Which way to Net Zero?

Comparative analysis of seven UK decarbonisation pathways

James Dixon

Institute for Energy & Environment | University of Strathclyde

Environmental Change Institute & Transport Studies Unit | University of Oxford

e: james.dixon@ouce.ox.ac.uk / james.dixon@strath.ac.uk

t: @jamesjhdixon

Energy Systems: Planning the transition to net zero
All-Energy Conference
Glasgow, 11 May 2022

Seven **2050 Net Zero pathways** were released by key players in the Energy Systems community in 2019/2020 following UK legislation

Energy Systems Catapult 'Innovating to Net Zero'

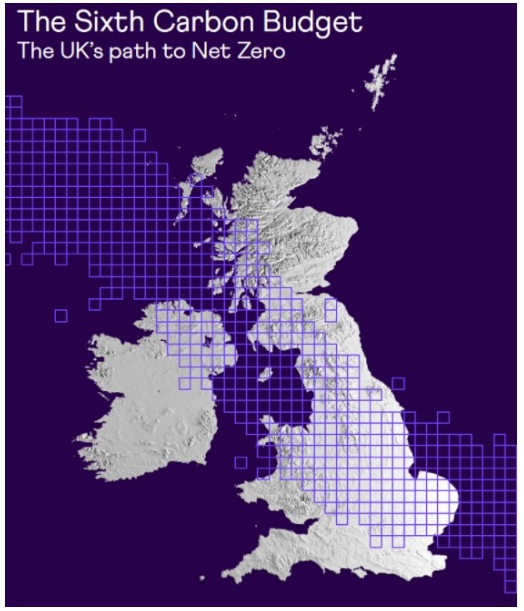
- 'Clockwork' (ESC-C)
- 'Patchwork' (ESC-P)

Future Energy Scenarios 2020

- 'Leading the Way' (FES-LTW)
- 'System Transformation' (FES-ST)
- 'Consumer Transformation' (FES-CT)

Centre for Alternative Technology, 'Zero Carbon Britain'

- 'Zero Carbon Britain' (CAT-ZCB)

