Managing Spatial Sustainability Trade-offs: The Case of Wind Power

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Presented at the 16th IAEE European Conference
Ljubljana, 25-28 August 2019

MultiplEE
Multiple Umweltwirkungen Erneuerbarer Energien

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

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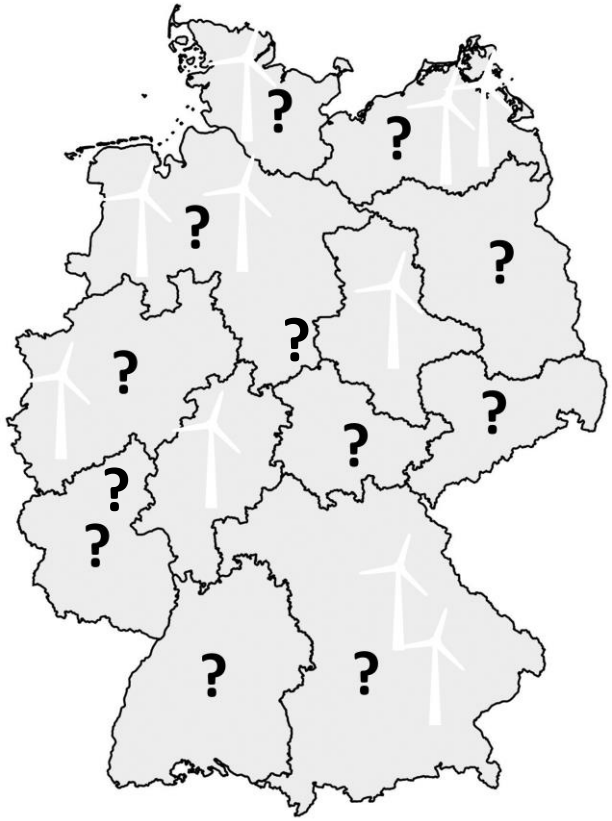
- Introduction
- Method
- Results
- Discussion

Spatial allocation of wind power

- Differing opinions on where to site expanding number of wind turbines in Germany

- Underlying spatial trade-offs between different sustainability criteria, e.g.,
  - **Minimization of power production costs**
  - **Minimization of power grid and system integration costs**
  - **Nature and landscape conservation**
  - **Distributive justice**



Research objectives

Main research question:

- Which challenges arise for decision-making if wind power generation capacity has to be allocated across regions in the presence of sustainability trade-offs?

Underlying questions:

- Is there a generally accepted ranking and definition of sustainability criteria?
- What is the relative importance of efficiency and equity arguments?

Literature review

Economic analyses

- E.g., Eriksen et al., 2017, Klein et al., 2017, Kopiske and Gerhard, 2018, Schlachtberger et al., 2017
- Focus on spatial optimization across different categories of energy system costs, no non-marketable sustainability criteria

Multi-criteria decision analyses

- E.g., Egli et al., 2017; Eichhorn et al., 2019; Eichhorn et al., 2017, Kienast et al., 2017, Hanssen et al., 2018
- More comprehensive consideration of sustainability criteria but very rigid assumptions regarding criteria weights

➔ Open question: How to rank sustainability criteria?

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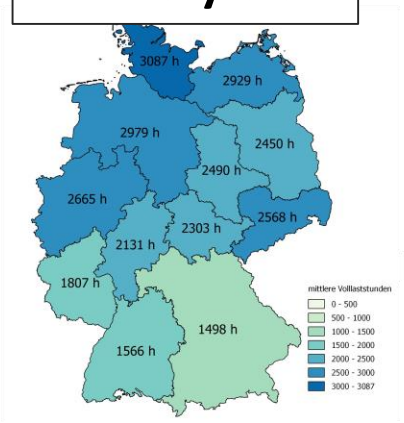
Method: Simulation Game

- Transdisciplinary game to reveal preferences regarding sustainability criteria
- Played with 30 stakeholders from administration, industry, civil society, science, and intermediary organizations during a workshop
- Participants diveded into five groups with the different expertise being equally represented in each group

Method: Simulation game

Räumliche Verteilung des Ausbaus der Windenergie an Land bis 2030 – Nachhaltigkeitskonflikte und -synergien

