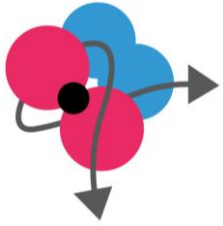


Perspectives on H₂ in a low carbon world

Nilay Shah

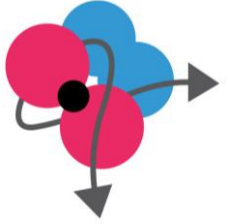
Imperial College London



Context

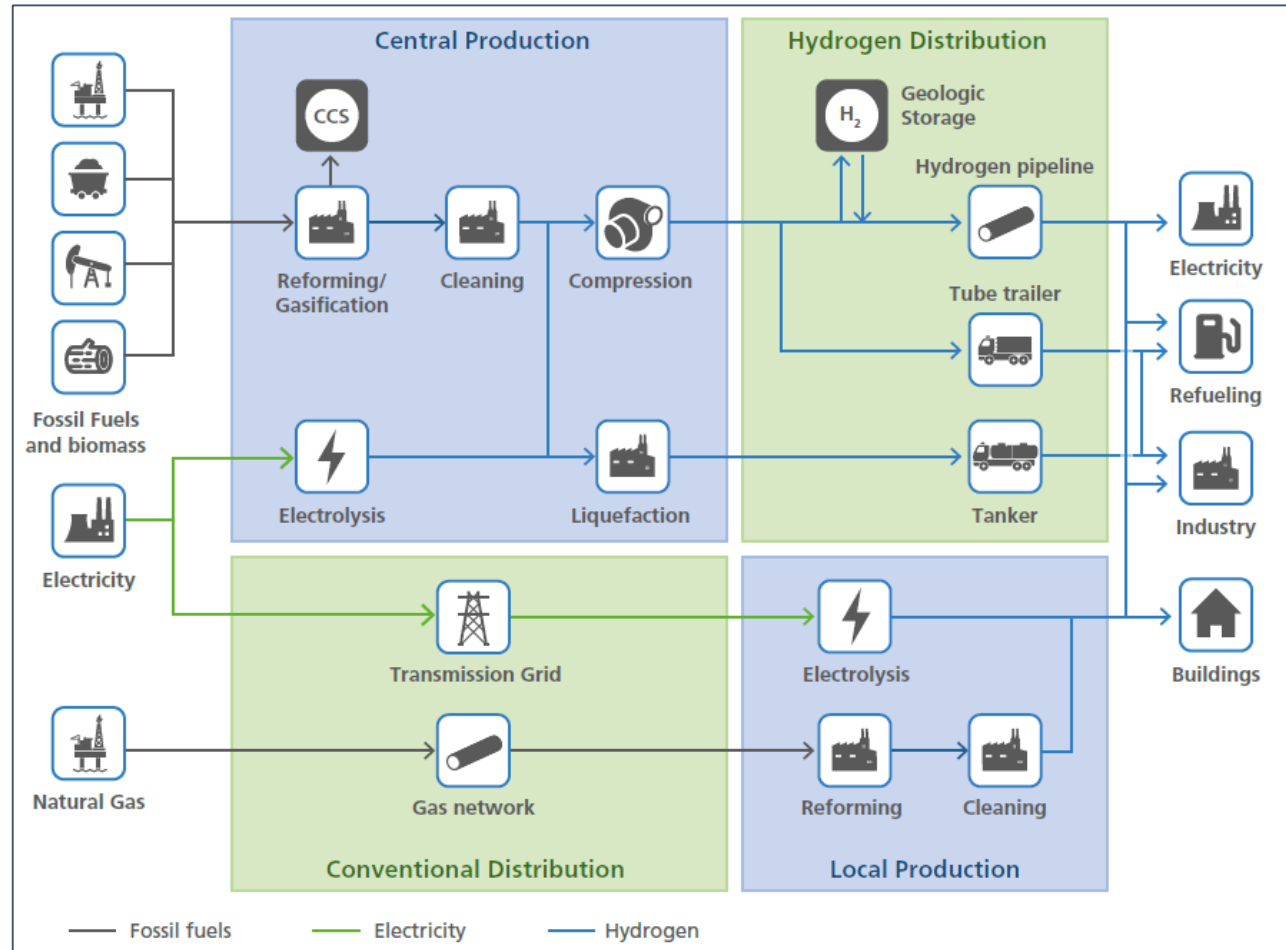
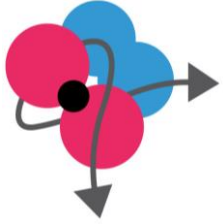
- 3 “waves” of interest in hydrogen
- 1970s – oil shock
- 1990s – climate change, advances in electrochemical technology
- 2020s and beyond – low carbon systems thinking
 - Hydrogen is an effective point source solution for many problems
 - But not always the single best (e.g. heat pumps, battery vehicles, biofuels)
 - Better to think of it as “middleware”
 - Deployment needs a systems approach

