Historic Drivers of Onshore Wind Power Siting and Inevitable Future Trade-offs

Jann Michael Weinand, Detlef Stolten et al.

*j.weinand@fz-juelich.de

IAEE Webinar

06.03.2023

IEK-3: Institute of Techno-economic Systems Analysis

Mainly based on:

Weinand, JM; McKenna, R; Heinrichs, H; Roth, M; Stolten, D; Fichtner, W. *Exploring the trilemma of cost-efficiency, landscape impact and regional equality in onshore wind expansion planning*. **Advances in Applied Energy** (2022).

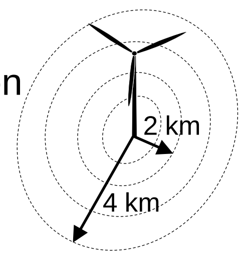
Weinand, JM; Naber, E; McKenna, R; Lehmann, P; Kotzur, L; Stolten, D. *Historic drivers of onshore wind power siting and inevitable future trade-offs*. **Environmental Research Letters** (2022).

Introduction – Non-Technical Siting Criteria

- Four key factors for onshore wind deployment[1]

1. Socially mediated health concerns

- Distribution of burdens
- Measured by affected population (disamenities* & regional equality**)



2. Distribution of financial benefits

- Job creation and economic benefits[4]
- Measured by costs (turbine LCOEs) & regional equality**

3. Meaningful engagement

- Local stakeholders oppose onshore wind, especially if not involved in planning process[1,5]
- Challenging to quantify/measure

4. Treatment of landscape concerns

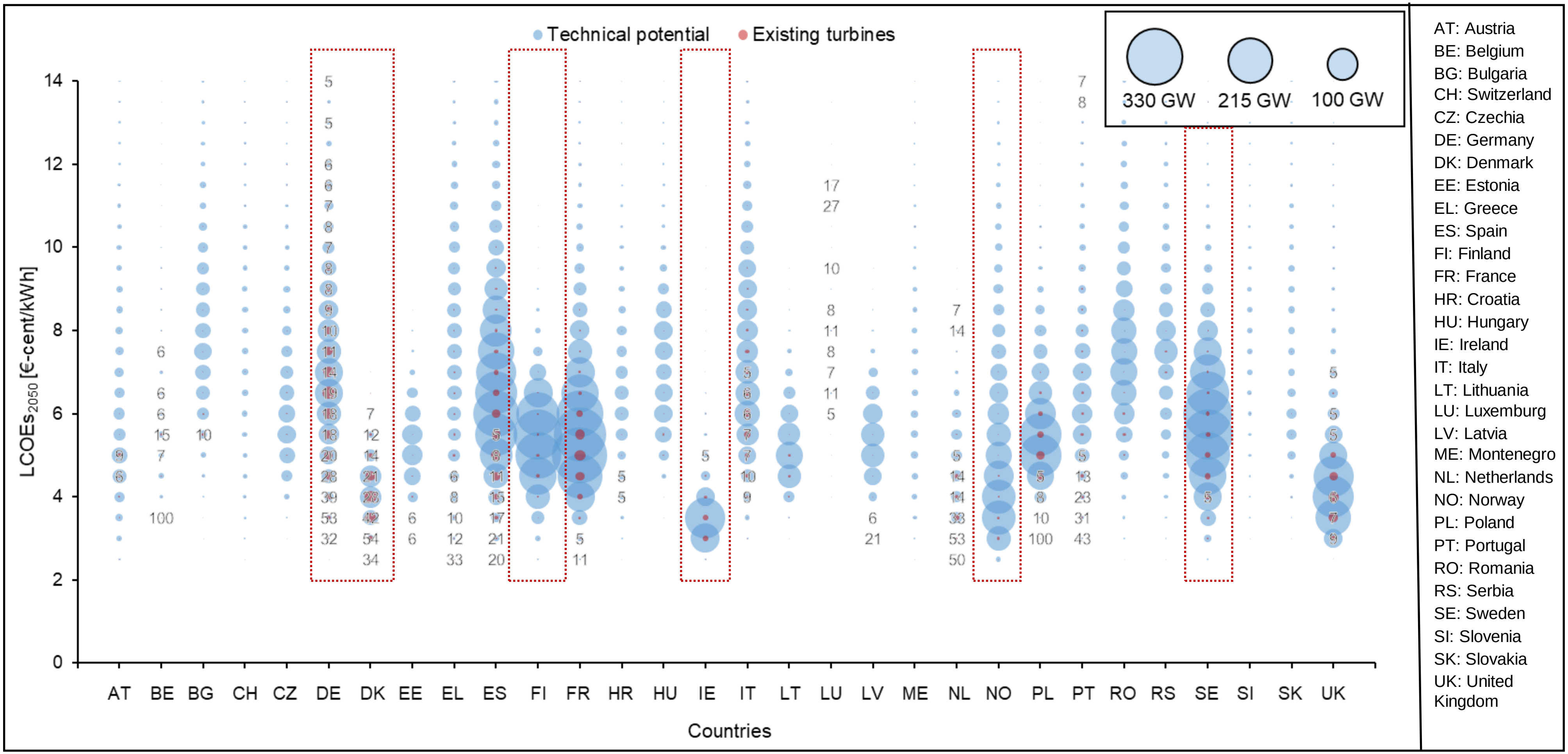
- Visual impact on landscape as main reason for opposition[6]
- Especially in landscapes with high aesthetic quality/scenicness[7]
- Measured by landscape quality ratings