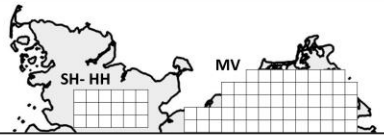
Wind yield



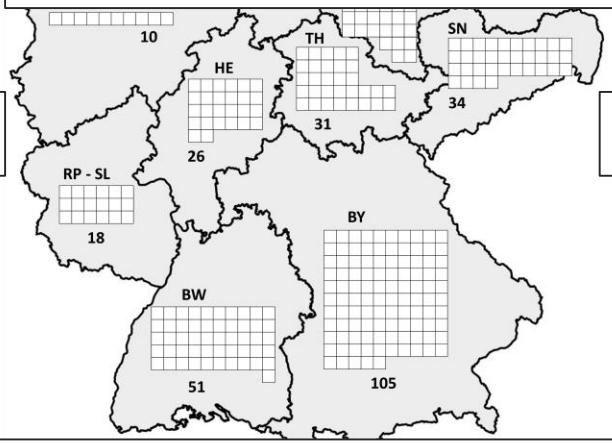
Quelle: Eigene Darstellung auf Basis von Masurowski (2016)

Leistungspotenzial

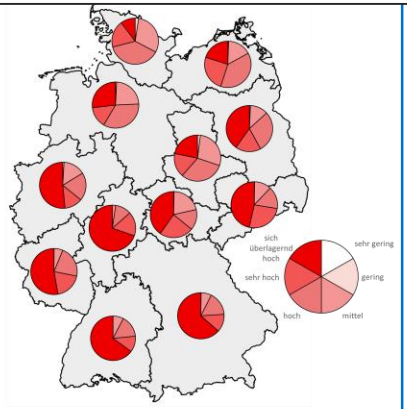
je Bundesland [in GW]



Federal state‘s potential capacity for onshore wind power in GW

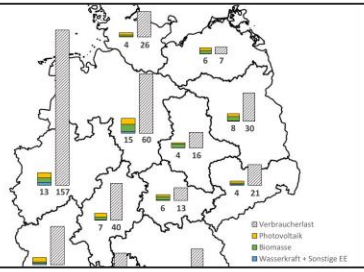


Ecological risk of conflict



Quelle: Eigene Darstellung auf Basis von Bosch & Partner/HS Ostwestfalen-Lippe 2018 (unveröffentlicht)

Spatial load proximity



Distributional justice

Minimierung der Gesamtbelastung des Ausbaus

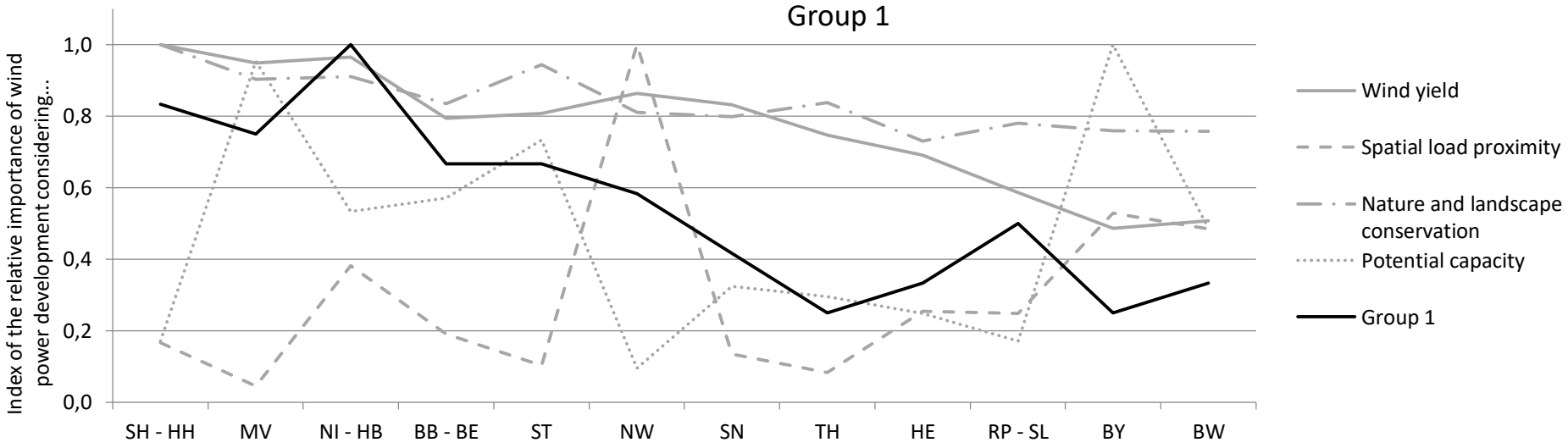
Balance zwischen Windertrag, Lastnähe, Natur- und Landschaftsverträglichkeit

