# MINIMUM DISTANCES OR ECONOMIC SITING INCENTIVES?

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## *An Ecological-Economic Analysis of Instruments for Governing Future Wind Power Deployment*

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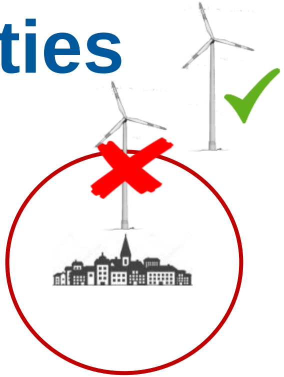
# Background and Motivation

- **Wind power**: promoted worldwide
- **Major benefits**: climate friendly, renewable, no nuclear threat
- **However**: wind turbines (WTs) can also have negative **environ. impacts**
  → **external costs**
- **Focus** of my work (partial analysis):
  - **Utility losses for residents**
    Frequently opposition to WT in direct vicinity
    → the closer a WT to residents, the more problematic
  - **Wildlife conservation problem: Red kite collisions**
    → the closer a WT to red kite nests, the more problematic

# Policy Options for Addressing the Externalities



## I. Minimum distance prescriptions

- Buffer zones (restricted areas) around red kite nests / settlements

ϟ Economic intuition: cannot lead to cost-effective allocations

  - Only binary: all locations inside (outside) buffer zones treated the same neglecting gradual differences in the negative impacts
  - Blindness for sites‘ properties not addressed by minimum distance

## II. **Economic incentive instruments** (can lead to cost-effective allocations)

- Idea: internalizing ext. costs -> efficient allocation from social cost perspective
  - Site-specific compensation payment obligations
  - Spatially differentiated wind power support

## III. Mixes

# Research Question

How can different policy options
to govern the future wind power deployment
be assessed from an ecological-economic perspective?

# Method: Modeling Approach

- **Expected WT allocations under different policy scenarios**
  - Assumption: Private investment decisions aiming at profit maximization

→ Optimization problem (solved in GAMS):

„Choose those potential sites that are the most profitable until an externally given (political) energy goal is met.“

# Method: Modeling Approach (cont‘d.)

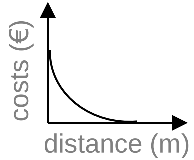
## Cost assessment for the allocations:

### I. Internal WT costs

- Site-independent invest. + O&M costs per WT *(cf. Wallasch et al. 2015, Durstewitz et al. 2016)*

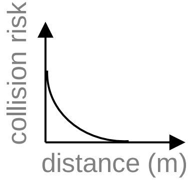
### II. External costs for residents

- Increasing marg. costs with decreasing resident-WT-distance
  → hyperbolic cost funct. *(cf. Drechsler et al. 2011, Krekel & Zerrahn 2017, Wen et al. 2018)*

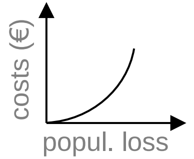


### III. External costs for red kite losses

- Exponential relationship of collision risk and nest-WT-distance
  *(cf. Eichhorn et al. 2012, Rasran & Dürr 2017)*



- Increasing marginal costs with increasing red kite impact
  → parabolic cost function *(cf. Drechsler 2011)*

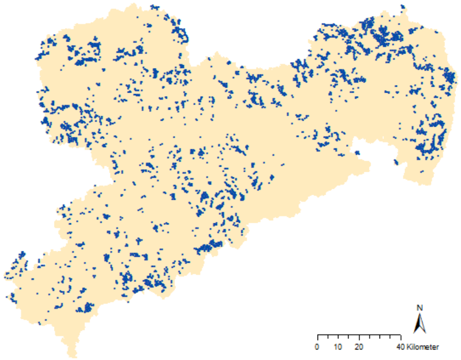


# Results

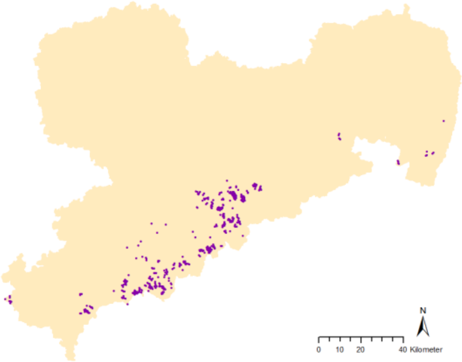
- **Study region:** Federal State of Saxony (energy goal: 2030)
  - GIS-based identification of potential WT sites and energy yields