*disamenities through negative externalities, e.g., noise or decrease in property prices[2,3]

**regional equality: spatially even distribution

[1]Fast S. et al. Lessons learned from Ontario wind energy disputes. Nature Energy (2016). [2]Zerrahn A. Wind Power and Externalities. Ecological Economics (2017). [3]Gibbons S. Gone with the wind: Valuing the visual impacts of wind turbines through house prices. Journal of Environmental Economics and Management (2015). [4]Slattery MC et al. The predominance of economic development in the support for large-scale wind farms in the U.S. Great Plains. Renewable and Sustainable Energy Reviews (2012). [5]Boudet HS. Public perceptions of and responses to new energy technologies. Nature Energy (2019). [6]Wolsink M. Co-production in distributed generation: renewable energy and creating space for fitting infrastructure within landscapes. Landscape Research (2018). [7]Molnarova K et al. Visual preferences for wind turbines: Location, numbers and respondent characteristics. Applied Energy (2012).

Historic Siting – Exploited Potential in Europe

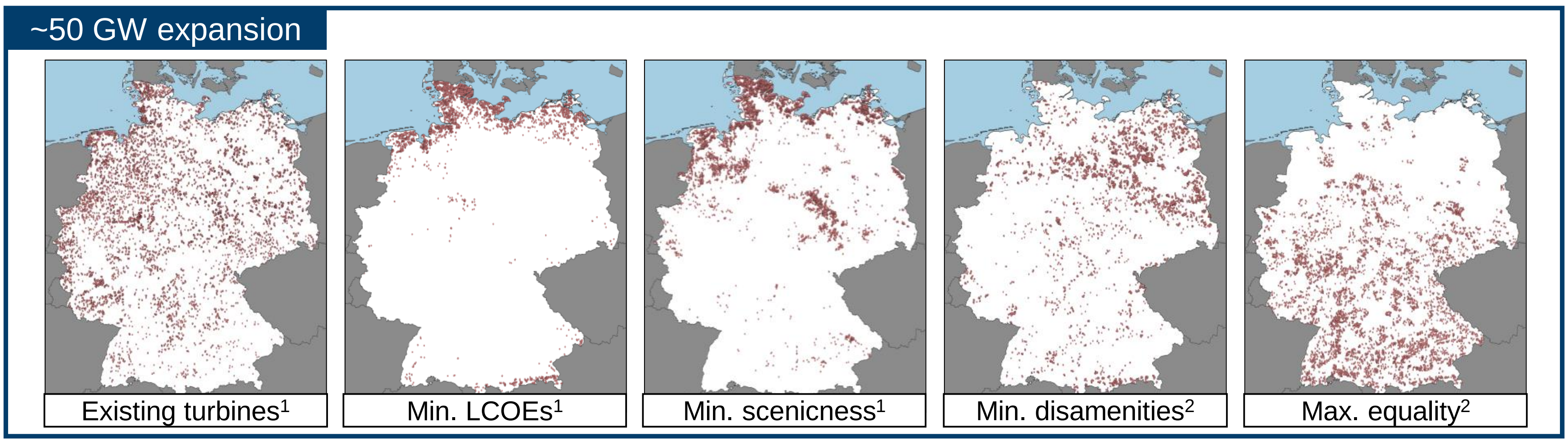


- Only 2% exploited and higher exploitation share for low LCOEs (only shares ≥ 5% are displayed)
- Large exploitation shares in Germany (DE) and Denmark (DK) (relatively low potential)
- Low onshore wind development in countries with high cost-effective potential

