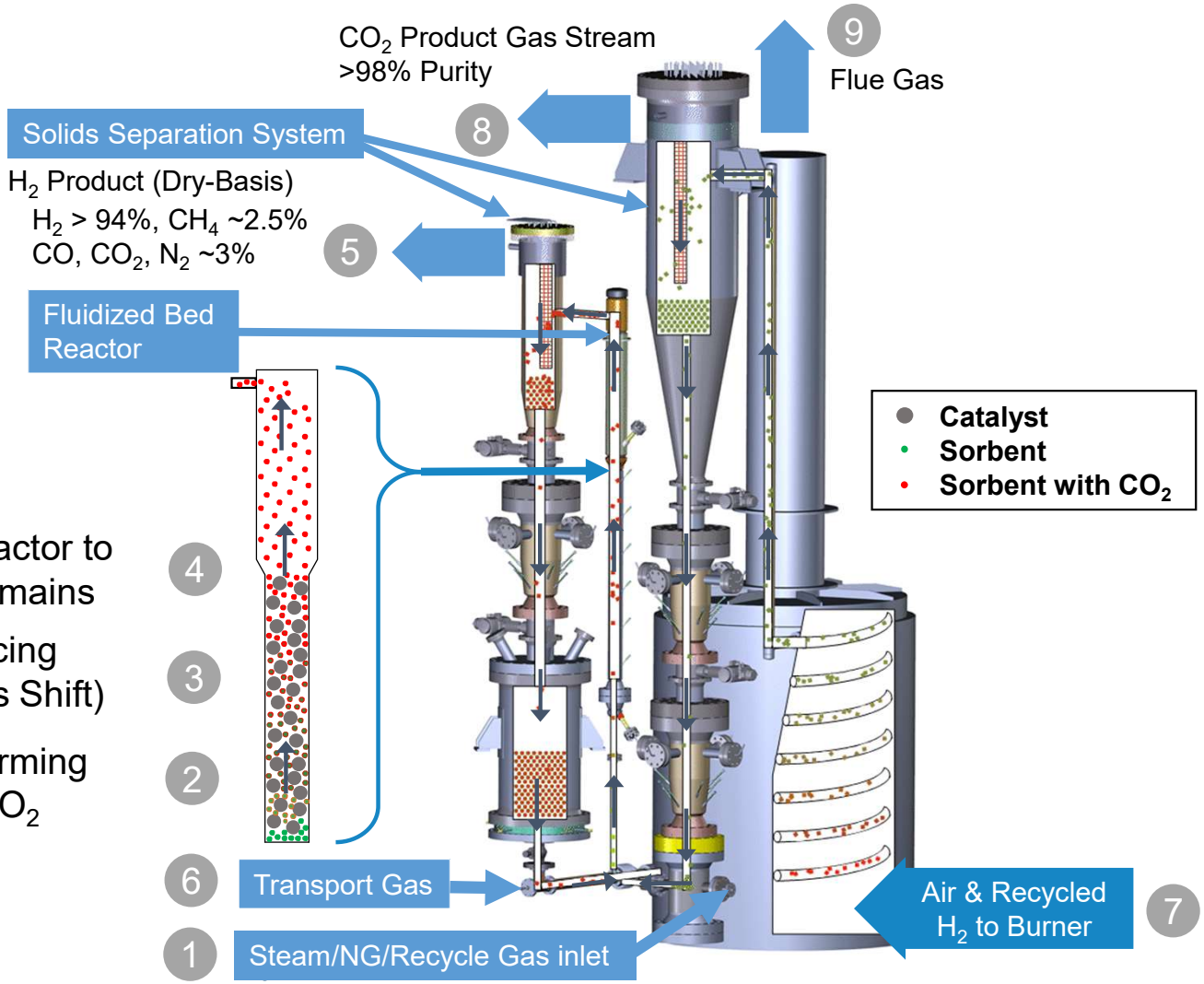
Sorption Enhanced Reforming (SER)

$$CH_4 + 2H_2O + Heat(a) \longrightarrow 4H_2 + CO_2$$
$$CaO + CO_2 \longrightarrow CaCO_3 + Heat(b)$$
$$CH_4 + 2H_2O + CaO \longrightarrow 4H_2 + CaCO_3$$
$$Heat(b) \sim 95\% \; Heat(a)$$