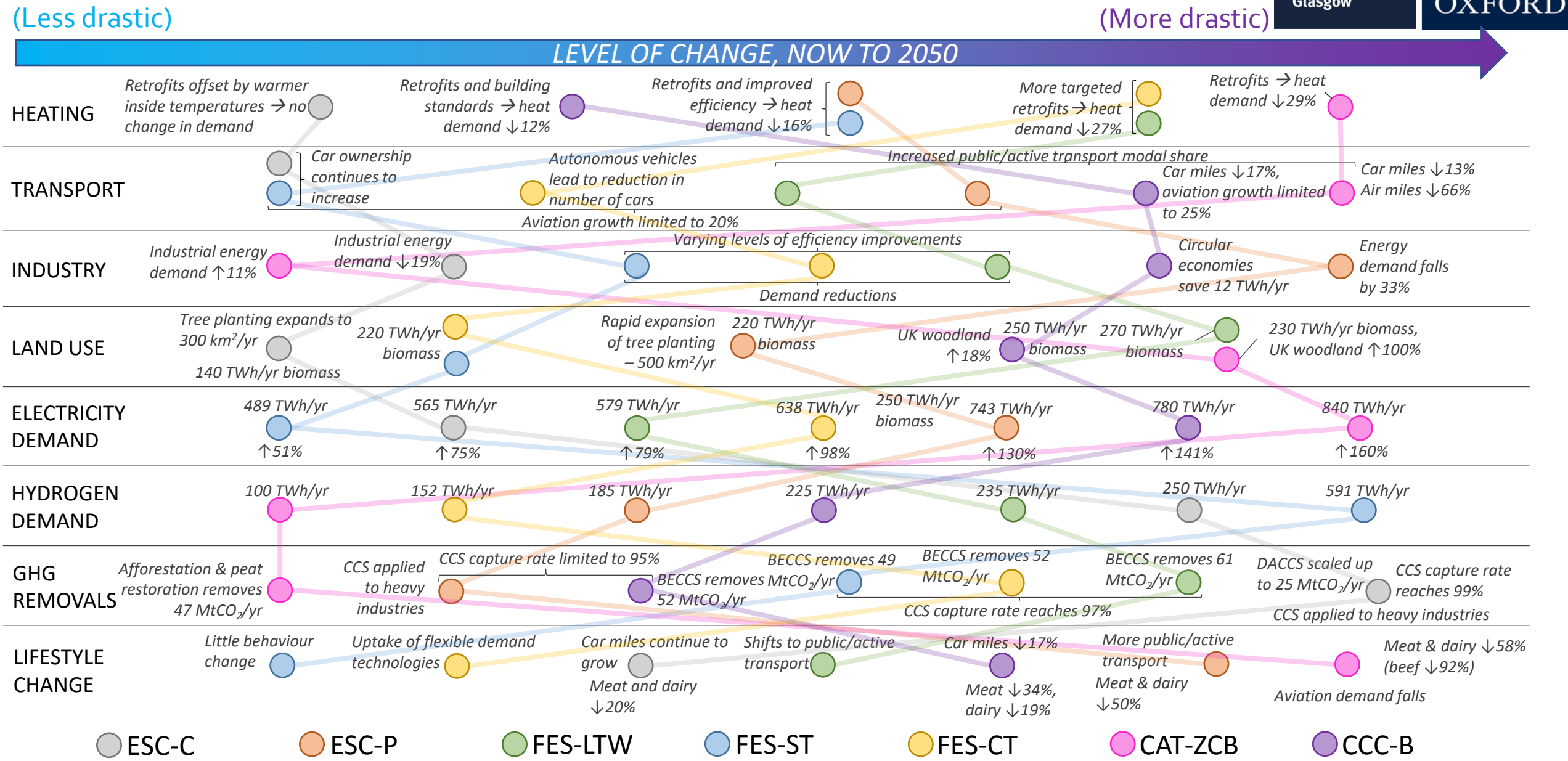


Climate Change Committee, "Sixth