- **Example** for one policy scenario:

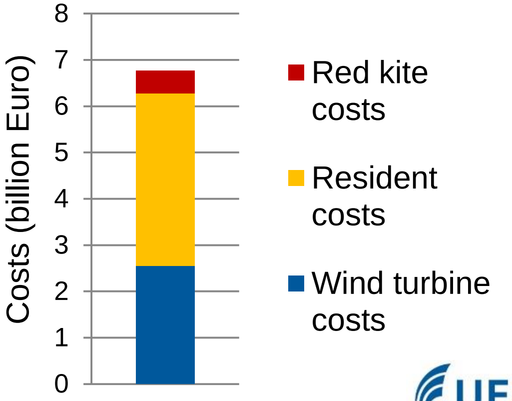
**Potential sites**



**Selected sites**



**Social costs**



# Results (cont‘d.)

- Cost-effective social planer case not reached by any min. dist. combination
- Higher min. dist. to settlements / red kites reduce respective external costs
- Higher min. dist. to settlements can increase red kite externality (and v. v.)
- Higher min. dist. increase generation costs: sites with high energy potentials get excluded s. t. more turbines are needed
- Total social cost effect of higher min. dist. is ambiguous
- Social planer case can be achieved by the economic incentive instruments, but only if the regulator has perfect information on all potential sites
- With more realistic assumptions about the regulator’s knowledge: econ. incentive instruments alone not better than min. distances

# Results (cont‘d.)

- Red kite externality can almost completely be avoided by min. distances
  - Externalities only at turbine-nest-distances <2,000m
    → assumed min. dist. of 1,500m covers most potential impacts

- Min. dist. to settlements unsuitable to minimize external resident costs
  - Externalities up to turbine-settlement-distances of 4,000m
    → But highest possible uniform minimum settlement distance is ca. 1,400m: many impacts not prevented

- Mix of min. red kite distance + econ. incentives for resident externality
  - Favorable, even if regulator is not perfectly informed

# Conclusions

**From a social cost perspective:**

- **Higher min. distances** (compared to lower) **not necessarily beneficial**
- **Econ. incentive instruments** alone are **not more favorable** than minimum distance regulations (if it is assumed that the regulator has not perfect information)
- **Instrument mix** of minimum distances to red kite nests and economic siting incentives addressing the resident externality **is promising**

# Thank you for your attention!

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# References

Drechsler, M., Ohl, C., Meyerhoff, J., Eichhorn, M. & Monsees, J. Combining spatial modeling and choice experiments for the optimal spatial allocation of wind turbines. *Energy Policy* **39**, 3845–3854 (2011).

Eichhorn, M., Johst, K., Seppelt, R. & Drechsler, M. Model-Based Estimation of Collision Risks of Predatory Birds with Wind Turbines. *Ecology and Society* **17**, art. 1 (2012).

Krekel, C. & Zerrahn, A. Does the presence of wind turbines have negative externalities for people in their surroundings? Evidence from well-being data. *J. Environ. Econ. Manag.* **82**, 221–238 (2017).

Rasran, L. & Dürr, T. Collisions of Birds of Prey with Wind Turbines – Analysis of the Circumstances. In: Hötker, H., Krone, O. & Nehls, G. (eds.): Birds of Prey and Wind Farms – Analysis of Problems and Possible Solutions. Springer. Chapter 12, 259–282 (2017).

Wen, C., Dallimer, M., Carver, S. & Ziv, G. Valuing the visual impact of wind farms: A calculus method for synthesizing choice experiments studies. *Sci. Total Environ.* **637–638**, 58–68 (2018).

