Imperial College London

Centre for Process Systems Engineering

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CleanFaB

TotalEnergies

The UK power sector in light with the 2050 net-zero emissions target

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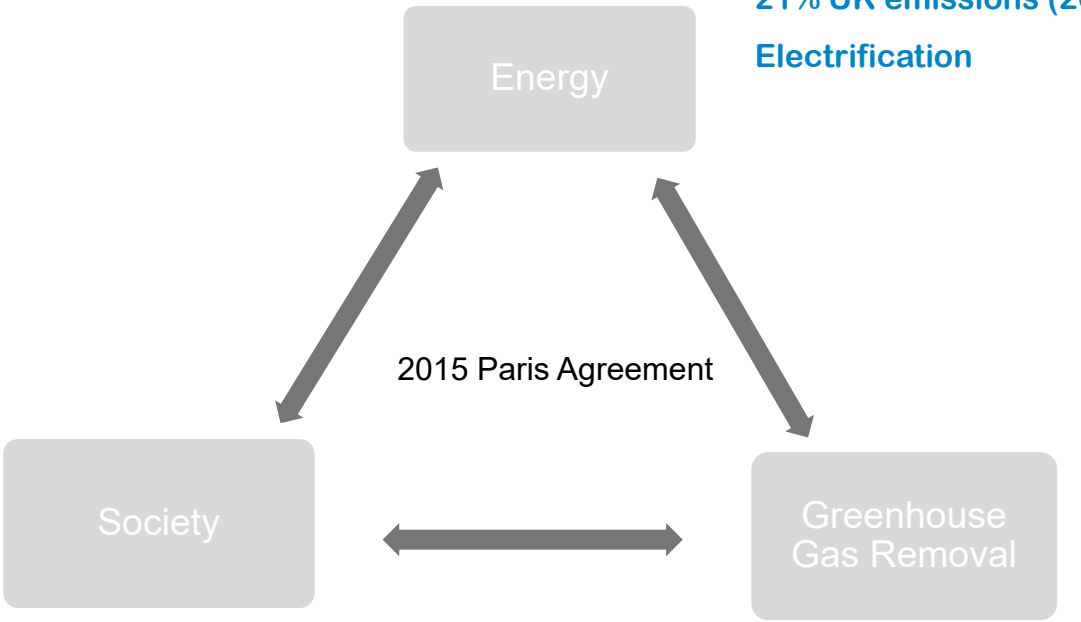
Trilemma



21% UK emissions (2019)

Electrification

GGR

‘Moral Hazard’

‘How many jobs for a Green power sector transformation?’

Trilemma

In the courtesy of Caroline Ganzer, Yoga Pratama

My PhD

ESO
Electricity Systems Optimisation Framework

2015 Paris Agreement

CCS

In the courtesy of Mathilde Fajardy, Solene Chiquier

JEDI
Jobs and Economic Development Impact[2]

Modeling and Optimisation of Negative Emission Technologies

Today's presentation

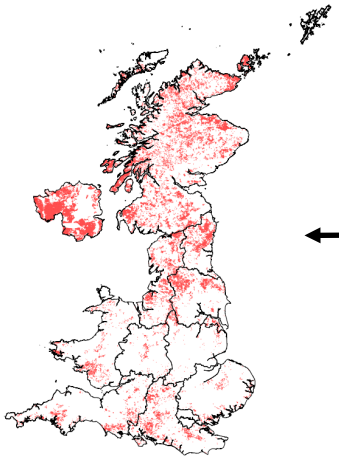
Current models

MONET-UK

Today-2050

12 regions in the UK

1 region



Marginal land[1]