Carbon Budget"

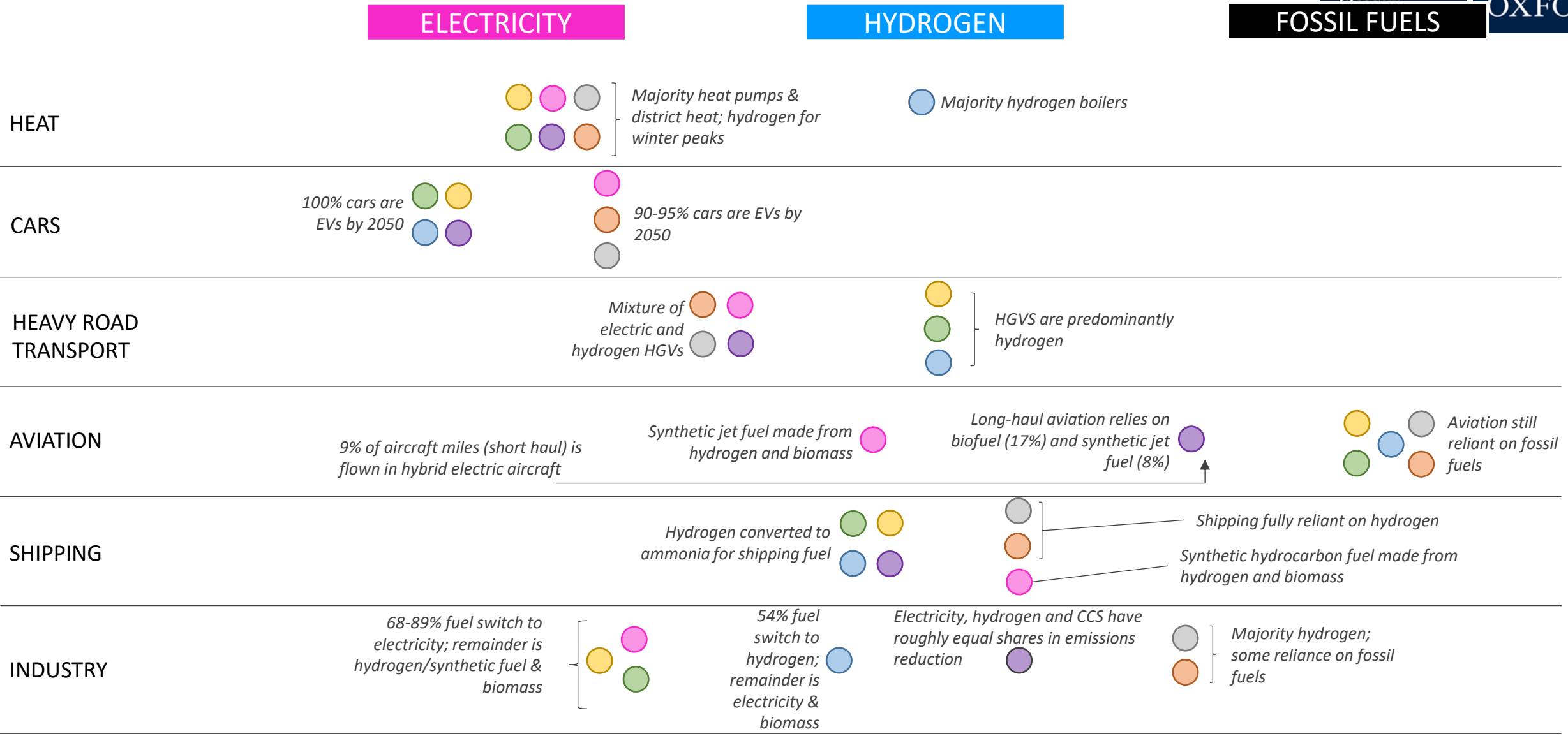
- 'Balanced' (CCC-B)