Weinand, JM et al. Historic drivers of onshore wind power siting and inevitable future trade-offs. Environmental Research Letters (2022).
Ryberg, DS et al. The future of European onshore wind energy potential: Detailed distribution and simulation of advanced turbine designs. Energy (2019).

Future Expansion – Scenario Results for Germany

- Mean values at existing locations:
  - $LCOEs_{2050}$: ~6.5 €-cent/kWh,
  - Affected population in 2 km radius: 1.4 thousand
  - Scenicness: 4.5 (with 1 ≙ low scenicness; 9 ≙ high scenicness)
  - Regional equality on NUTS-3 level: 25%
- All scenarios mostly show improvements among criteria
- Best wind conditions in the north (min. LCOEs)
  - Lower LCOEs (-30%), affected population (-5%), scenicness (-5%)
- Weaker trade-offs between turbine LCOEs and scenicness
- Minimizing affected population to 200 implies 60% higher turbine LCOEs
- Higher regional equality (max. ~40%) needed to meet south quota (by worsening all other criteria)



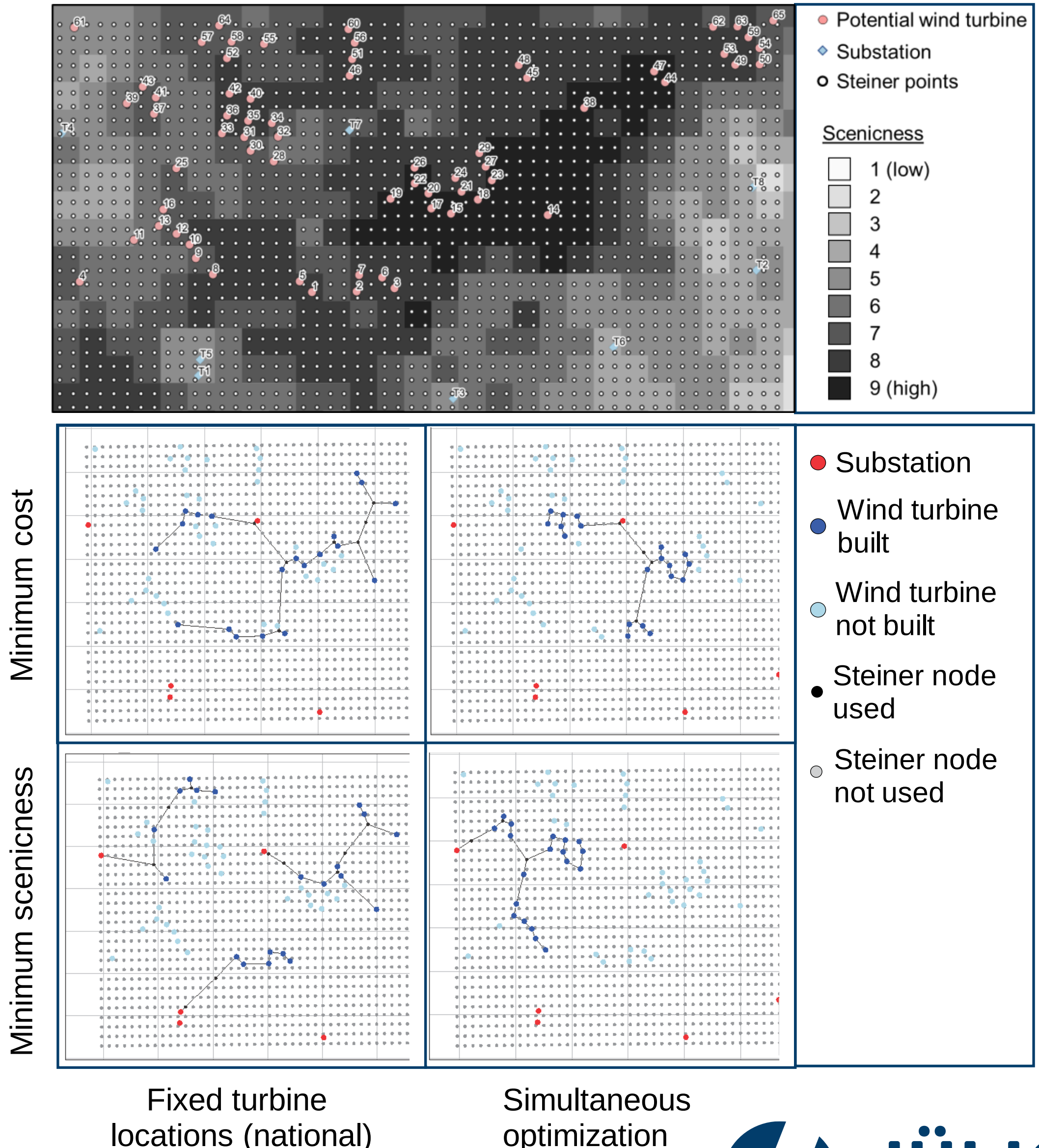
[1]Weinand, JM et al. Exploring the trilemma of cost-efficiency, landscape impact and regional equality in onshore wind expansion planning. Advances in Applied Energy (2022). [2]Weinand, JM et al. Historic drivers of onshore wind power siting and inevitable future trade-offs. Environmental Research Letters (2022).