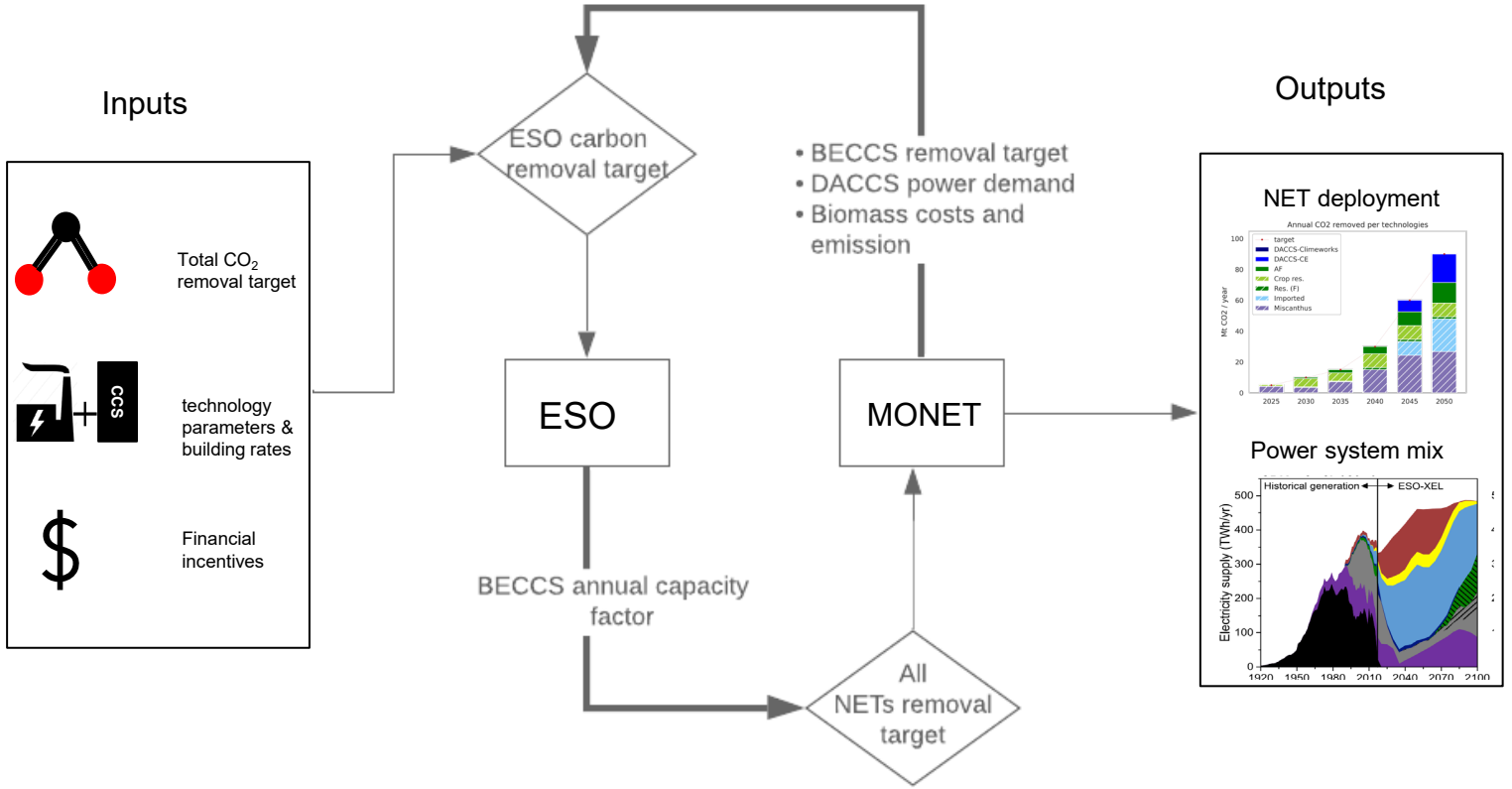
ESO
Electricity Systems Optimisation Framework

DACCS

BE-CCS

Afforestation

[1]Cai et al. (2010) Land availability for Biofuel production. [2]Griscom et. al (2019) Natural Climate Solution.
[3]Zhang et al. (2020). Unlocking the potential of BECCS with indigenous sources of biomass at a national scale.



Convergence criteria: $\mathrm{C(l)} = \sum_{t,i \in power\_tech} |CAP(tech_i, t, l) - CAP(tech_i, t, l-1)| \leq \varepsilon$

Assumptions

AF, BECCS and DACCS technology available

3C-LIMIT and **3C-UNLIMIT**: Limited and Unlimited Imported pellet

Carbon Tax (penalising emission)

Carbon removal target (in light with the net-zero 2050)

What results ?