Comparing Net Zero pathways can give us insights into **what the energy systems community thinks** and help us analyse **relative risk**

Pathways generally trade **more drastic** behavioural & technological changes off in some sectors with **less drastic** changes in others

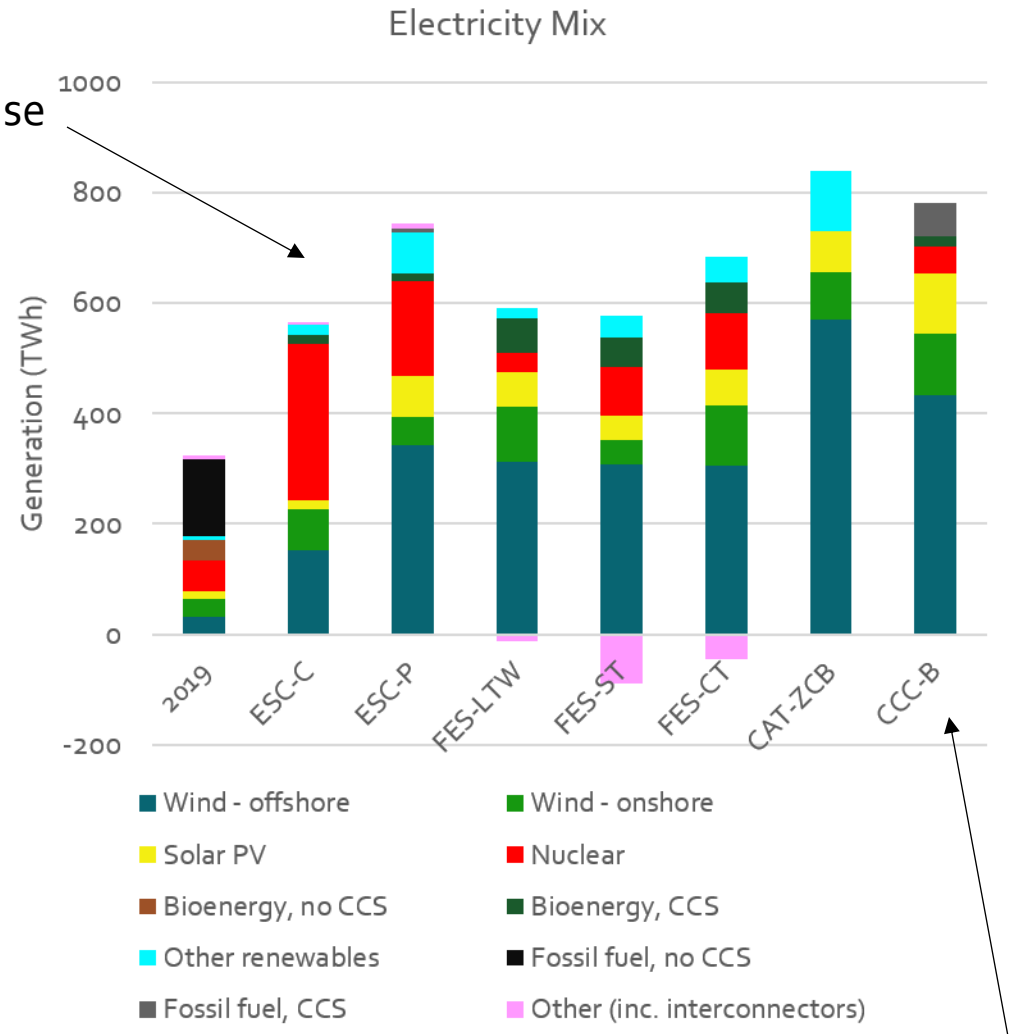


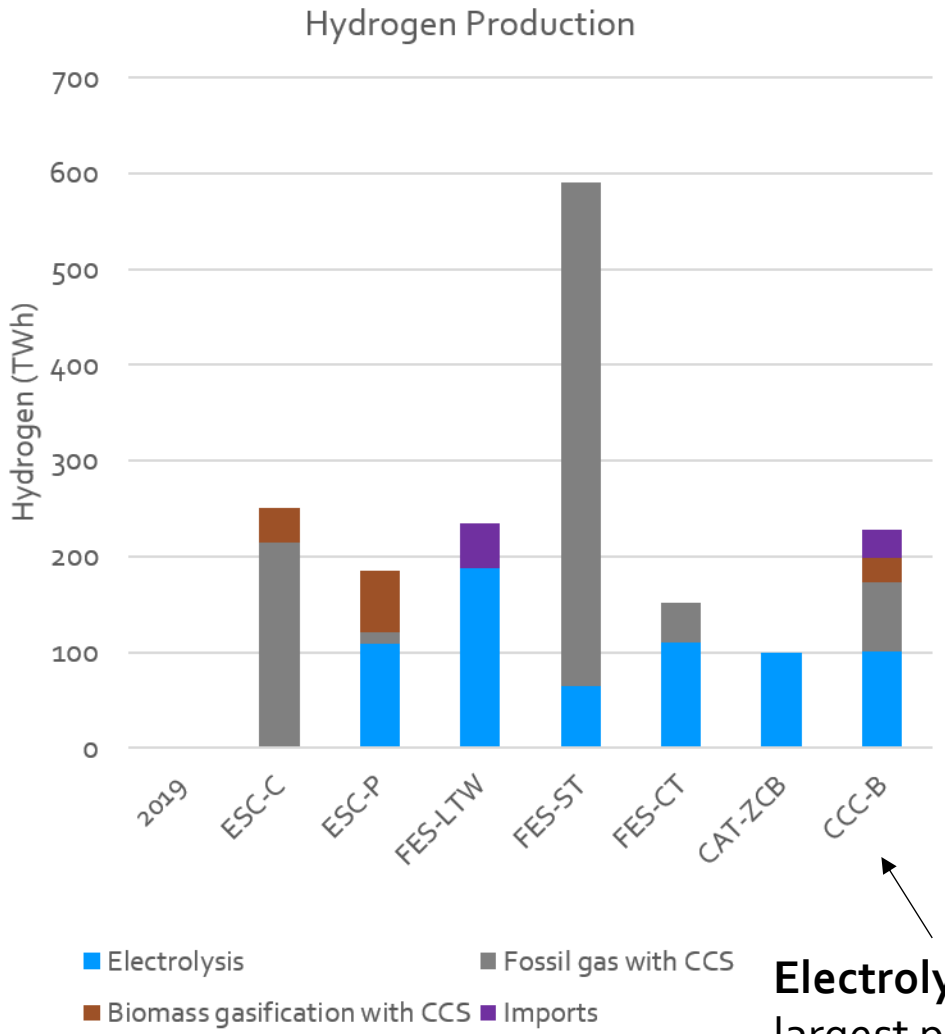
Major **fuel switching** will occur in all sectors, but **fossil fuels to be used in aviation in 2050 in 6/7 pathways**



Electricity **and** hydrogen are important energy vectors in **all** Net Zero pathways

