Inferring local social cost from renewable zoning decisions

Evidence from Lower Austria's wind power zoning

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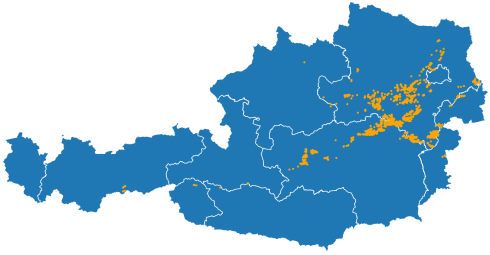
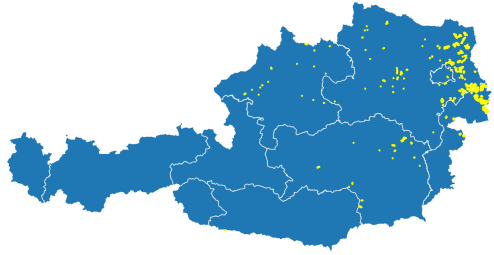
Where are wind turbines placed?

Locations with best wind resources



Source: Global Wind Atlas 3, own computations

Actual locations (Feb 2022)



Source: IG Windkraft, BEV

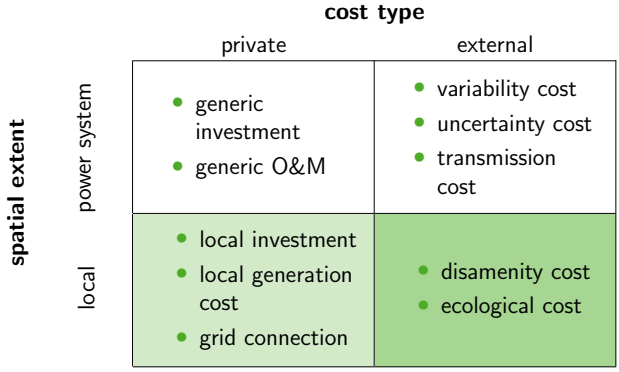
Wind power zoning in Austria

- Spatial planning by federal states prescribes wind power locations
- A collection of locations is enacted as *zoning*
- By federal law location choice must consider several spatial attributes
- Otherwise, federal states are free in their choice of wind power locations
- However, further attributes evidently important (e.g. wind resources)

Research Question

Which valuation of spatial attributes is consistent with the enacted wind power zoning?

The social cost of wind power



Method Sketch

- Understand zoning process as if a social planner maximizes public welfare by location choice
- The observed wind power zoning reveals (social) preferences over spatial attributes
- Estimate a discrete choice logit-model (in willingness-to-pay space)
- Overcome technical difficulties of sample

Social Preferences

- Partition area in pixels indexed ℓ
- p equals LCOE of each pixel
- Further attributes of pixels in X
- Unobservable attributes in ε
- $\varepsilon \sim \text{Gumbel}(0, \sigma^2\pi^2/6)$

- $\omega = -\beta/\alpha$ is the marginal WTP for an attribute change
- $\lambda = -\alpha/\sigma$ scales observable to unobservable part of valuation

Social preferences are represented by

$$w_\ell = X_\ell\beta + p_\ell\alpha + \varepsilon_\ell \qquad (1)$$

as preferences are ordinal, we can normalize (1) for α and σ

$$w_\ell = \lambda\left(X_\ell\omega - p_\ell\right) + \varepsilon_\ell \qquad (2)$$

which is a discrete choice model in willingness-to-pay space

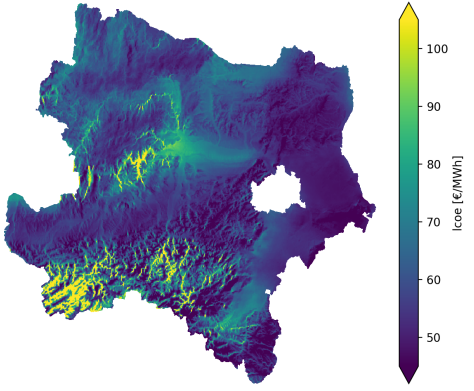
Estimated local social cost

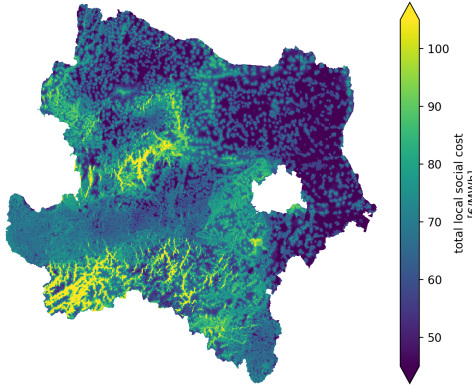
Table: Iterated estimation with log-linear proximity to residential buildings

Dependent variable: wind power zoning					
important bird areas	4.120	***	d(greenland bldg)	-0.808	***
protected areas	6.209	***	d(greenland zoning)	0.532	***
imp. bird * protected areas	0.492		flight zones	3.308	***
tree cover density (tcd)	7.250	***	d(high level roads)	0.022	
leaf type (lftp)	-10.013	***	d(high voltage grid)	-0.100	***
tcd * lftp	5.894	***	water bodies	-1.548	*
elevation	0.011	***	d(wind turbines 2014)	0.899	***
slope	0.265	***	d(wind turbines 2014)^2	-0.024	***
d(residental bldg)	-192.16	***	overnight stays	0.040	***
ln(d(residential bldg))	2.594	***	complementarity	-27.714	***
d(res'l bldg) * ln(d(res'l bldg)	22.355	***			

d() ... distance in km, bldg ... buildings
mean log-likelihood: -725.2
mean adj. R^2: 0.89

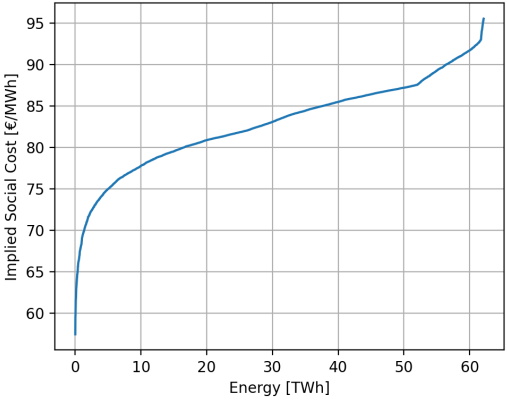
Spatial distribution of estimated local social cost



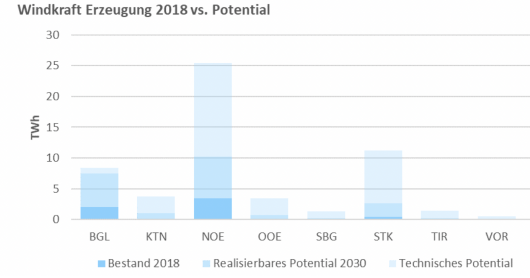


Wind power supply curve

Local social cost in Lower Austria



State of the policy debate



Source: Austrian Energy Agency, 2021

Discussion

- We empirically estimate local social cost incl. disamenity and ecological cost
- Estimates reflect the outcome of a political process
- Estimated willingness-to-pay is robust in preference and WTP space
- Estimates based on LCOE of specific turbine type (Enercon E-101)
- Incomplete representation of the (relevant) electricity network levels

Conlusion

Our results

- can inform optimal capacity choice in power system models
- allow for damage-minimizing wind turbine siting
- can inform consistent policy making

Our approach

- highlights the non-existence of strict ‘economic’ or ‘feasible’ potentials

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Local social cost components