Power system deployment

Negative Emission Technology deployments

Interactions

Table: Carbon prices (**BEIS Policy report** values) and UK carbon target (**The Sixth Carbon Budget, Dec 2020**)

Year	CCC removal target (Mton CO_2)	Carbon Tax Prices £/tCO_2
2025	0.1	52
2030	7	89
2035	28	126
2040	-	162
2045	-	200
2050	90	236

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Negative Emission Technology deployments (today-2050)

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MONET - Baseline scenario

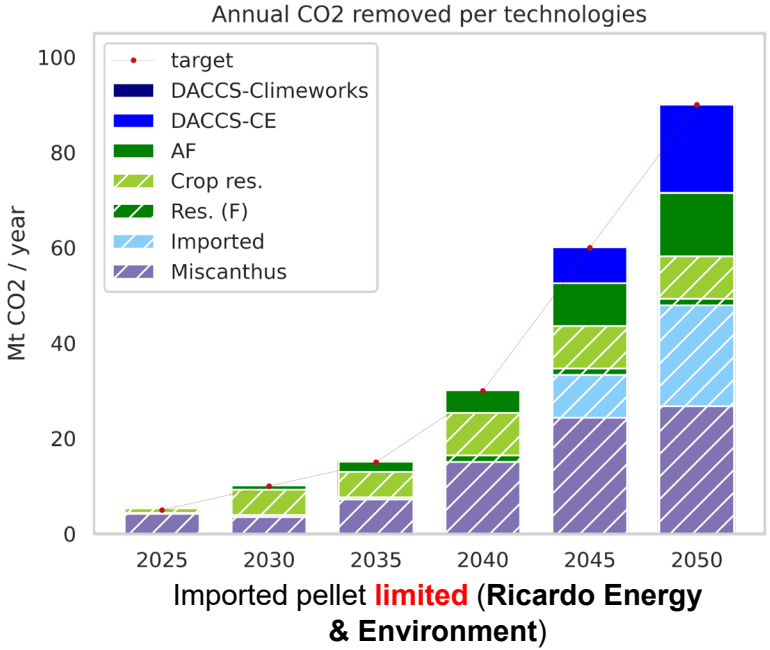
	2025-2030 Capacity (BR Multiplier x2)	Linear BR	Land Availability (Mha)
AF	-	30000 ha / year (CCC)	14 (57% of UK land) [1]
BECCS	2 plant	-	1.4 (6% of UK land)[2]
DACCS	1Mt CO_2	-	-

AF limitation factor

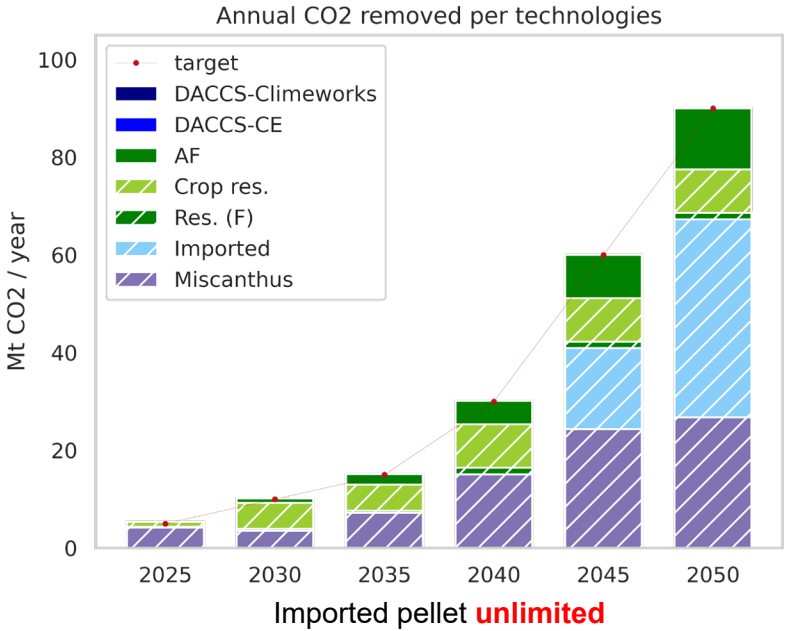
BECCS limitation factor

Table: Building rate and land availability

Figure: NETs deployment in the UK under CCC removal target



Imported pellet **limited** (**Ricardo Energy & Environment**)



Imported pellet **unlimited**

Figure: NETs levelized costs (2021-2050)