Hydrogen – roles in the future energy system



- Industrial feedstock and reductant
 - Existing and new processes (iron, synthetic fuels, ...)
- Industrial, commercial and residential heating
- Low carbon power generation/CHP
- Transport
 - Heavier duty/longer range vehicles, trains, marine, aviation?
- Energy storage and renewables integration/cost reduction
- Long distance low-carbon energy transport
- ...

Systems view



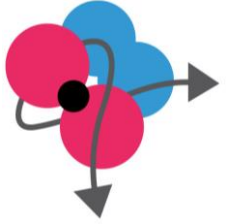
Future low carbon systems need **low carbon energy vectors**:

- Electricity
- Hydrogen
- Biofuels
- Synthetic fuels

Different regions will have different proportions...

New service: negative emissions

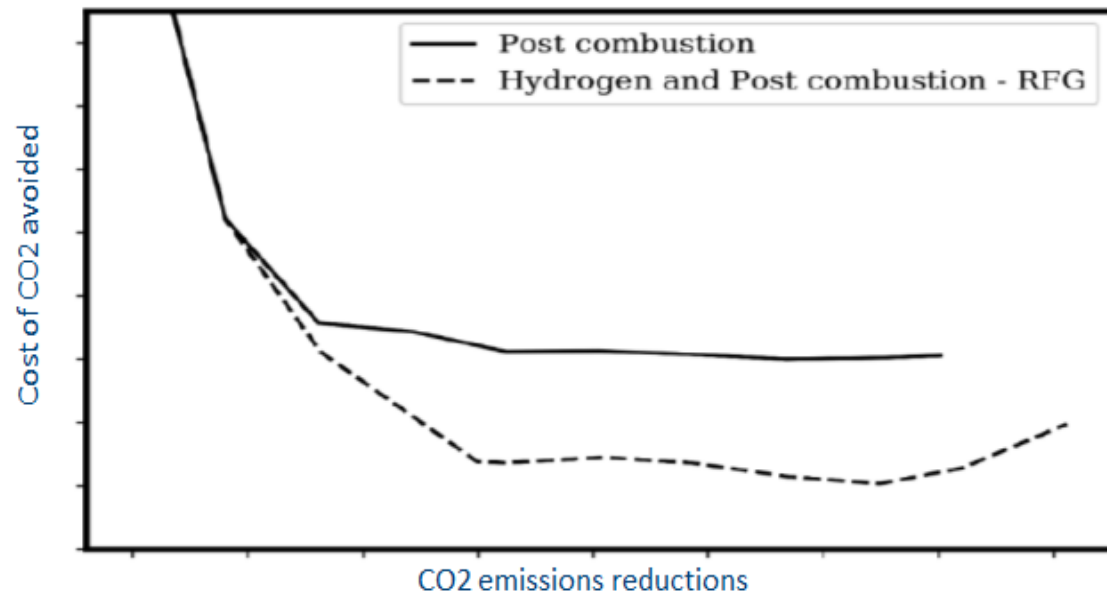
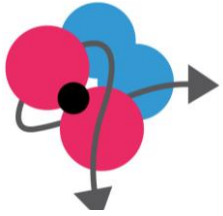
(H2FC Supergen Hub)



