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Cost-potential curves of onshore wind energy: the role of disamenity costs

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Cost-Potential Curves of Onshore Wind Energy: the Role of Disamenity Costs

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Abstract
Numerical optimization models are used to develop scenarios of the future energy system. Usually, they optimize the energy mix subject to engineering costs such as equipment and fuel. For onshore wind energy, some of these models use cost-potential curves that indicate how much electricity can be generated at what cost. These curves are upward

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The models-reality gap in onshore wind

Models

- Substantial expansion of onshore wind energy
- At relatively low costs
- Concentrated in high-wind-speed areas

Real world

- Expansion is slow in many places, sometimes even slower than in the past
- Often attributed to local resistance due to adverse impact of turbines on scenery, noise etc.

Research question:
Can this gap be explained by disamenity costs?

Also:
What is the trade-off between engineering and disamenity costs?

Disamenity cost functions

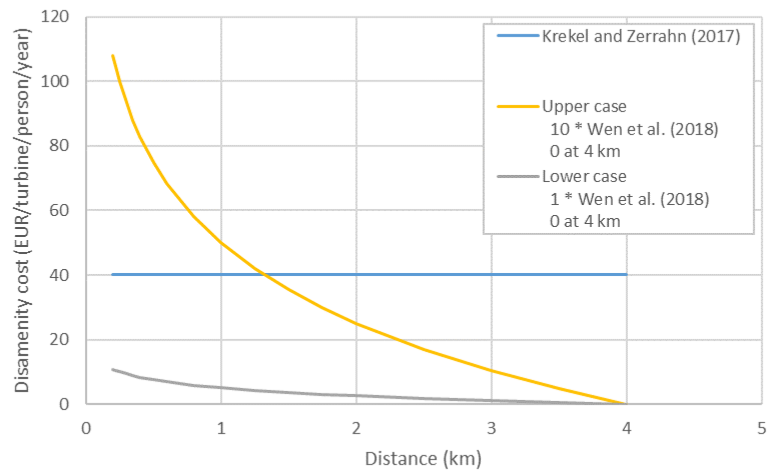
Disamenity cost

- The monetarization of the perceived adverse effect onshore wind energy has on the local human population

Three possible approaches to valorize non-market good

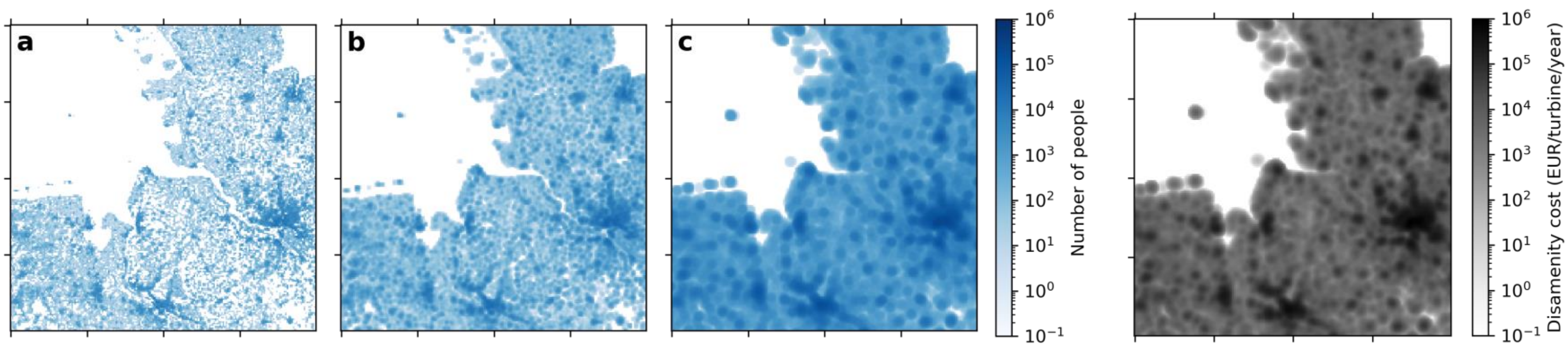
- Hedonic pricing: ambiguous results and hard to operationalize
- Choice experiments: relative value of a change in distance
- Life satisfaction approach: absolute value for turbines within 4 km

