Spatial Implications of Low Carbon Energy Futures

Gemma Delafield, Greg Smith, Brett Day & Ian Bateman, University of Exeter

BACKGROUND

- Decarbonising the UK's energy system is essential if the country is to meet its greenhouse gas reduction targets.
- Energy models are used to inform the UK Government about how different technologies might contribute to the future energy mix.
- **Existing energy models are not spatially explicit** limiting the government's ability to take a whole systems approach when transitioning to a low carbon future.

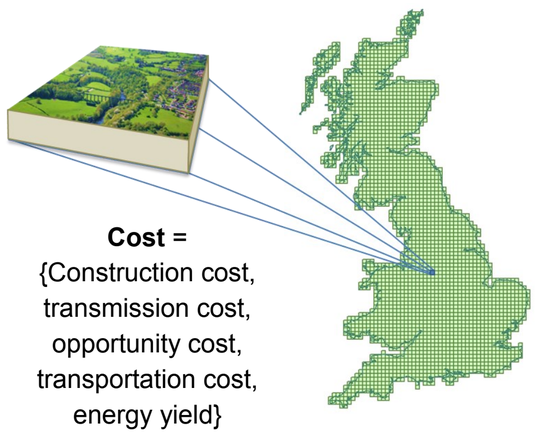
AIMS

- Develop a **national scale cost minimization model** to explore the spatial implications of multiple renewable energy technologies.
- Determine the **cost and spatial implications of excluding areas of land** from renewable energy development to **protect the environment and food security** including National Parks, Areas of Outstanding Natural Beauty (AONB) and high quality agricultural land.

MODEL

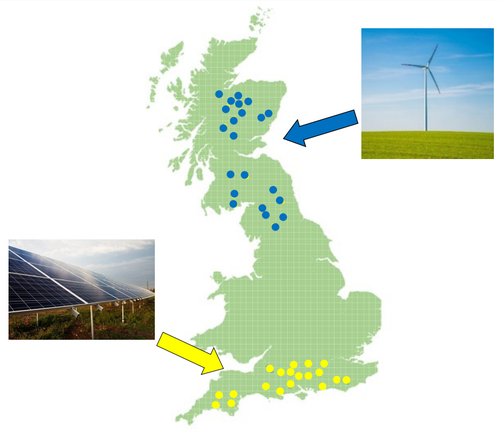
The model explores the **optimal spatial configuration** of new **solar, wind and bioenergy** generation to ensure future energy demand is met at the **least cost**. The model solves various spatial problems including (1) the least cost route to the electricity transmission network for each electricity generator and (2) the locations where bioenergy crops should be grown.

1. Identify cost of locating infrastructure in each cell



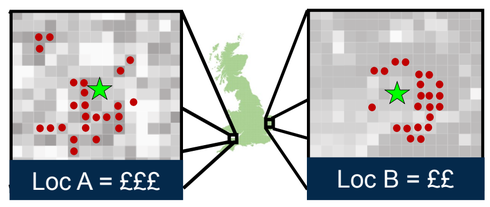
Cost =
{Construction cost, transmission cost, opportunity cost, transportation cost, energy yield}

2. Optimize the locations of solar and wind



3. Optimize the locations of bioenergy incl. crops

Step 1: Optimize where bioenergy crops (●) should be grown for multiple power plant locations (★) across UK

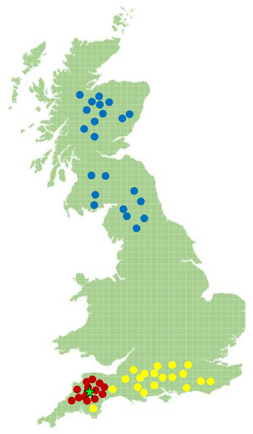


Step 2: Choose the least cost power plant location overall (i.e. Location B)

■ High crop yield ☐ Low crop yield

4. Resolve clashes between wind/solar & bioenergy

Resolve conflicts by considering **relocation costs** (i.e. the cost of moving energy to the next best location)

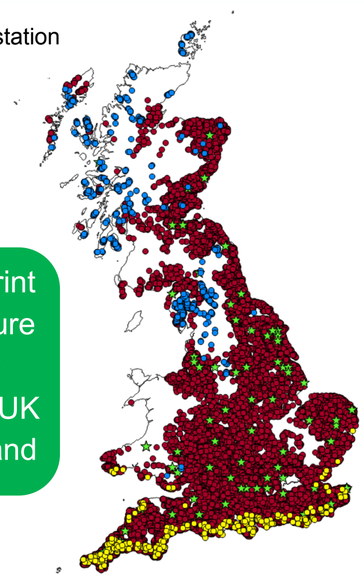


PRELIMINARY FINDINGS

The spatial implications of the UK Energy Research Centre's (UKERC) energy pathway 'Low Carbon - no Carbon Capture and Storage' are shown below. The spatial footprint and cost of the energy system increase as land is excluded.