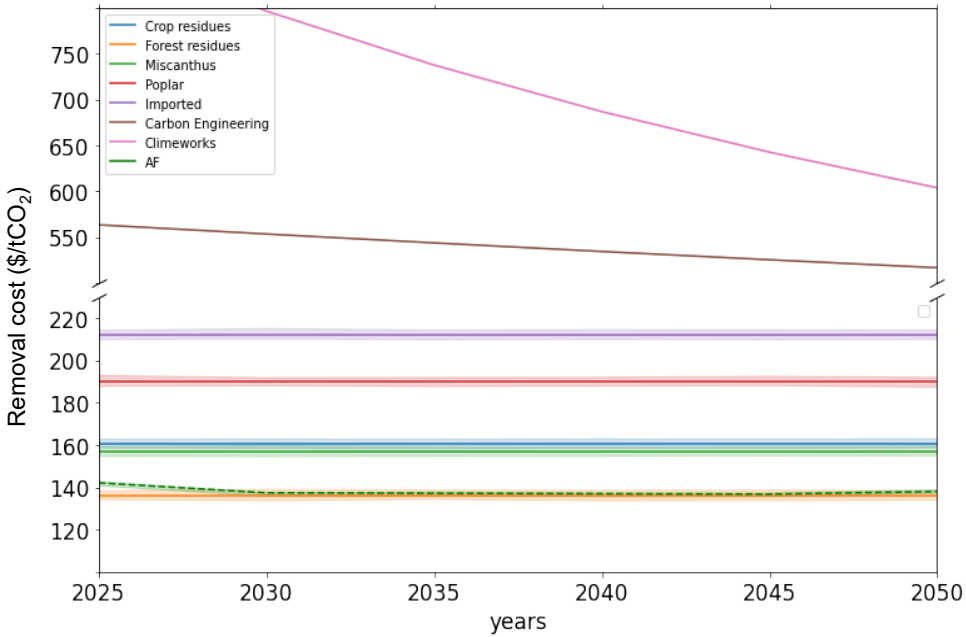
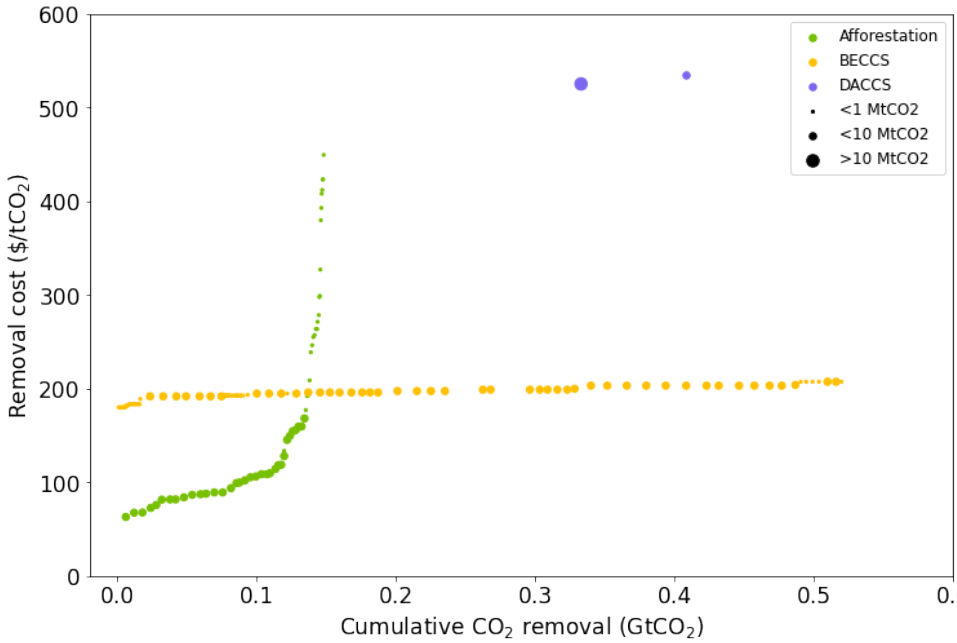