51-160% increase

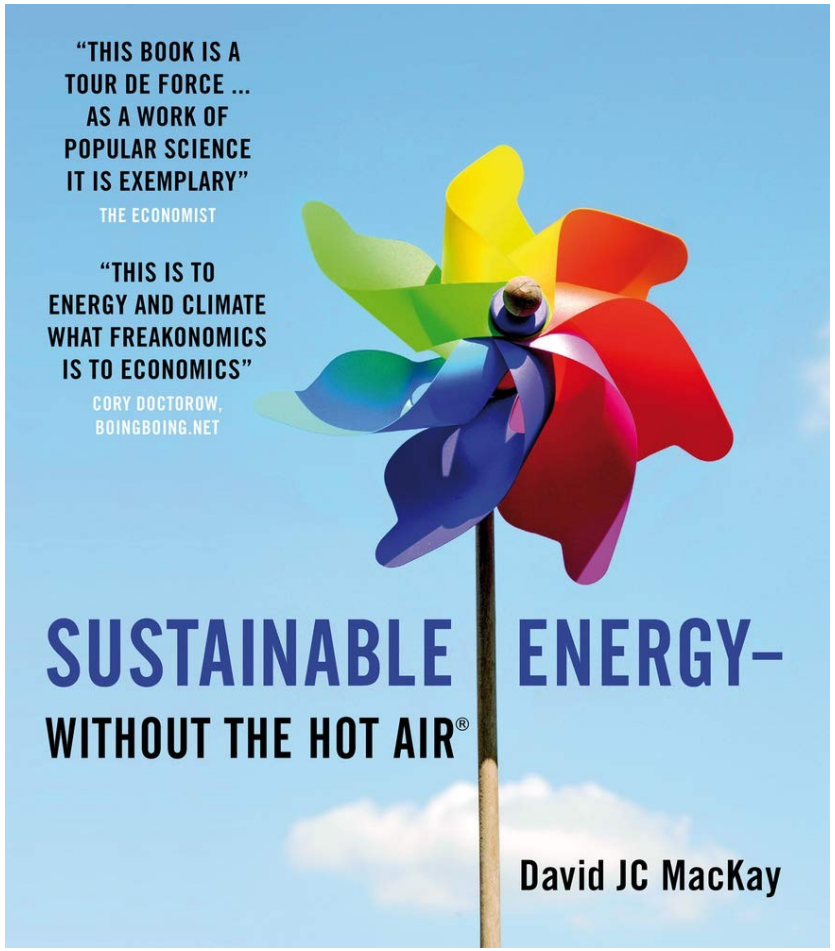


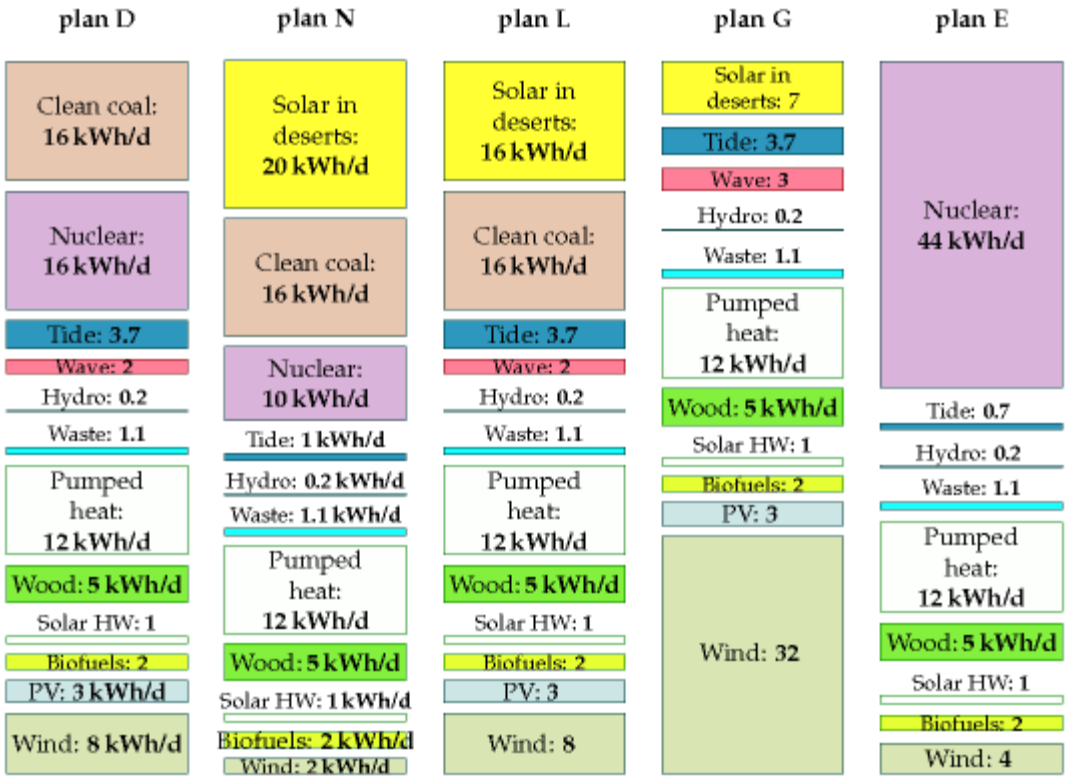


Offshore wind is majority