Sorbent elutriates through reactor to filter while heavier catalyst remains

CO_2 absorbed by sorbent forcing more CO_2 to form (Water-Gas Shift)

Steam Methane Reforming produces H_2, CO & CO_2

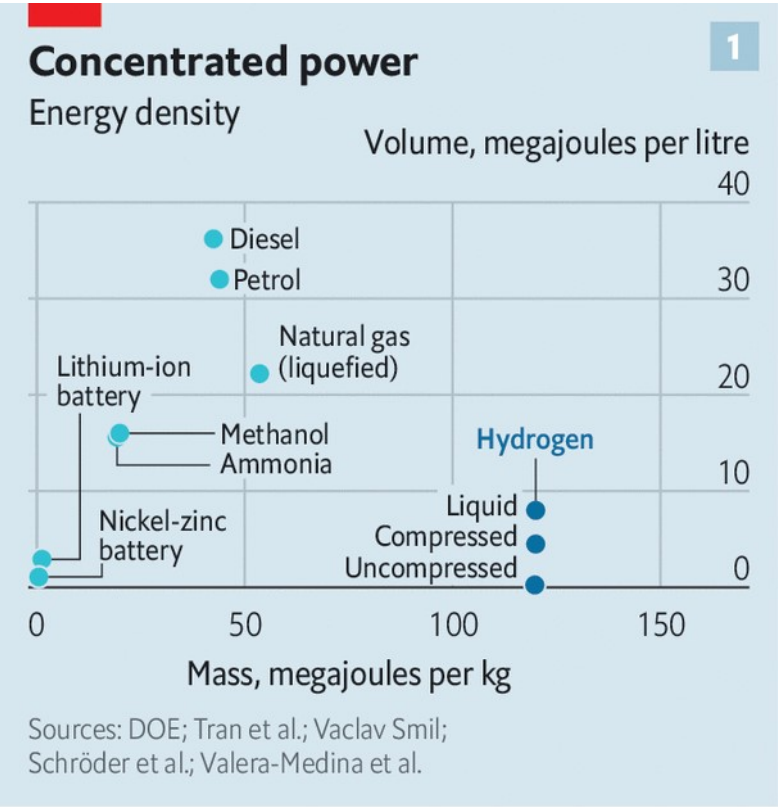


Performance Evaluation

Compared to SMR+CCS or ATR+CCS, SE-SMR technology can achieve:

- ~25% lower Levelised Cost of Hydrogen
- >50% reduction in CAPEX with similar OPEX
- ~97% CO_2 capture rates with equivalent H_2 purity
- <40% lower carbon footprint
- Smaller physical footprint due to integrated nature of the SE-SMR process
- Potential to scale the CHG up to the hundreds of MW

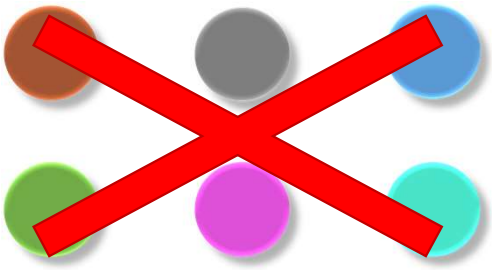
H_2 Energy density



The Economist

- H_2 has a very high energy density by mass but low by volume
- Generally, about 3 times more gas/liquid H_2 is needed compared to the equivalent gas/liquid fossil fuel due to its lower energy density
- H_2 has been safely used in industry for many decades
- Lots of options for H_2 use with some 'better' than others

So what choice should aerospace/aircraft/airports make?



- Don’t think about H_2 colour now
- Think about speed and negotiating future contracts
- Electrify as much as possible

Conclusions

- We can decarbonise the UK and reach net zero
- We need everything yesterday
- We should not wait for a unicorn
- There is not one solution for everything
- UK will likely see more H_2 use than other countries
- Socio-political issues will become more important

Further reading:

Does the world need hydrogen to solve climate change?

(Carbon Brief, 2020)

https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change