Figure: UK supply curves



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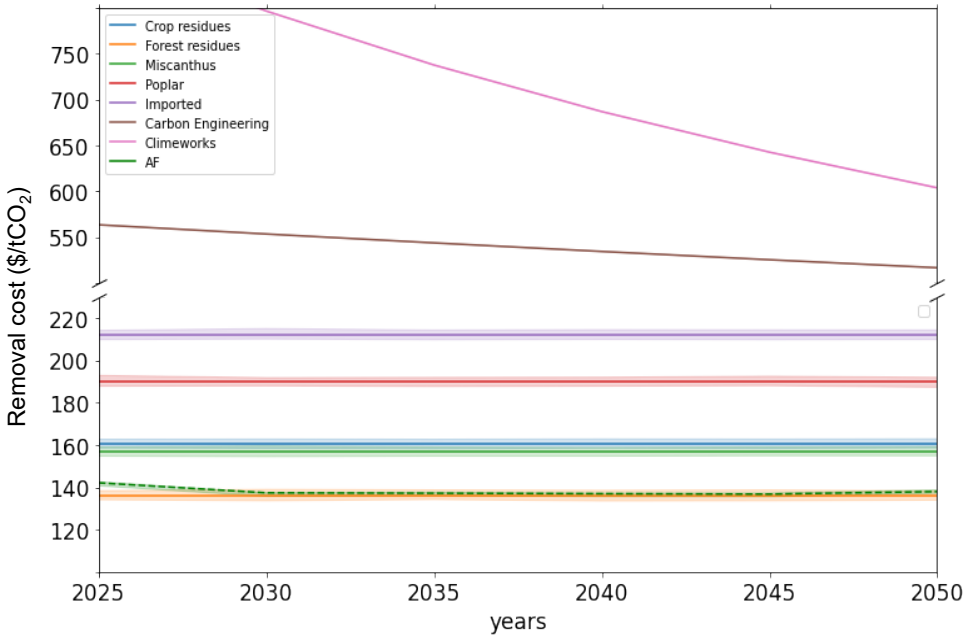

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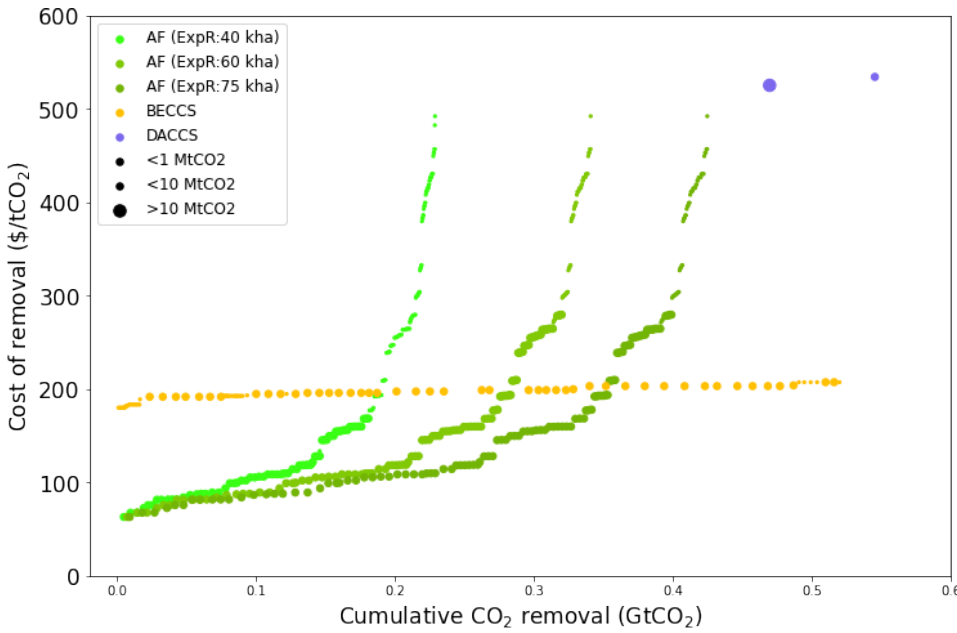


AF project length -> less interesting for short-term investments.

AF limited by expansion rate / BECCS by marginal lands & imports.

AF and BECCS limited potential => Need for other NETs to meet 90 $MtCO_2$ removal per year in 2050.

Direct Air Capture has a cost of ~500 $/$tCO_2$

… Interaction with the electricity sector?