# BACKUP

# Economic incentive instruments

- First-best assumption:
  Perfect information on the potential external costs of all potential sites
  - Environmental impacts of sites relative to each other
  - Cost levels of externalities
- Considered more realistic case: pragmatic approach of regulator
  - assumes linear distance-damage-relations

# External costs for red kite losses

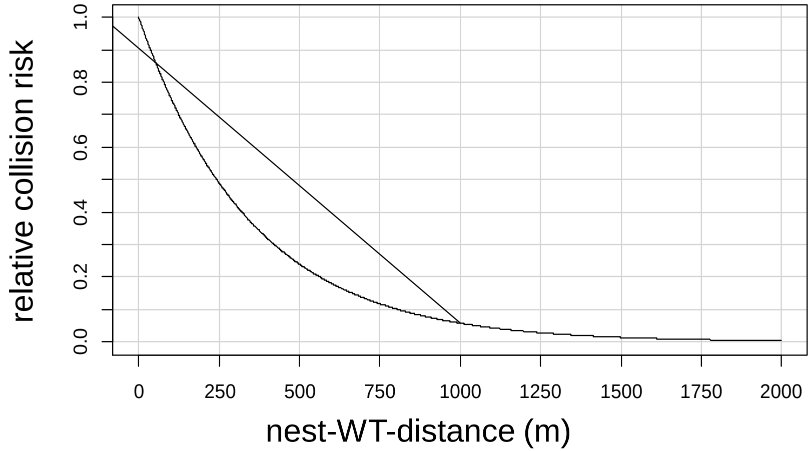
- Exponential relationship of collision risk and nest-WT-distance *(cf. Eichhorn et al. 2012, Rasran & Dürr 2017)*

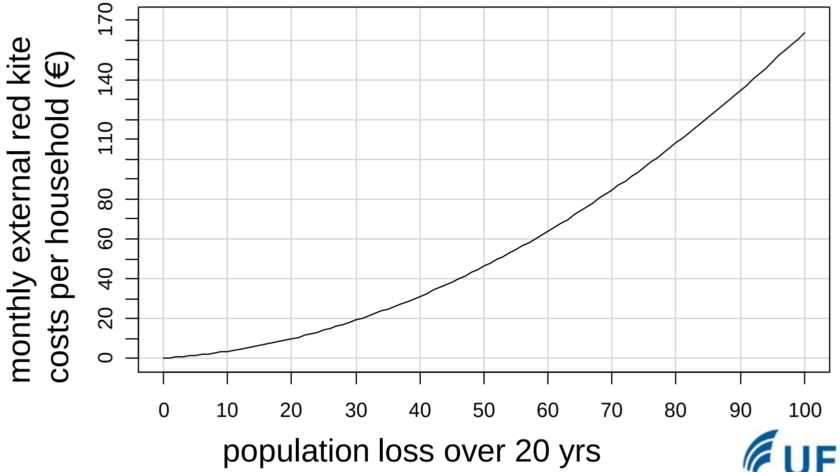
- Population effect: *research gap*
  → simplified assumption:
  linear relationship of collision risk and population effect
  *(cf. Drechsler 2011)*

- Cost function:
  Increasing marginal costs with increasing red kite impact
  → parabolic cost function (*cf. Drechsler 2011)*

- Aggregation over time:
  discounted and summed up over 20 yrs

- Aggregation over space:
  multiplied by number of households in study region





# General idea for modelling external resident costs:

- **Increasing external costs with decreasing resident-turbine-distance**
  (cf. Jones & Eiser 2010, Meyerhoff et al. 2010, Molnarova et al. 2012, Fimereli & Mourato 2013, Jensen et al. 2014, Mirasgedis et al. 2014, Vecchiato 2014, Betakova et al. 2015, Gibbons 2015, Mariel et al. 2015, Dröes & Koster 2016, Wen et al. 2018)

- **Irrelevance threshold: no additional harm for residents**
  → assumed at: 4 km (cf. Krekel & Zerrahn 2017, Gibbons 2015)

# General shape of cost function:

- **Hyperbolic function derived from Drechsler et al. (2011)**
  (fitted with results of choice experiments)