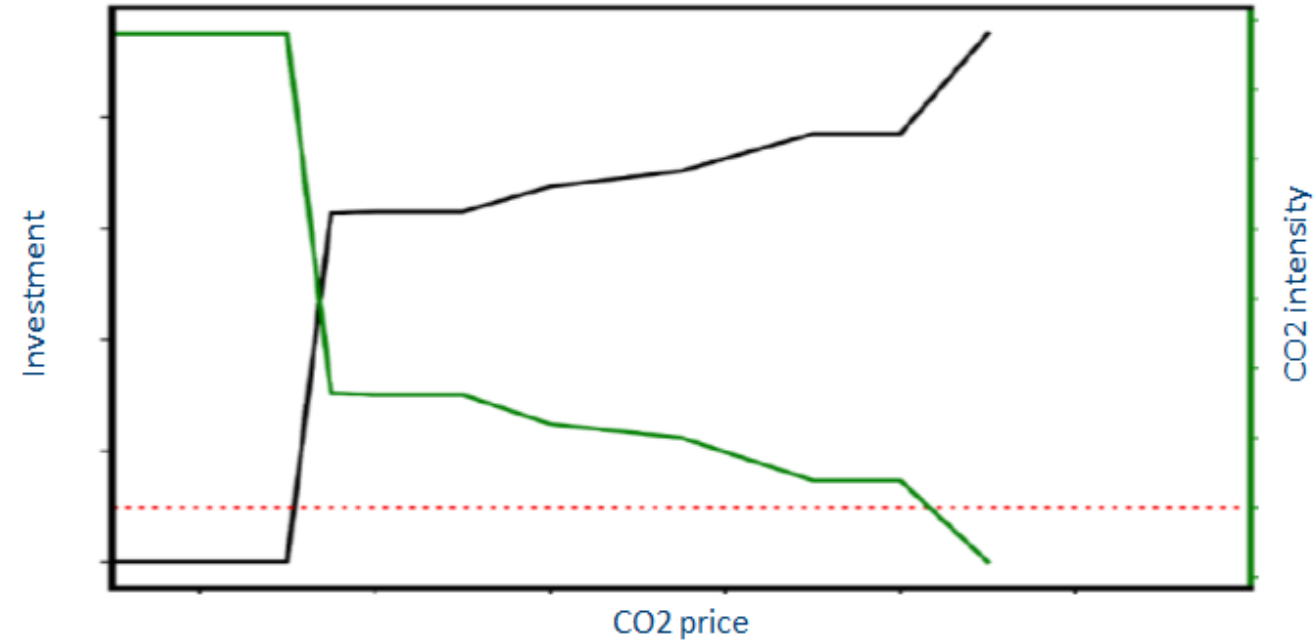
Hydrogen – pathways to deployment

- Find the best niches and grow out from there; do the harder things over time
- UK implication may be that hydrogen hubs at low carbon industrial clusters
 - Initially driven by “blue” hydrogen to scale quickly (gas is already available)
 - Supplemented by “green” over time
- Then linking to other users
 - Transport fleets (logistics, local authorities, public transport)
 - Feed local gas distribution networks for commercial and residential heat
- Interconnected regional systems → national system
 - Ensures longer term resilience

