UCL

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How competitive are sustainable aviation fuels in a net zero energy system in the UK?

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Motivations

Why is it important to consider **sustainable aviation fuels (SAF)** in our decarbonisation strategies?

Residual hydrocarbon demands are bottlenecks for reaching net zero

In mitigation pathways, the remaining emissions are mostly petroleum-based hydrocarbons
(i) Fuels with high energy density and high specific energy, (ii) products contain carbon

Could invest in synthetic carbon based fuels from **sustainable feedstocks**

Aviation

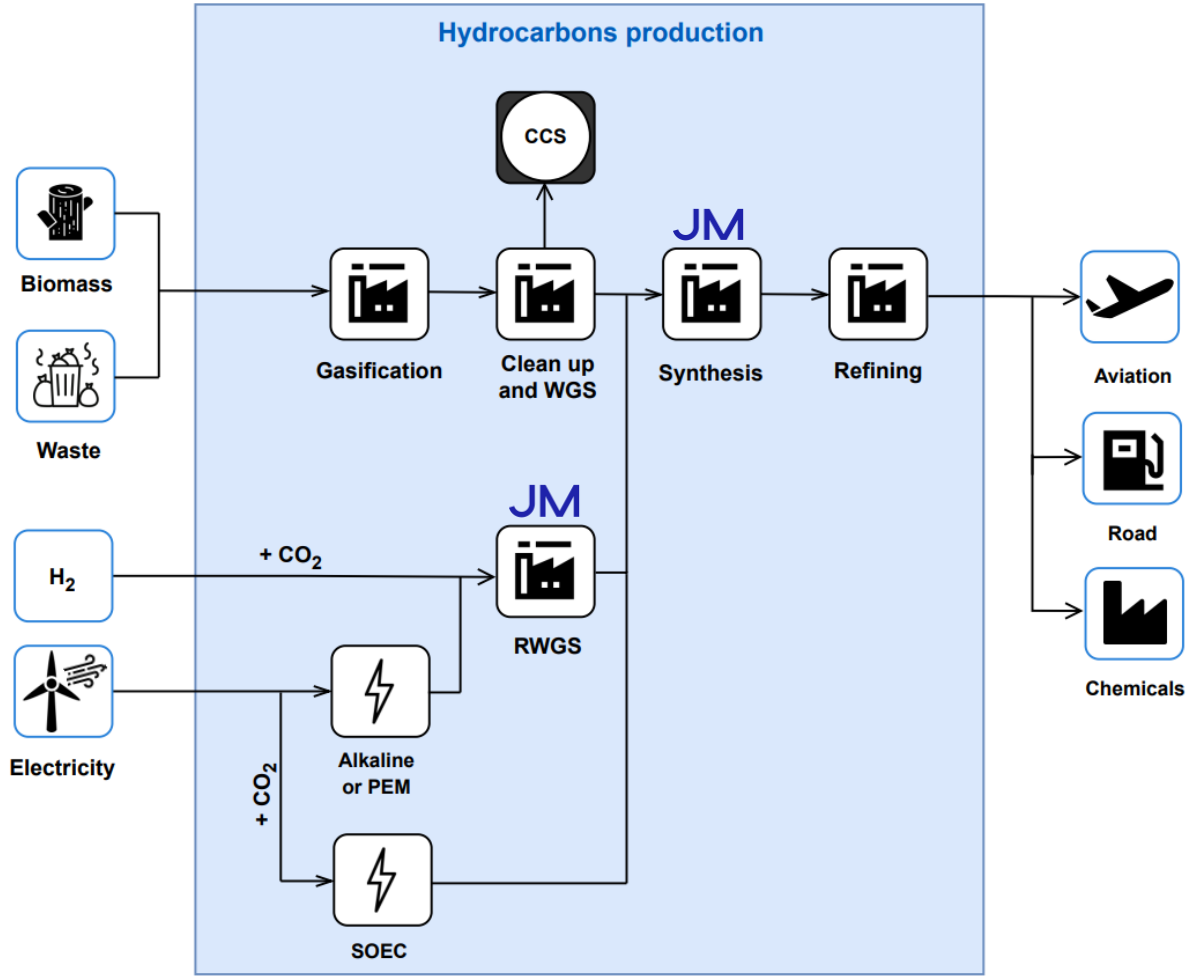
Large low-carbon industrial plants, CAPEX intensive and dependent on feedstock availability

Q) How competitive are SAF in a net zero economy in the UK?