  → monthly costs of a household (h) depending on *minimum* distance (d) of turbines to settlements

$$CMD_h(d) = -\frac{A}{B-d} - C$$

Parameters:
A=1054, B=543, C=0.3

# Adjusted hyperbolic function used for modelling

## 1. Scaling of function according to results of Krekel & Zerrahn 2017

- To get a function for monthly costs of a household depending on the *actual* distance of a certain turbine to the household

→ Factor: $E = 90$

## 2. Temporal aggregation for period of examination (20 yrs – typical lifespan of turbines) including discounting of future costs (assumed discount rate: r=0.03)

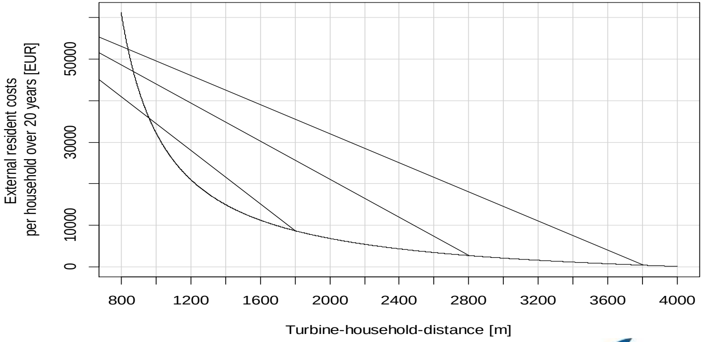
- To get a function for the costs of a household depending on the *actual* distance of a certain turbine (i) to the household (h) for 20 years

→ Factor: $F = 12 * \sum_{t=1}^{20} \frac{1}{(1+r)^t} = 179$

➢ **Combined adjustment factor:** $E * F = 16{,}110$

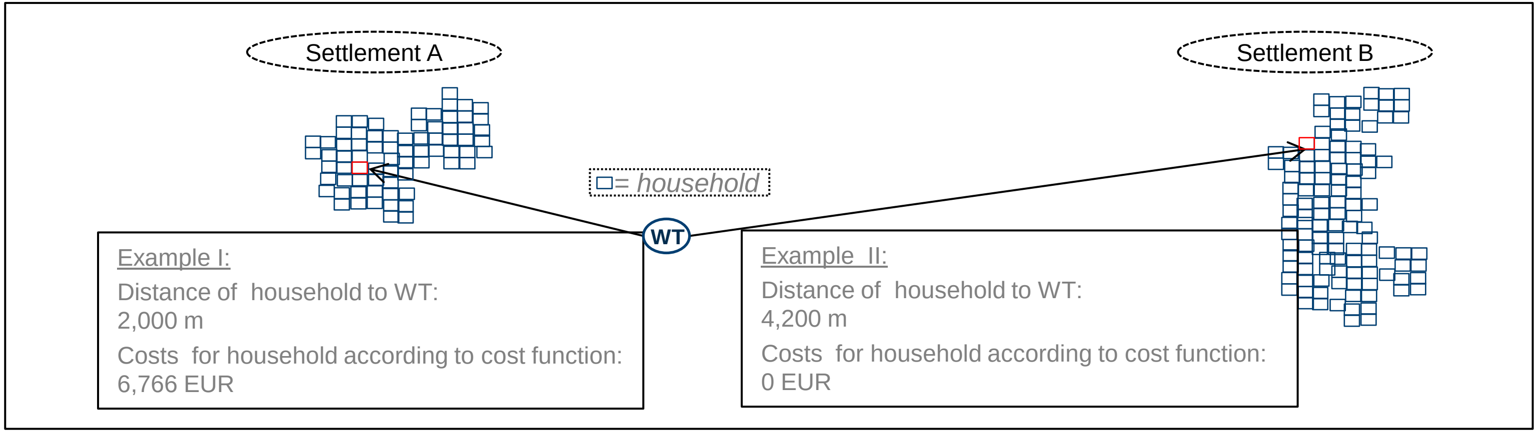
→ **Adjusted hyperbolic cost function:**
costs per household caused by a certain turbine over 20yrs

$$CAD_h(d_{h,i}) = \left(-\frac{1054}{543-d_{h,i}} - 0.3\right) * 16{,}110$$



# Spatial aggregation over all households in study region

1. GIS: measuring all distances from each wind turbine to each household in study region
2. Calculating external costs of all turbines for each household using the cost function