We define two cost functions to reflect large uncertainty



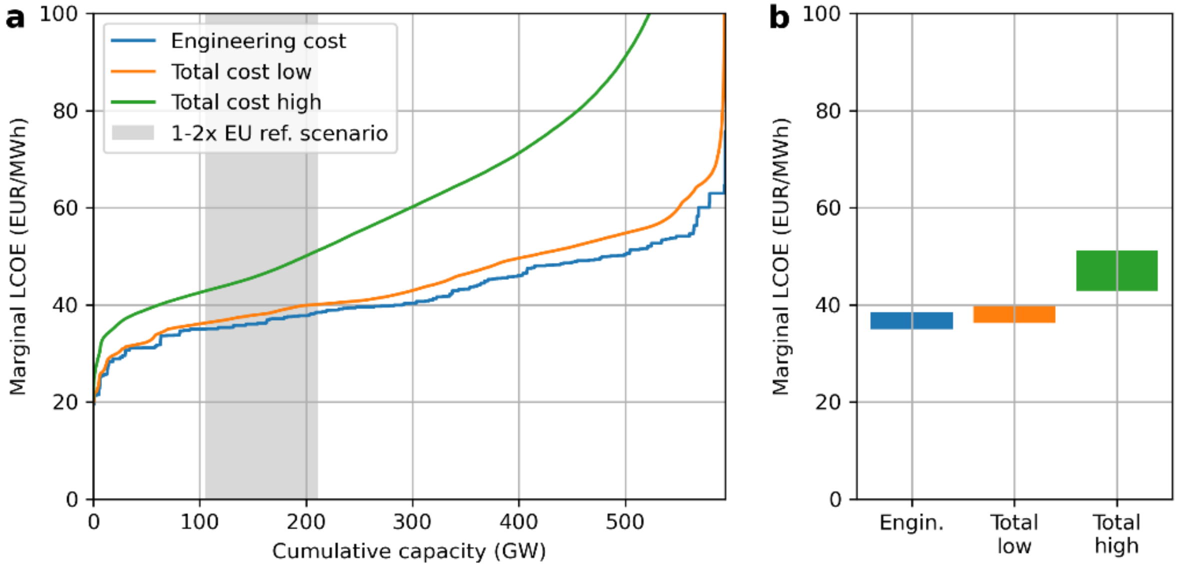
Deriving cost potential curves

1. Deriving disamenity cost maps (see below)
2. Combining this with engineering cost maps (Tröndle et al. 2019)
3. Placing turbines within eligible land (Ryberg et al. 2018)
4. Sorting these turbines by cost