Future Expansion – Optimizing Network Integration

- Method: optimization of wind turbine location and network integration (Steiner tree approach)

- If turbine locations are fixed before network connection
  - ~20% higher costs
  - ~40% higher landscape impact

➢ Future studies need to simultaneously optimize turbine locations and network connection



Pedersen, J; Weinand, JM, Syranidou, C; Rehfeldt, D. Work in Progress.

Discussion

- Four key factors for onshore wind deployment[1]
  - Socially mediated health concerns → disamenities
  - Distribution of financial benefits → cost-effectiveness & regional equality
  - Meaningful engagement → should be investigated in case studies
  - Serious treatment of landscape concerns → some national analyses[2-6], but unavailability of further data

- Strong disparities among countries in historical onshore wind deployment

- Strong trade-offs also for expansion
  - Significantly better locations than in the past
    - Questionable, if expansion scenarios are feasible → criteria weighting needed
    - System LCOEs (network integration!)
  - Wind expansion targets cannot be achieved by siting decisions alone → procedural and financial participation

Special thanks to

Russell McKenna

Elias Naber

Jaap Pedersen

Paul Lehmann

Michael Roth

Heidi Heinrichs

Wolf Fichtner

Detlef Stolten

as well as

Daniel Rehfeldt
Leander Kotzur
Chloi Syranidou

[1]Fast, S. et al. Lessons learned from Ontario wind energy disputes. Nature Energy (2016). [2]Weinand, JM et al. The impact of public acceptance on cost efficiency and environmental sustainability in decentralized energy systems. Patterns (2021). [3]Weinand, JM et al. Exploring the trilemma of cost-efficiency, landscape impact and regional equality in onshore wind expansion planning. Advances in Applied Energy (2022). [4]Lehmann, P et al. Optimal siting of onshore wind turbines: Local disamenities matter. Available at https://www.ufz.de/export/data/global/255615_DP_2021_4_Lehmannetal.pdf (2021). [5]Tafarte, P & Lehmann, P. Quantifying trade-offs for the spatial allocation of onshore wind generation capacity - a case study for Germany. Available at https://www.ufz.de/export/data/global/253051_DP_2_2021_Tafarte_Lehmann.pdf (2021). [6]McKenna, R et al. Scenicness assessment of onshore wind sites with geotagged photographs and impacts on approval and cost-efficiency. Nature Energy (2021).

Thank you for your attention!

For further questions, please contact:

Dr. Jann Michael Weinand
+49 175 498 5402
j.weinand@fz-juelich.de

Prof. Dr. Detlef Stolten
+49(0)2461 61 5147
d.stolten@fz-juelich.de

IEK-3 profile
go.fzj.de/iek3

IEK-3 publications
go.fzj.de/iek3-publications

GHG net zero scenario
go.fzj.de/ksg45

Project DacStorE
go.fzj.de/dacstore

H2 Atlas Africa
go.fzj.de/h2africa

Project Resur
go.fzj.de/resur

JÜLICH Forschungszentrum