Industrial cluster decarbonisation - example



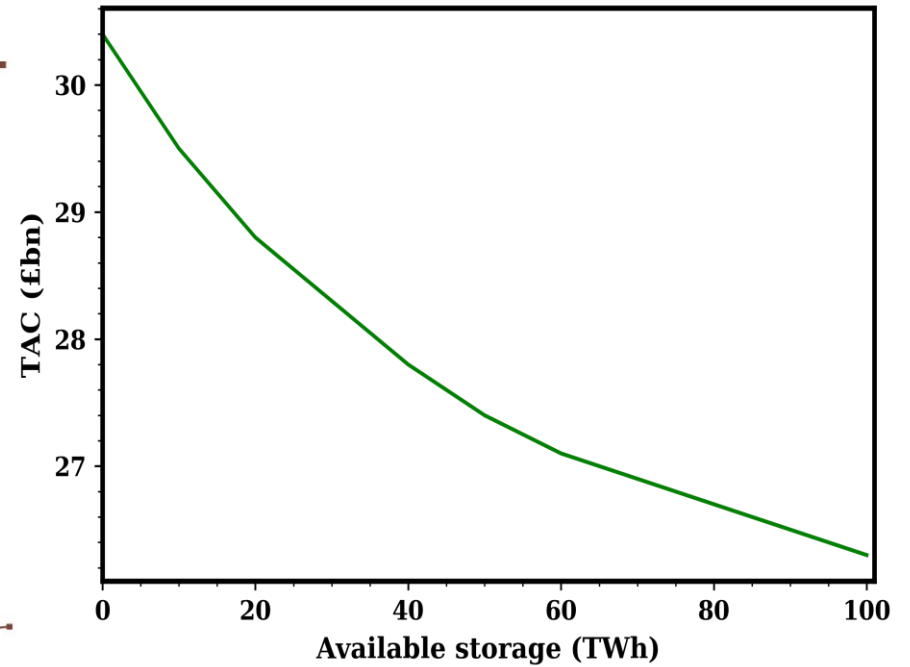
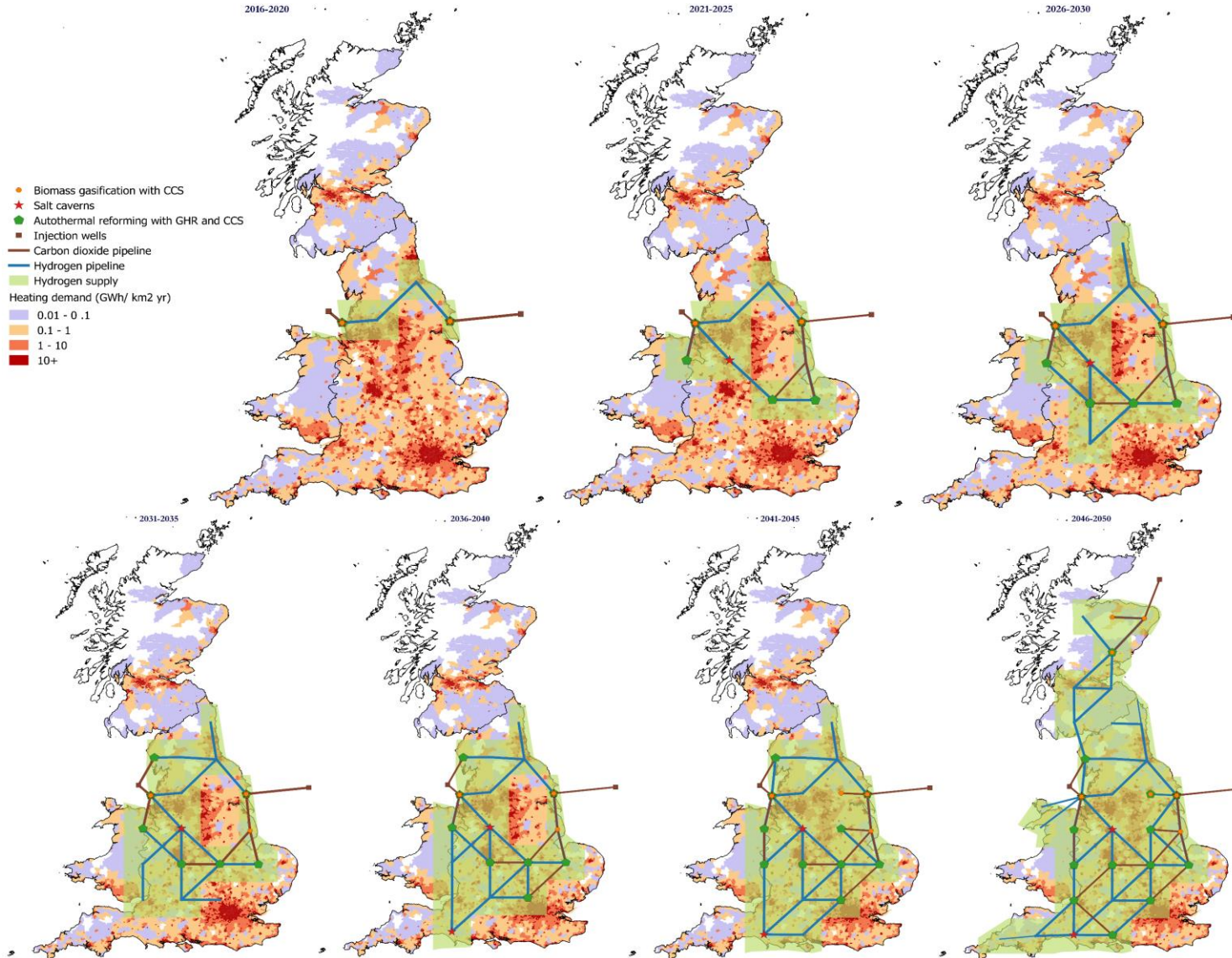
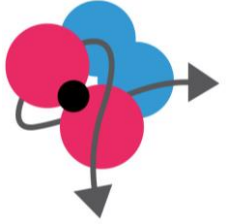
Deeper and cheaper with hydrogen **and** CCS



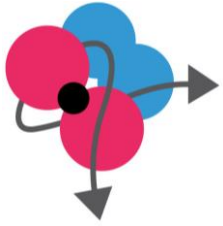
Incentives to drive investment can be quantified



Phased regional to national, need for storage



Geological storage reduces system cost



Summary

- Increasingly sophisticated understanding of role of hydrogen in future low carbon energy systems
- Most policies and interventions are still single-issue based (e.g. transport, grid balancing, heating,)
- “Policy paradox” (Grübler) – greatest benefit is from systems integration but policy frameworks are weakest in this area
- All forms of low carbon hydrogen will be required