Industrial SAF production facilities at a glance

- Can convert solid (biogenic) or gaseous (H_2 with CO_2) carbon-based energy sources to fuels and chemicals
  - ➢ Synthetic biofuels
  - ➢ **E-fuels (or power-to-liquid)**
- Industry interested in producing SAF using Fischer-Tropsch (JM)
- Opportunities for CCS and CCU

- **High uncertainties** when using sustainable feedstocks;
  - Resource availability
  - Scale and deployment
  - Practicality
  - Chemical structure



This diagram represents syngas pathways. Other opportunities that can convert biogenic resources into hydrocarbons are not reflected here (i.e. anaerobic digestion, fermentation, pyrolysis or hydrothermal liquefaction)

Methods - Energy System Modelling

Energy system models – *what are they?*

Q) How can I decarbonise my energy system as cheaply as possible?

How are they useful to us?

1. Allows for a detailed, technology-explicit representation of the energy system, while providing normative scenario pathways that reach minimum system cost
2. Captures cross-sectoral as well as supply- and demand-side technology interactions, and provides implications in the competitiveness of various technologies in the wider system
3. Suited to model radically different futures, such as substantial decrease in technology cost over a time horizon or ambitious emission reduction targets

UK TIMES

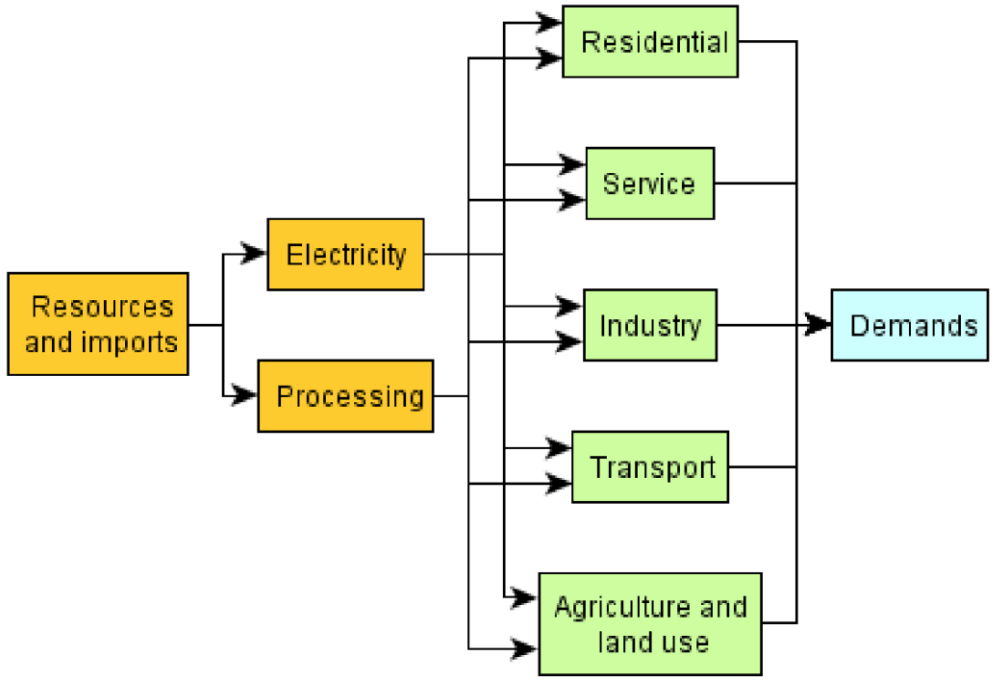
Model typology:

- Bottom-up
- Partial equilibrium
- Cost-optimisation
- Perfect foresight

It can contribute towards understanding;