Deploy 200 TWh onshore wind energy among the german federal states in 2030

Analysis of criteria ranking

Sources for evaluation

- Self-reported group ranking of sustainability criteria
- Transcribed group discussions
- Correlation of quantitative group results with hypothetical allocations that are based on single criteria



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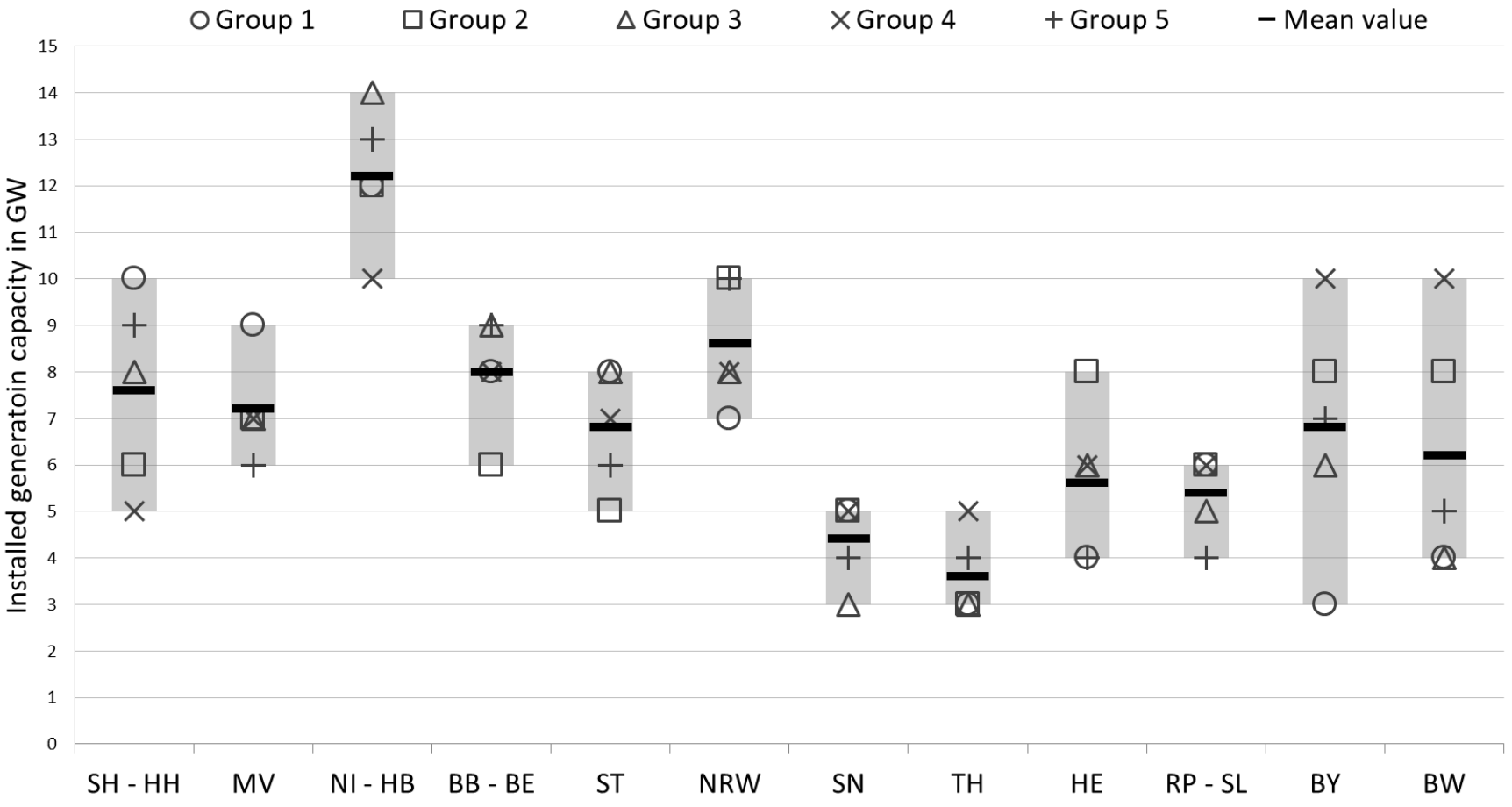
Allocation of wind power expansion over the five groups



