

Environmental impacts of the energy system transformation to net zero

1 MOTIVATION: Net zero is an energy AND land-use transition

- Renewables and forest planting are central to net zero. Renewables have a larger land footprint than the energy production they displace. These land use changes generate competition with food production.
- Where technologies are located changes not only financial costs, but carbon emissions, ecosystem services, landscape impacts and agricultural displacement.
- A spatial decision framework therefore needs to value market costs and wider environmental impacts together, and account for spillovers beyond the UK.

THE QUESTION

How much societal value is missed when a Net Zero pathway is sited to minimise only financial cost?

2 MODELLING ARCHITECTURE: Fix the pathway, optimise where it is delivered

1. NET ZERO PATHWAY Balanced UK energy pathway to 2050

Technology quantities are held fixed across experiments.

2. SPATIAL DEPLOYMENT

Solar + wind
Bioenergy + CCS/CHP
Forest planting
CCS network / industry

3. COSTS & CONSEQUENCES VALUED AT EACH LOCATION

FINANCIAL Land • grid • transport
DOMESTIC CO₂ Emissions + sequestration
ENVIRONMENT Recreation / visual • pollination • N & P • flood
LEAKAGE Overseas CO₂ from displaced food production

3 EXPERIMENT: Four progressively broader least-cost objectives

In every experiment the model chooses the spatial deployment that MINIMISES the total cost categories included in that objective.

A
FINANCIAL
£

B
FINANCIAL + CO₂
£ + CO₂

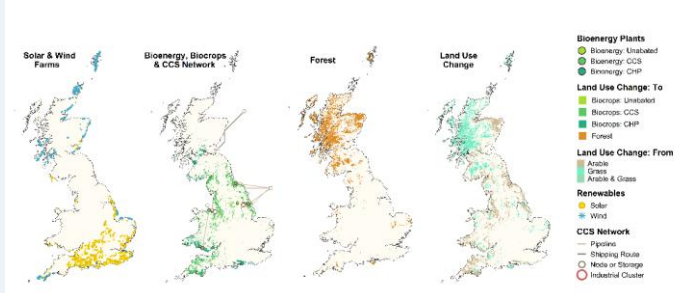
C
+ ENV. EXTERNALITIES
£ + CO₂ + ENV

D
+ LEAKAGE
£ + CO₂ + ENV + WORLD

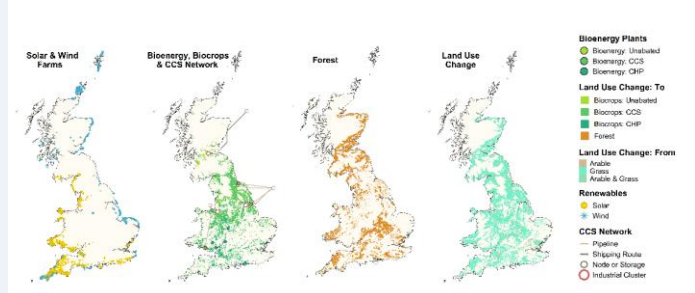
4 RESULTS: PLANTING & DEPLOYMENT STRATEGIES

Adding wider impacts changes where technologies and land-use change are placed - even though the Net Zero energy pathway itself is unchanged.

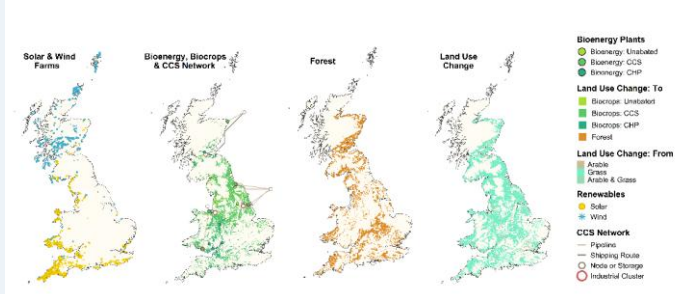
A Minimise Financial



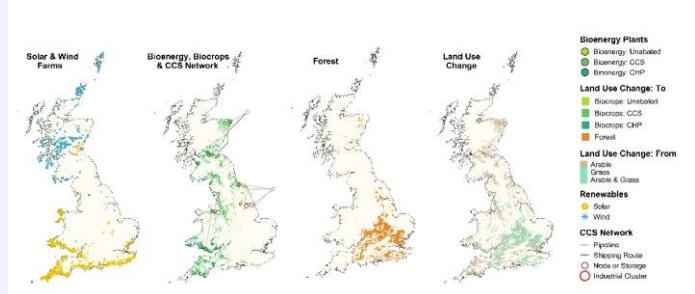
B Minimise Financial + CO₂



C Minimise Financial + CO₂ + Externalities



D Minimise Financial + CO₂ + Externalities + Leakage



5 RESULTS: COSTS & BENEFITS (NPV in 2020, £2020 million)

Positive = cost | Negative = benefit. The pathway delivers the same energy; the value comes from choosing better locations.

Objective	Energy	Financial	CO ₂	Env. ext.	CO ₂ leakage	Total
Financial	-203,988	148,604	-322,174	22,507	12,390	-138,673
Financial + CO₂	-203,996	170,319	-437,147	37,458	60,357	-169,013
+ Externalities	-203,997	171,916	-435,903	83	60,300	-203,605
+ Leakage	-204,012	158,962	-404,970	66	20,408	-225,535

£10.4bn
extra financial cost



£86.9bn
increase in net societal benefit

6 CONCLUSIONS: Wider objectives change WHERE net zero is delivered - and materially increase value

1

Financially cheapest is not socially best
Siting on financial cost alone overlooks large carbon, environmental and overseas consequences.

2

Integrated optimisation finds very large gains
A ~£10bn increase in financial expenditure is associated with ~£87bn greater net societal benefit (>8:1).

3

Policy needs spatial targeting, not only exclusions
The gains come from careful deployment choices across energy, forestry and land use; blunt exclusion zones can miss these trade-offs.