- Potential future energy flows through the entire economy
- Scenarios that may have a big impact on the UK's energy system

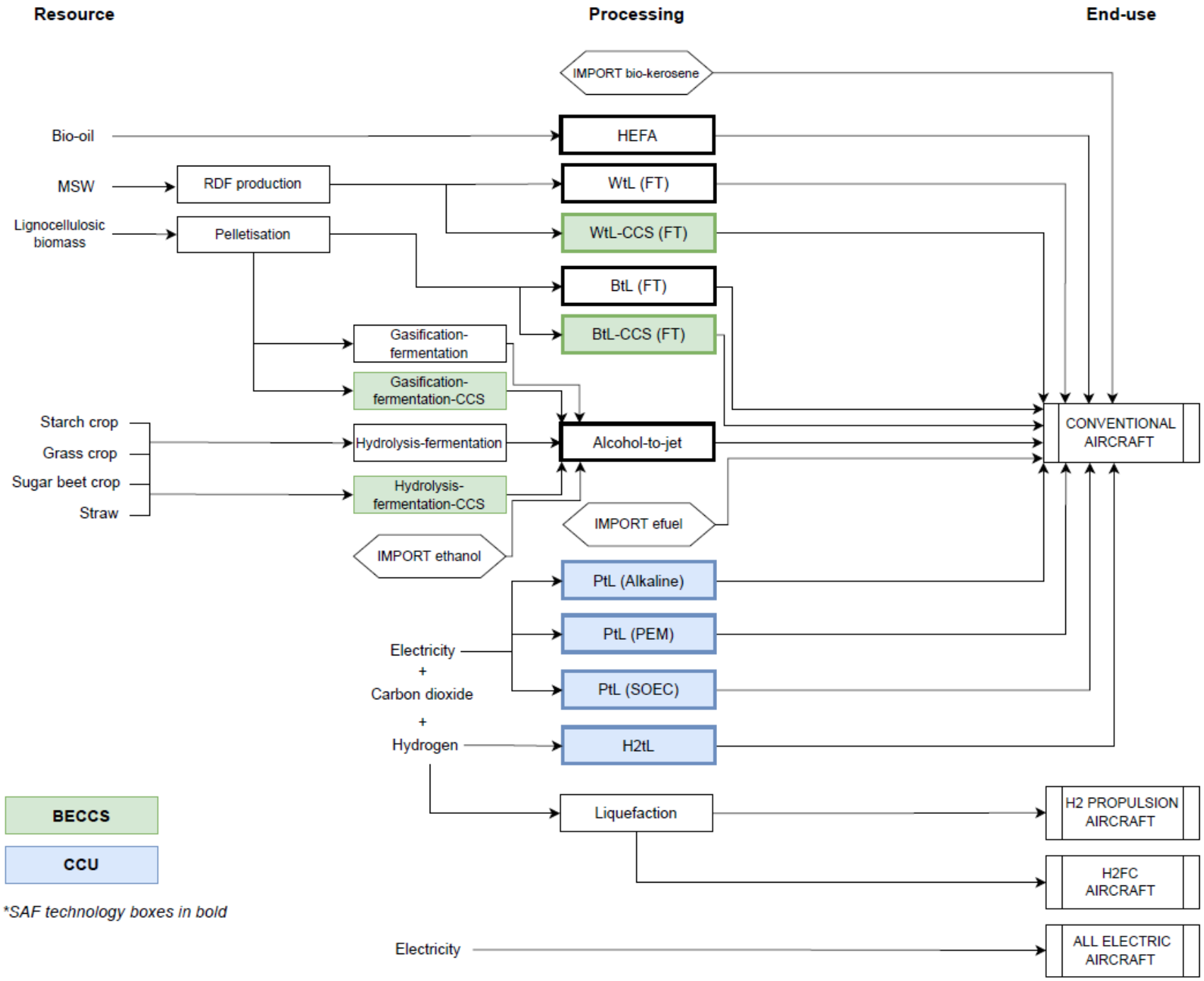
Already widely applied in underpinning policy-making in the UK