Joint System

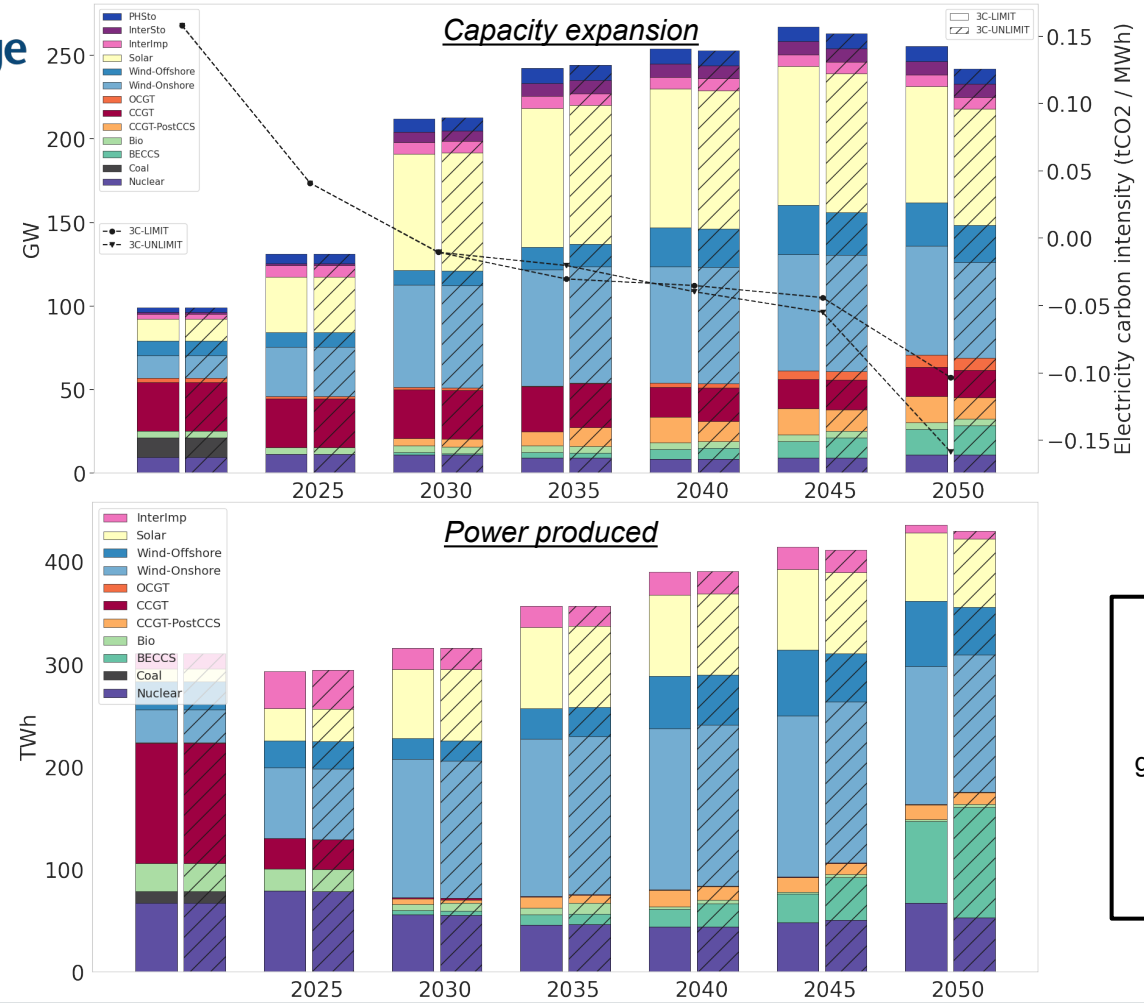


Figure:

Deployment of power generating technologies (bars, left axis) from joint system optimisation for 2 scenarios.

