Spatial Optimization of Energy Infrastructure

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Energy models

- Energy models tell us **how much** energy we need

- But **NOT where** energy should be located
Land use conflicts
Excluding areas of land

High grade agricultural land

National Parks & AONB

High quality ag land NP & AONB
My research objectives

1) Develop a spatial cost minimization model to identify where the **optimal locations for new energy infrastructure** across the UK.

2) Apply the model to determine the cost to the energy system **when areas of land are excluded from energy development** to protect food security / biodiversity.
Model development
How do we spatialize UKTM output?
Gridded model

Which combination of cells deliver the energy system at the least cost?

>250,000 1km² cells
Spatial optimization model
Spatial optimization techniques

- Connecting to transmission network
  - Dijkstra’s algorithm

- Solar-Wind
  - Greedy algorithm or Hungarian algorithm

- Bioenergy
  - Mixed integer linear programming
  - Greedy algorithm

- Solar-Wind-Bioenergy
  - Iterative Hungarian and Greedy algorithm
Spatial optimization: Bioenergy

Low yield
High yield
Application of model
Preliminary findings
1 in 5 of the good locations for solar farms were also good for growing the bioenergy crop *Miscanthus*.
Energy-Food Conflicts

Exclude:
- Nothing

Exclude:
- High grade ag

<table>
<thead>
<tr>
<th>Spatial footprint</th>
<th>2.25M ha</th>
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<tbody>
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<td>£1.81 billion</td>
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<th>Spatial footprint</th>
<th>2.32M ha (+3%)</th>
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<td>Annualised cost</td>
<td>£1.84 billion (+23M)</td>
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Energy-Environment Conflicts

Exclude:
- Nothing

Spatial footprint: 2.25M ha
Annualised cost: £1.81 billion

Exclude:
- National Parks
- AONB

Spatial footprint: 2.46M ha (+9%)
Annualised cost: £1.96 billion (+143M)

487,000 ha bioenergy crop in National Parks or AONB
Future focus: Externalities

Use environmental economics literature to value the **externalities**.

Include these values alongside the financial costs when choosing energy generation locations.
Thank you for listening!

Key messages:

1. Spatial optimization allows us to improve our understanding of how energy futures might impact the UK’s landscape.

2. Determining the implied costs of excluding land from energy development can help inform decision-making.