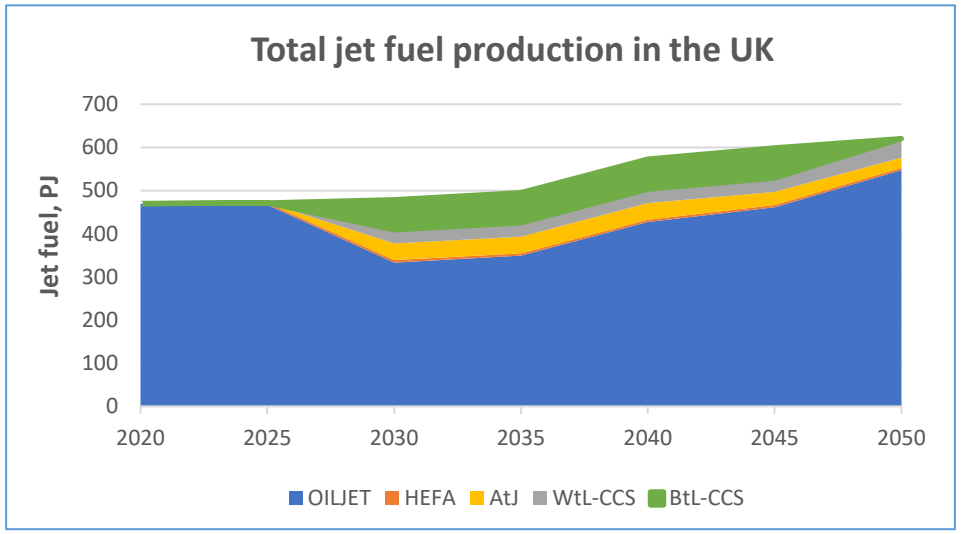
UK energy system represented with 3 supply sectors and 5 demand sectors

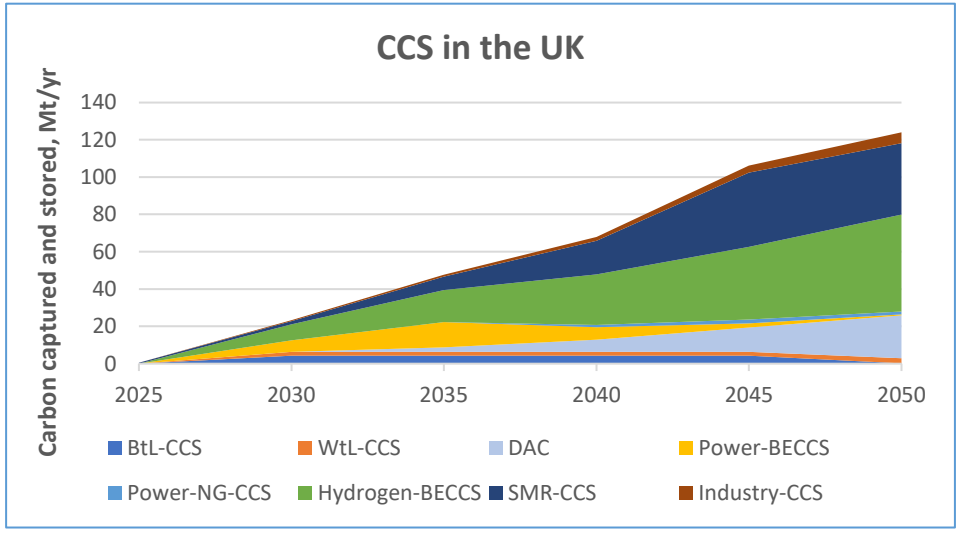
Representation of sustainable aviation fuels pathways in UK TIMES

- A robust set of SAF production pathways
- Representing the possibilities for BECCS and CCU where possible