Population | Population within 1 km | Population within 3 km | Disamenity cost

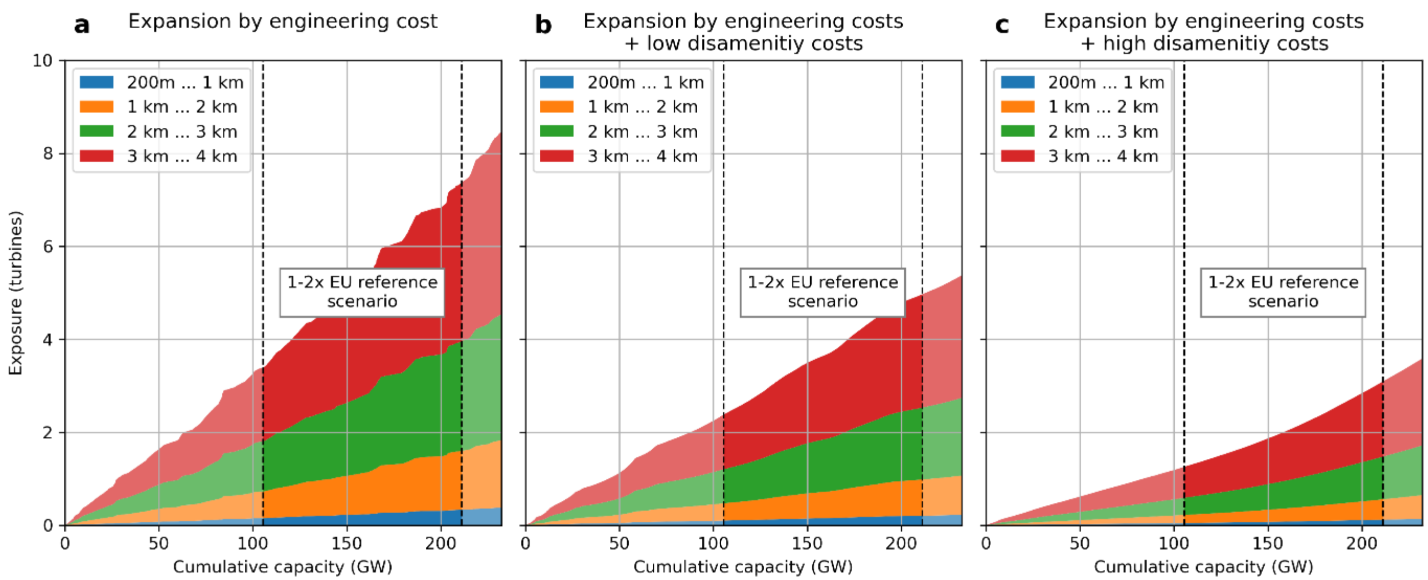
Cost potential curves for the example of Germany



Small to moderate effect of disamenity costs

- Depending on the underlying disamenity cost assumptions (low/high)
- Marginal cost of wind energy expansion increases by 4% (low) to 30% (high)
- Turbine placement changes significantly toward less windy areas
  → 5% higher engineering cost (when considering high disamenity costs)

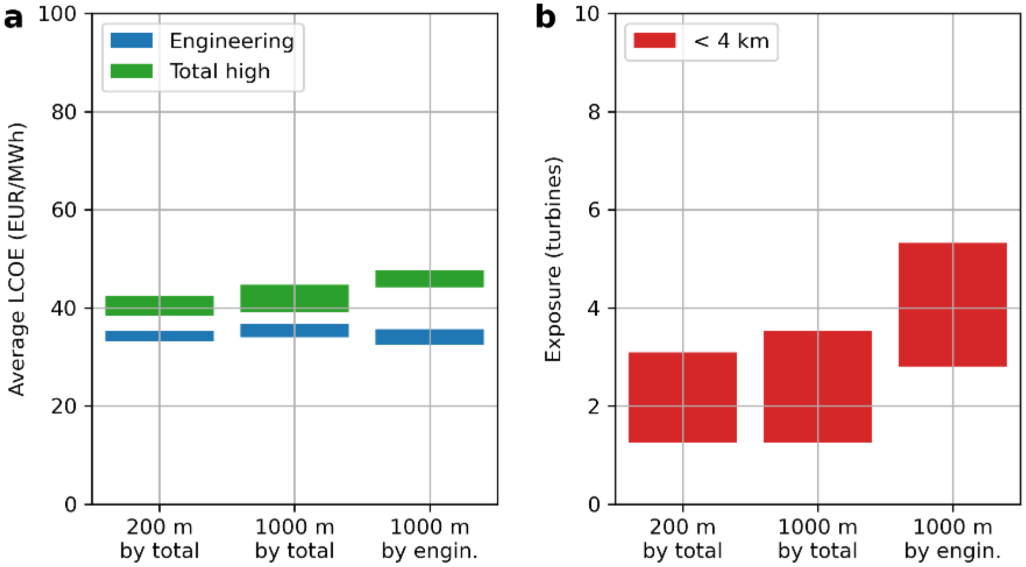
People's exposure to wind turbines (example of DE)