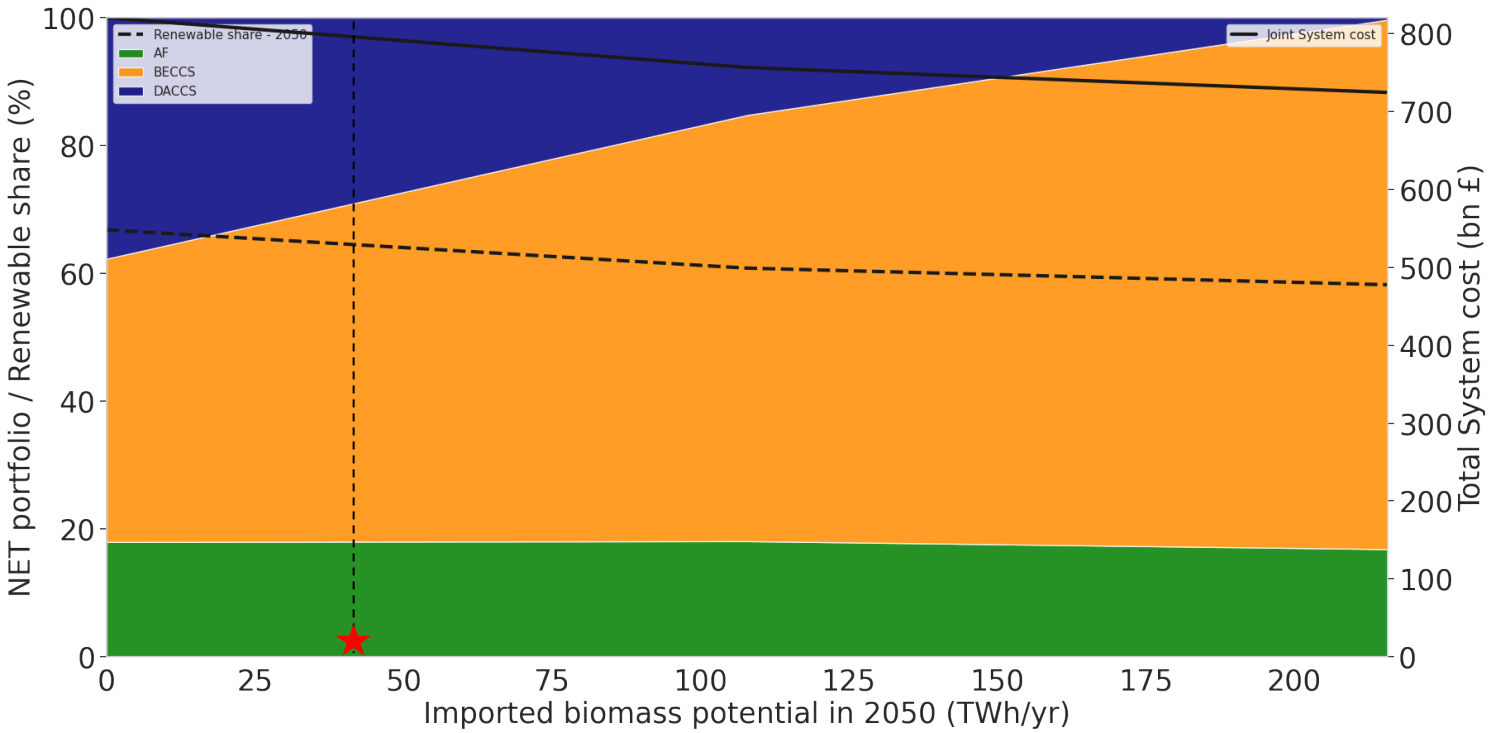
Conclusion

Renewable share of 60% in 2050 (vs 80% projected by CCC)

Increasing BECCS displaces renewables and nuclear

Carbon free power generation by 2030

Carbon negative in 2050 => -100 kg/MWh (-150 kg/MWh)


Renewable share - 2050
AF
BECCS
DACCS
Joint System cost
NET portfolio / Renewable share (%)
Total System cost (bn £)
Imported biomass potential in 2050 (TWh/yr)
0
20
40
60
80
100
0
100
200
300
400
500
600
700
800
0
25
50
75
100
125
150
175
200

Conclusion

Deploying BECCS (when possible) is cost-effective for system, as AF is limited and DAC is expensive.

BECCS affects the power sector by reducing renewable share to 60% (-20%) compared to national projections and by increasing dispatchable power share.

GGR sector affects the power sector, via BECCS. And indirectly via DAC and AF.

Future Work

Socio-economic impacts (jobs, GVA[1])

Need for more NETs

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Thank you for attending

QUESTIONS?