UK TIMES net zero scenario



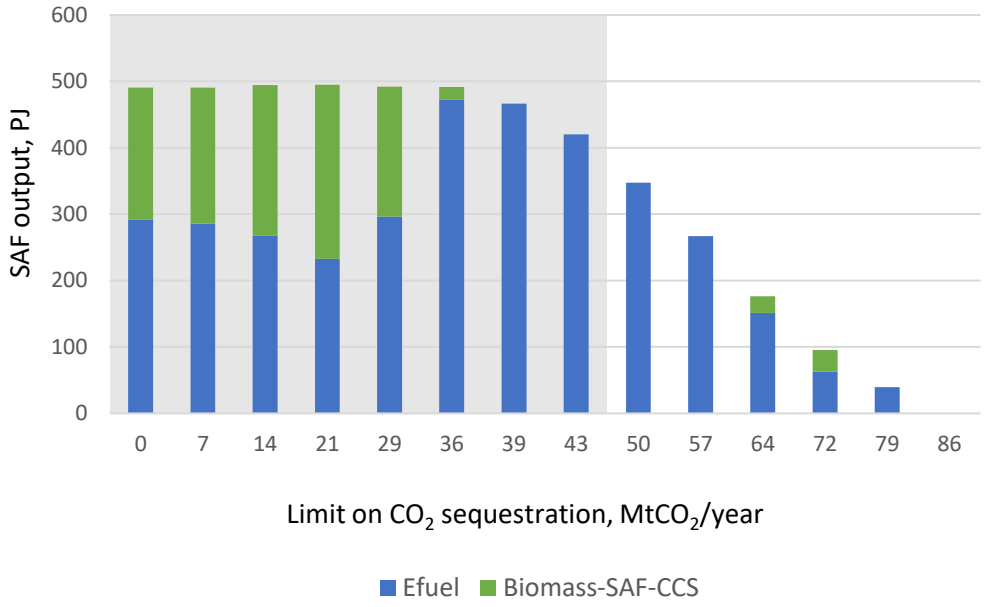


- Various SAF are competitive - AtJ, HEFA, WtL-CCS and BtL-CCS
- BtL-CCS has a transitionary role from 2025 to 2045
- The UK has a large geological storage capacity for CO_2 (using DAC, SMR-CCS and BECCS-hydrogen)
- More economical to sequestrate than utilise CO_2 and there is no market for CCU, thus e-fuels have no output

SAF have a limited role (~13%) in the UK in 2050

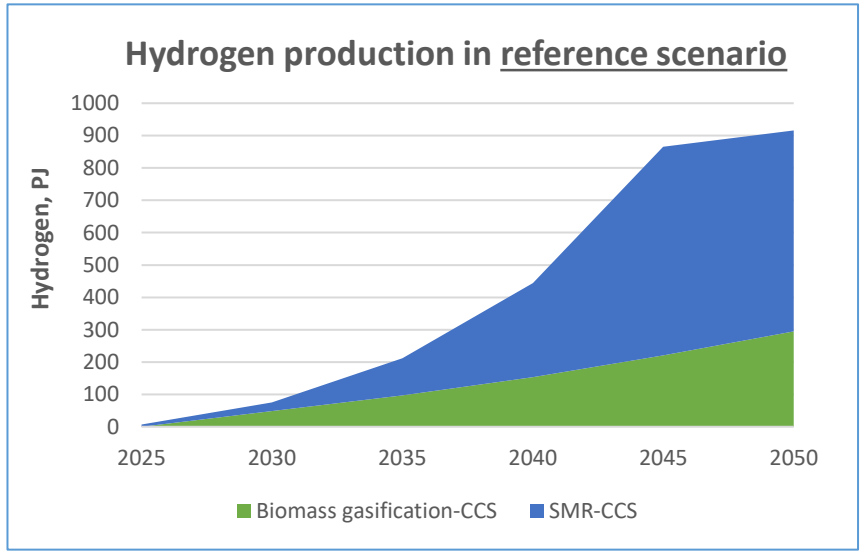
Substantial market share in some scenarios…