in 6/7 scenarios

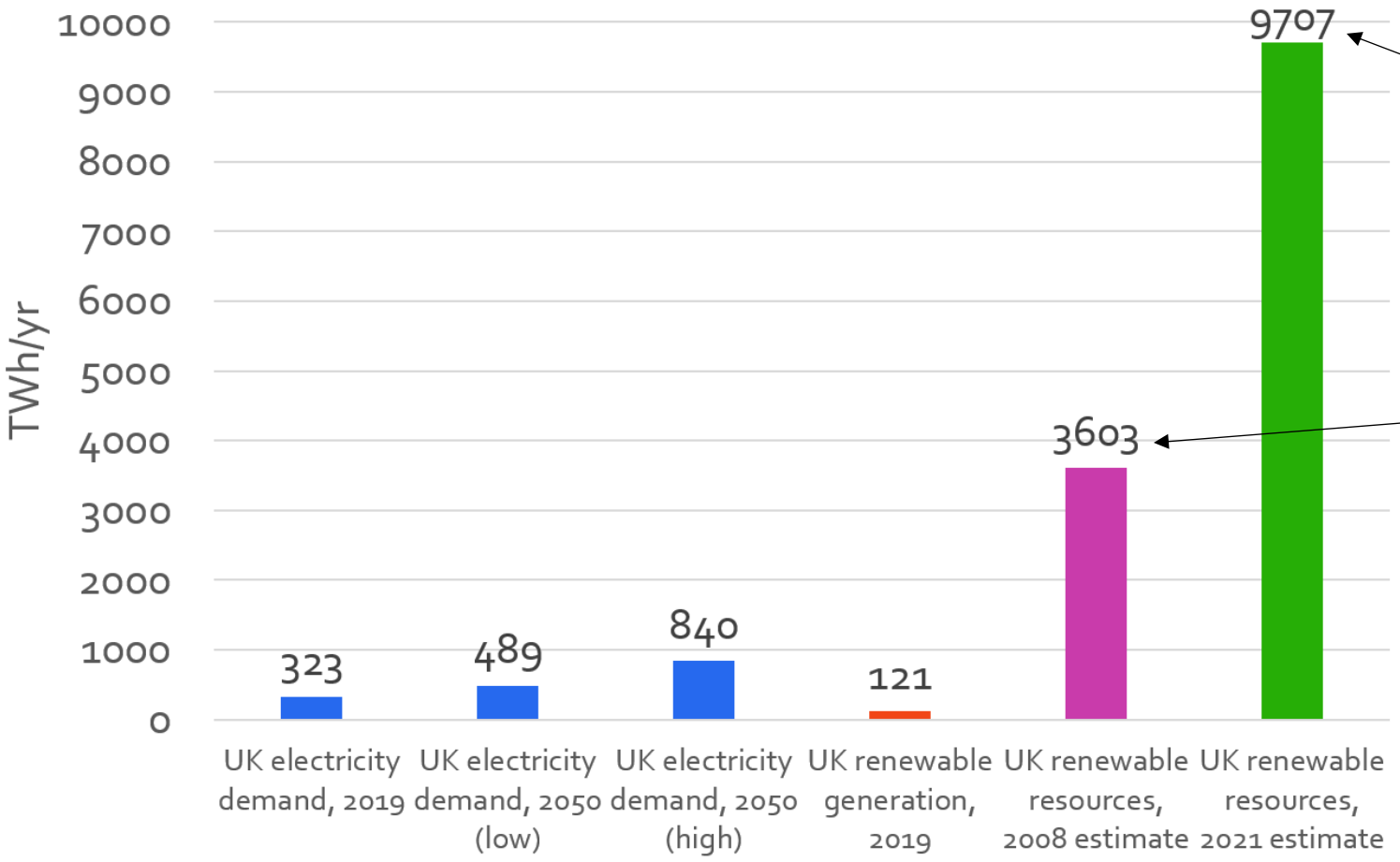
Electrolysis is the largest production method in 5/7 scenarios