Consideration of disamenity costs significantly reduces exposure

- Low disamenity costs: 30% less turbines within 4 km
- High disamenity costs: 60% less turbines within 4 km
- The latter can be achieved at a 5% increase in engineering cost

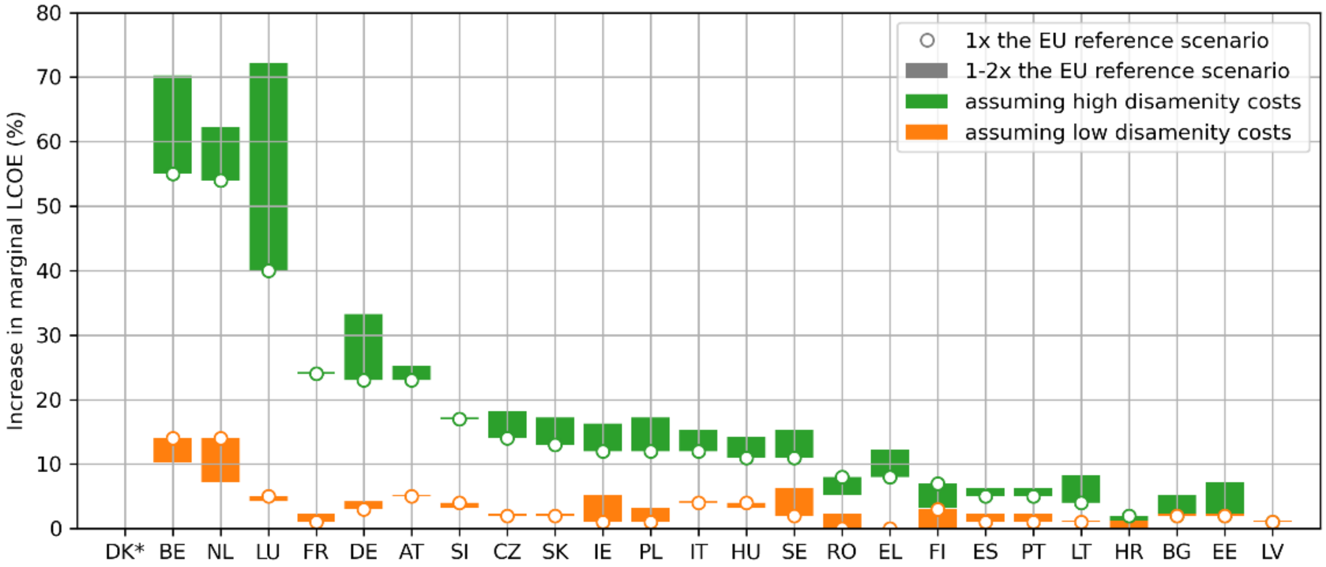
Enforcing setback distances (example of DE)



Larger setback distances increase total costs

- Without reducing the overall exposure to wind turbines
- Even worse when only considering setback distances & engineering cost
- Disamenity costs account for distance **and number of people**

Cross-country comparison



Large differences across countries

- Tight situation in Denmark, Belgium, the Netherlands, and Luxemburg
- More relaxed situation in most other countries
- More details in our article

Discussion & conclusion

Discussion

- High uncertainty regarding many factors but still better to include in models
- Real-world expansion does not follow cost optimization (Hedenus et al. 2022)
- Our analysis takes a social cost perspective and is agnostic to whether a (first-best) Pigouvian tax or citizen compensation exists
- We assume disamenity costs to be only dependent of people's own exposure to wind turbines, but acceptance may also depend on other's exposure (fairness)

Conclusion

- Disamenity costs will likely not be a major hurdle for the expansion of onshore wind energy in Europe
- However, they may change wind turbine placement & the energy mix
  → further research based on our dataset
- Further research may also expand the scope to other social cost components (e.g., environmental costs)

Thank you!

I am happy to receive your feedback and questions – now and via ruhnau@hertie-school.org