Least cost locations

★ Bioenergy power station
● Bioenergy crop
● Solar farms
● Wind farms

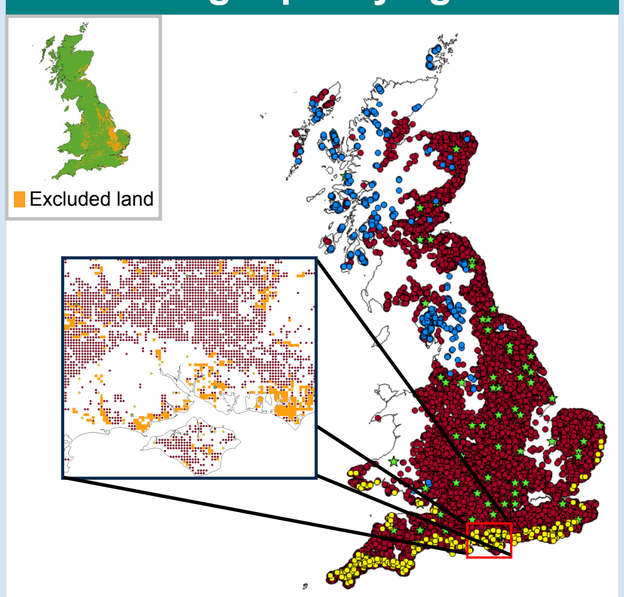


Spatial footprint of infrastructure equates to **13%** of total UK agricultural land

Spatial footprint	2.25M ha
Annualised cost	£1.81 billion

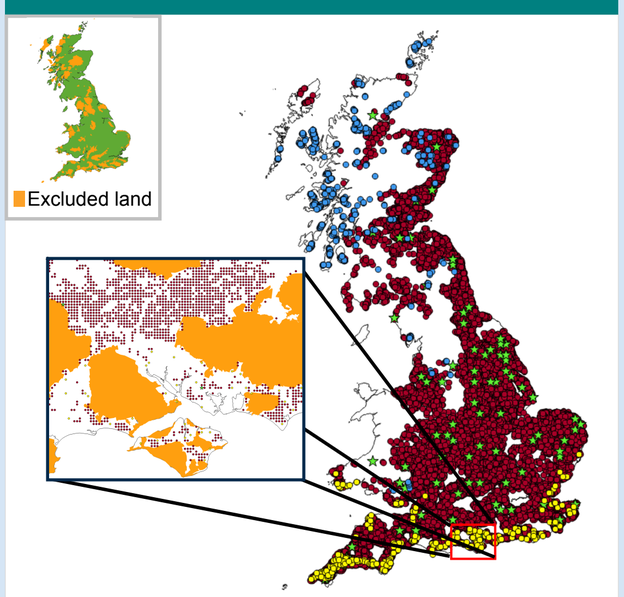
Existing studies **exclude land to protect food security and the environment** without considering the wider implications

Excl. high quality ag. land



Spatial footprint	2.32M ha
Annualised cost	+2%

Excl. National Parks & AONB



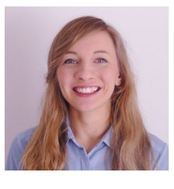
Spatial footprint	2.46M ha
Annualised cost	+8%

CONCLUSIONS

Spatial optimization can help us **improve our understanding of how future energy mixes might impact the UK's landscape** and **explore the consequences of excluding land from development**.

FUTURE FOCUS

Consider the impacts that new energy infrastructure has **on the provision of ecosystem services** in the spatial optimization model including **carbon sequestration**, **water quality**, **biodiversity** and **visual impact**.



Gemma Delafield
G.Delafield@exeter.ac.uk
@G_Delafield

UNIVERSITY OF EXETER · ADVENT · UKERC UK Energy Research Centre · NERC SCIENCE OF THE ENVIRONMENT · UEA University of East Anglia · UCL · UNIVERSITY OF Southampton · UNIVERSITY OF ABERDEEN