We revisited a **key text** in the field to **update numbers on efficiencies, technologies and space constraints –** to find out if it's ***possible to do this***





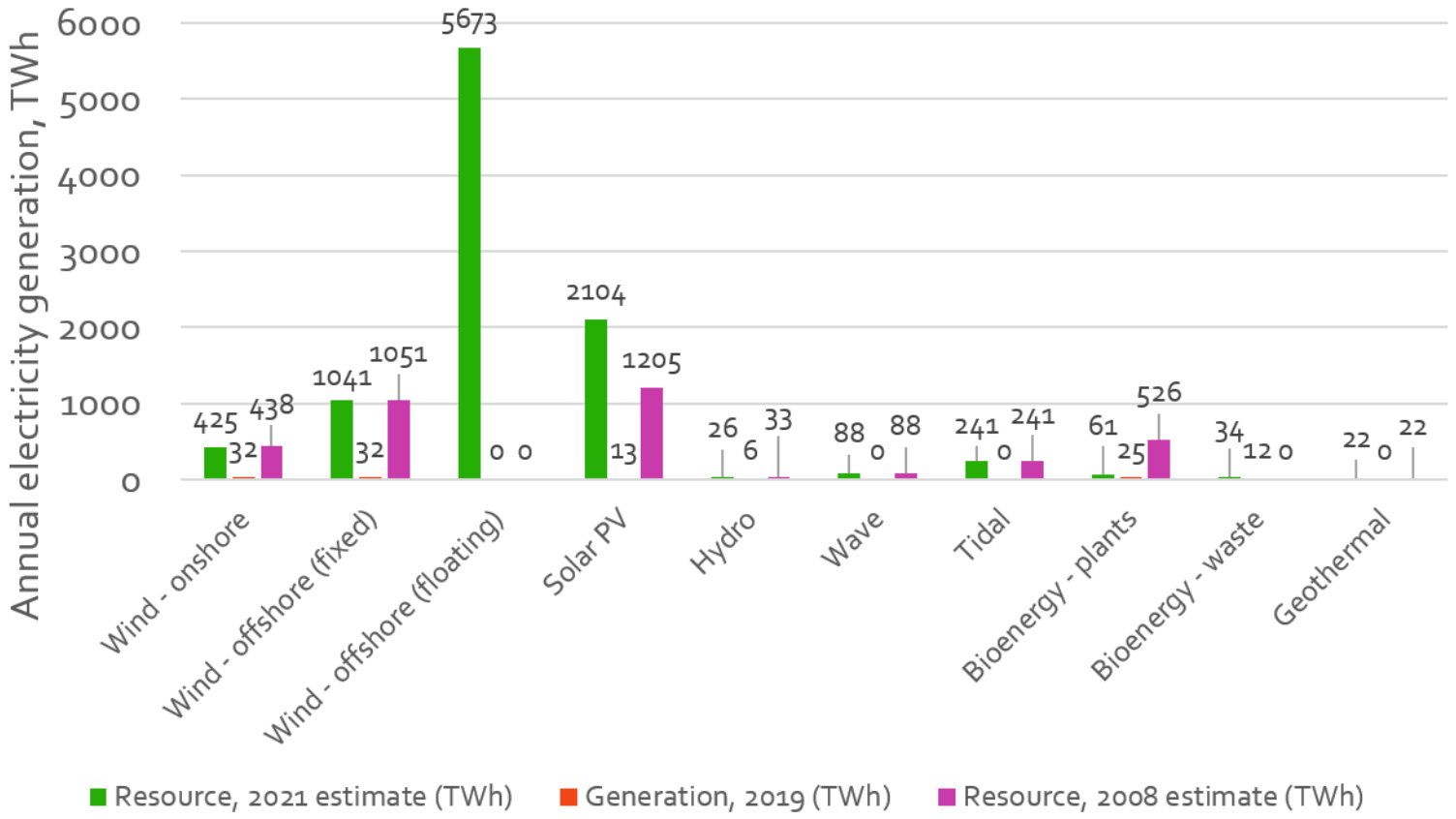
Renewable resource **outstrips the UK's projected 2050 electricity demand by a factor 12–20**