Example I:
Distance of household to WT:
2,000 m
Costs for household according to cost function:
6,766 EUR

Example II:
Distance of household to WT:
4,200 m
Costs for household according to cost function:
0 EUR

*Figure: Illustration of steps 1 + 2*

3. Summing up the costs of all households per turbine
4. Summing up the costs of all turbines for getting the total external resident costs caused by the entire wind turbines allocation in the study region

# References

Betakova, V., Vojar, J. & Sklenicka, P. Wind turbines location: How many and how far? *Appl. Energy* **151**, 23–31 (2015).

Drechsler, M., Ohl, C., Meyerhoff, J., Eichhorn, M. & Monsees, J. Combining spatial modeling and choice experiments for the optimal spatial allocation of wind turbines. *Energy Policy* **39**, 3845–3854 (2011).

Dröes, M. I. & Koster, H. R. A. Renewable energy and negative externalities: The effect of wind turbines on house prices. *J. Urban Econ.* **96**, 121–141 (2016).

Fimereli, E. & Mourato, S. Assessing the effect of energy technology labels on preferences. *J. Environ. Econ. Policy* **2**, 245–265 (2013).

Gibbons, S. Gone with the wind: Valuing the visual impacts of wind turbines through house prices. *J. Environ. Econ. Manag.* **72**, 177–196 (2015).

Jensen, C. U., Panduro, T. E. & Lundhede, T. H. The Vindication of Don Quixote: The Impact of Noise and Visual Pollution from Wind Turbines. *Land Econ.* **90**, 668–682 (2014).

Jones, C. R. & Richard Eiser, J. Understanding 'local' opposition to wind development in the UK: How big is a backyard? *Energy Policy* **38**, 3106–3117 (2010).

Krekel, C. & Zerrahn, A. Does the presence of wind turbines have negative externalities for people in their surroundings? Evidence from well-being data. *J. Environ. Econ. Manag.* **82**, 221–238 (2017).

Mariel, P., Meyerhoff, J. & Hess, S. Heterogeneous preferences toward landscape externalities of wind turbines – combining choices and attitudes in a hybrid model. *Renew. Sustain. Energy Rev.* **41**, 647–657 (2015).

Meyerhoff, J., Ohl, C. & Hartje, V. Landscape externalities from onshore wind power. *Energy Policy* **38**, 82–92 (2010).

Mirasgedis, S., Tourkolias, C., Tzovla, E. & Diakoulaki, D. Valuing the visual impact of wind farms: An application in South Evia, Greece. *Renew. Sustain. Energy Rev.* **39**, 296–311 (2014).

Molnarova, K. *et al.* Visual preferences for wind turbines: Location, numbers and respondent characteristics. *Appl. Energy* **92**, 269–278 (2012).

Vecchiato, D. *How do you like wind farms? Understanding people's preferences about new energy landscapes with choice experiments*. (Aestimum, 2014). doi:10.13128/Aestimum-14707

Wen, C., Dallimer, M., Carver, S. & Ziv, G. Valuing the visual impact of wind farms: A calculus method for synthesizing choice experiments studies. *Sci. Total Environ.* **637–638**, 58–68 (2018).

Often many residents live very close to each other (settlements)

→ A number of cases where high resident costs arise because *many* residents are affected by turbines which are installed in distances beyond the min. distance

# Method: Modeling Approach

- **Expected WT allocations under different policy scenarios**
  - Assumption: Private investment decisions aiming at profit maximization

    → Optimization problem (solved in GAMS):

    „Choose those potential sites that are the most profitable until an externally given (political) energy goal is met.“

- **Benchmark: Social planer case (cost-effective allocation)**
  - „Choose those potential sites that minimize total social costs until an externally given (political) energy goal is met.“