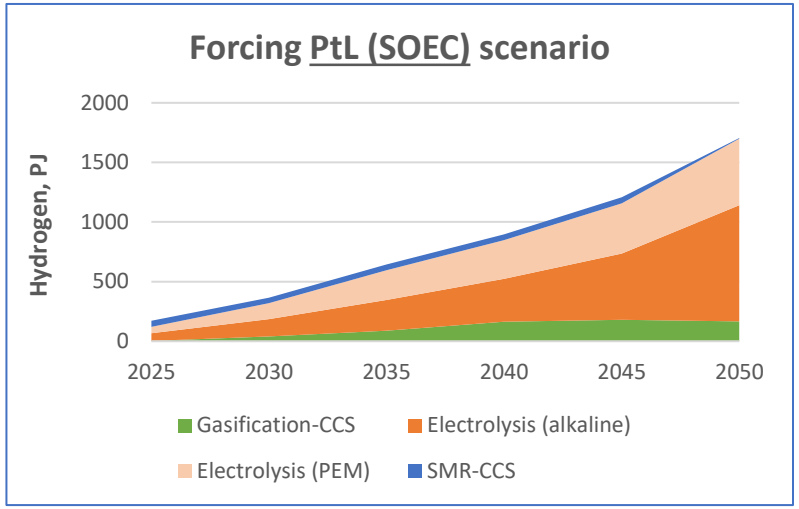
- One of these scenarios is assuming CCS is limited in the UK's energy system
- Both synthetic biofuels and e-fuels have a significant market share when CCS is assumed limited below 86 Mt in 2050.
- This shows that there is a close relationship between CCS, negative emissions and synthetic jet fuels output

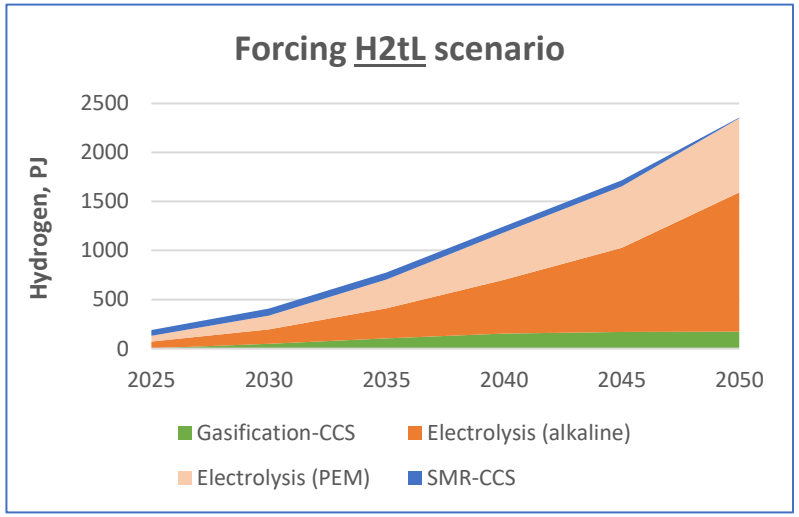


UK SAF production in 2050 (PJ yr-1), from net zero scenarios with varying degree of CCS constrained in the UK TIMES energy system model. Grey area cover scenarios that achieve net zero through imported emissions credit

Implications of e-fuel use on the wider system







- Hydrogen production technologies change drastically
- Quicker and greater deployment of renewables along with e-fuels infrastructures required for the e-fuels scenarios
- E-fuels scenarios have higher overall system costs

Hydrogen production methods for two scenarios designed to impose e-fuels in the energy system to meet 50% of UK's aviation demand in 2050 (~300 PJ)

Conclusions

1. Reduced reliance on CCS raises the value of e-fuels in mitigation pathways

2. Inclusion of e-fuels have systems wide implications – promoting green H_2 but requires substantial investment in renewables

3. Enabling e-fuels is essential if the UK is interested in deep decarbonisation of aviation without offsets using technological GGRs

4. H_2 and CO_2 available to unlock e-fuels but this requires a targeted approach spanning across 'themes' (i.e. renewables, hydrogen production and CCU)

Unknown how the market is going to develop and it is important to explore all SAF in the near term

Thanks!

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