Same approach, but with **updated numbers** and **new assumptions**

What David MacKay estimated we could ***practically*** **generate using the UK's renewable resources**

The increase in resource is due to **increases in solar PV efficiency** and the viability of **floating offshore wind** – and *despite* a **reduction in land for biomass**



MacKay (2008)	Dixon et al. (2021)
Efficiency of solar PV = 10%	Efficiency of solar PV = 18%[1]
Offshore wind constrained to fixed installations, depth ≤ 50 m	Floating offshore wind is a viable technology[2]
75% of the total UK land area could be dedicated to growing energy crops	7% of current UK *agricultural land area* for energy crop cultivation[3]

[1]Average efficiency of crystalline silicon PV cells in 2019 (representing 95% of global installation) (IRENA, 2019)
[2]4.3 GW pipeline of global floating offshore projects as of 2019 (Hannon et al., 2019)
[3]Set by the CCC in 2018 *Biomass in a low-carbon economy* report

We can infer some (hopefully) **useful conclusions** from the comparison of these pathways

- Technology and behavioural change are at a trade-off:
  - **Pathways that rely on little behavioural change to 2050 rely on significant changes in technology**
  - **Pathways that rely on significant behavioural change to 2050 rely on less significant changes in technology**
- Electricity and hydrogen are important energy carriers across all pathways
- Emissions removals are needed in all pathways
  - DACCS, BECCS, afforestation, peatland restoration
- **Aviation is not allowed to grow more than 25% in any pathway**

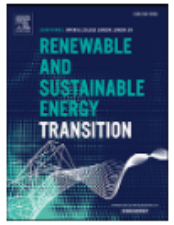
More information can be found in our **open access(!)** paper

Renewable and Sustainable Energy Transition 2 (2022) 100016

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Transition

journal homepage: www.elsevier.com/locate/rset



Perspective

Which way to net zero? a comparative analysis of seven UK 2050 decarbonisation pathways

James Dixon [a,b,*], Keith Bell [a], Susan Brush [a]

[a] Institute for Energy & Environment, University of Strathclyde, 99 George Street, Glasgow G1 1RD, United Kingdom
[b] Environmental Change Institute, University of Oxford, South Parks Road, Oxford OX1 3QY, United Kingdom

ARTICLE INFO

Keywords:
Net zero
Decarbonisation
Whole energy system

ABSTRACT

Since the UK's Net Zero greenhouse gas emissions target was set in 2019, organisations across the energy systems community have released pathways on how we might get there – which end-use technologies are deployed across each sector of demand, how our fossil fuel-based energy supply would be transferred to low carbon vectors and to what extent society must change the way it demands energy services. This paper presents a comparative analysis between seven published Net Zero pathways for the UK energy system, collected from Energy Systems Catapult, National Grid ESO, Centre for Alternative Technology and the Climate Change Committee. The key findings reported are that (i) pathways that rely on less stringent behavioural changes require more ambitious technology development (and vice versa); (ii) electricity generation will increase by 51–160% to facilitate large-scale fuel-switching in heating and transport, the vast majority of which is likely to be generated from variable renewable sources; (iii) hydrogen is an important energy vector in meeting Net Zero for all pathways, providing 100–591 TWh annually by 2050, though the growth in demand is heavily dependent on the extent to which it is used in supplying heating and transport demand. This paper also presents a re-visited analysis of the potential renewable electricity generation resource in the UK. It was found that the resource for renewable electricity generation outstrips the UK's projected 2050 electricity demand by a factor 12–20 depending on the pathway. As made clear in all seven pathways, large-scale deployment of flexibility and storage is required to match this abundant resource to our energy demand.

bit.ly/**37XsMyw**

OPEN ACCESS