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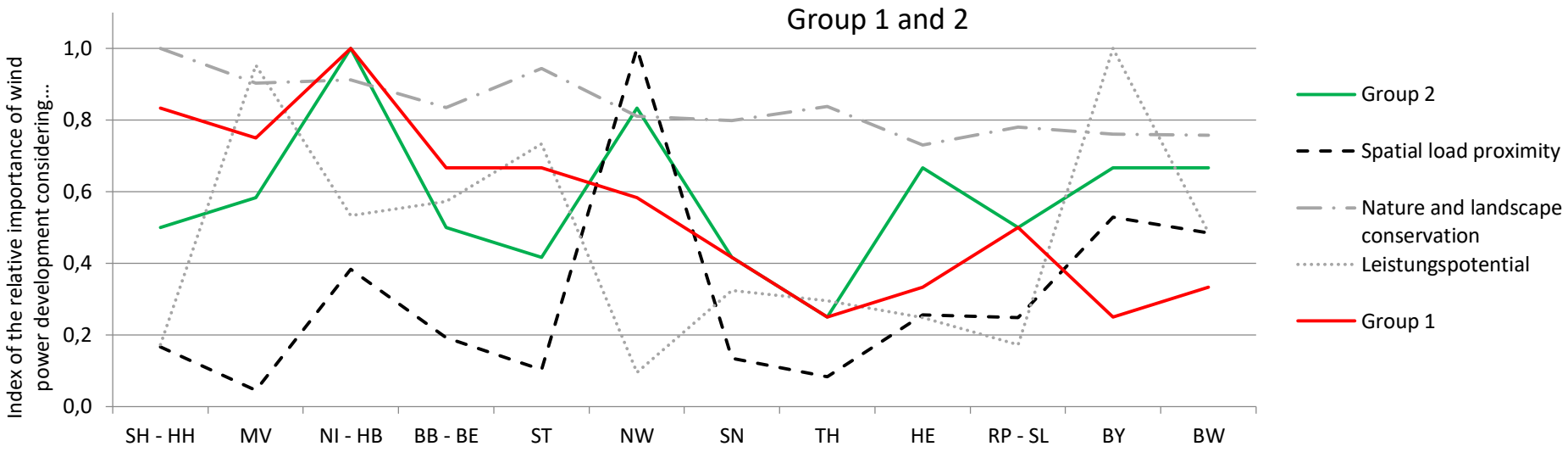
Ranking of sustainability criteria I



Ranking of sustainability criteria II

- **Different weights for the four criteria** eventuate in different spatial allocations of wind power among states
- **Dominance of the trade-off** between minimization of power production cost and minimization of grid and system integration cost
- **Equal-distribution approach** for all groups, but different concepts of equity
- **Weak consideration** of nature and landscape conservation criterion

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Implications for modelling

- **Results of conventional multi-criteria decision analyses** aggregating over multiple sustainability criteria not very reliable (primarily useful as tools for practitioners)

- Important for future research:
  - More **trade-off analyses** comparing different mono-criterion optimizations in a consistent framework
  - Identification of robust „**no-regret sites**“ drawn in any mono-criterion optimization

Implications for policy-making

- Minimum requirement: **transparency of criteria ranking** underlying political decisions on wind power allocation
- **Societal consensus** needed regarding which criteria should matter more or less for the spatial allocation of wind power
- **Participation** of all relevant stakeholders in policy-making:
  - Multi-level governance and participatory decision-making
  - Critical revision of developments to centralize decisions and to allocate more competencies to executive and judiciary branches of government

Thank you for your kind attention!

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