

Impact of Legislation and Social Acceptance on Wind Potentials in Germany

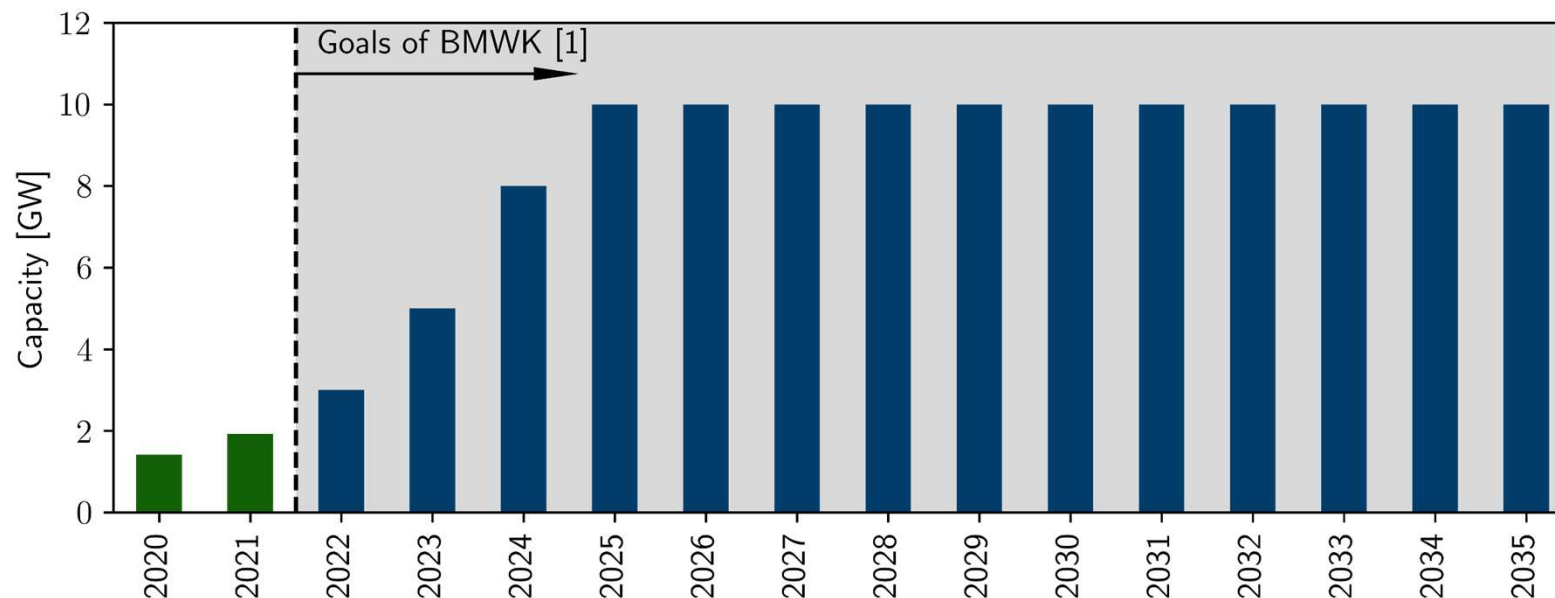
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Motivation

- Germany wants to achieve greenhouse gas neutrality until 2045 ^[1]
- Need for wind expansion:
 - Studies show need for significant increase in installed wind capacities (180 – 213 GW) ^[2-4]
 - Easter package of BMWK¹ proposes 10 GW/year and installed capacity of 160 GW in 2040 ^[5]
- Expansion not sufficient
 - Acceptance problems of wind turbines due to visual impact and noise
 - Regulatory inequalities between federal states
- What is the impact of legislation and acceptance on the possibility to build wind turbines?

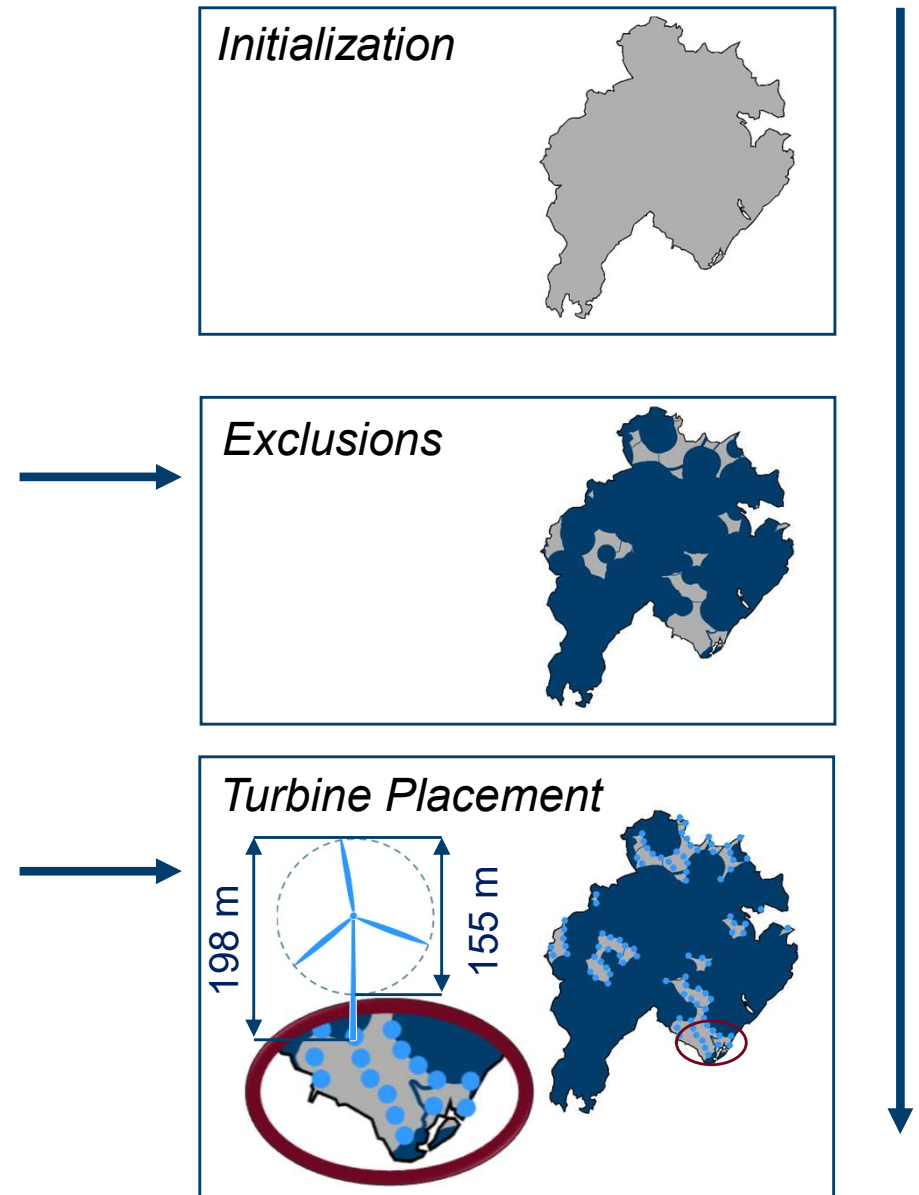


¹ BMWK: Federal Ministry of Economic Affairs and Climate Actions
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Methods

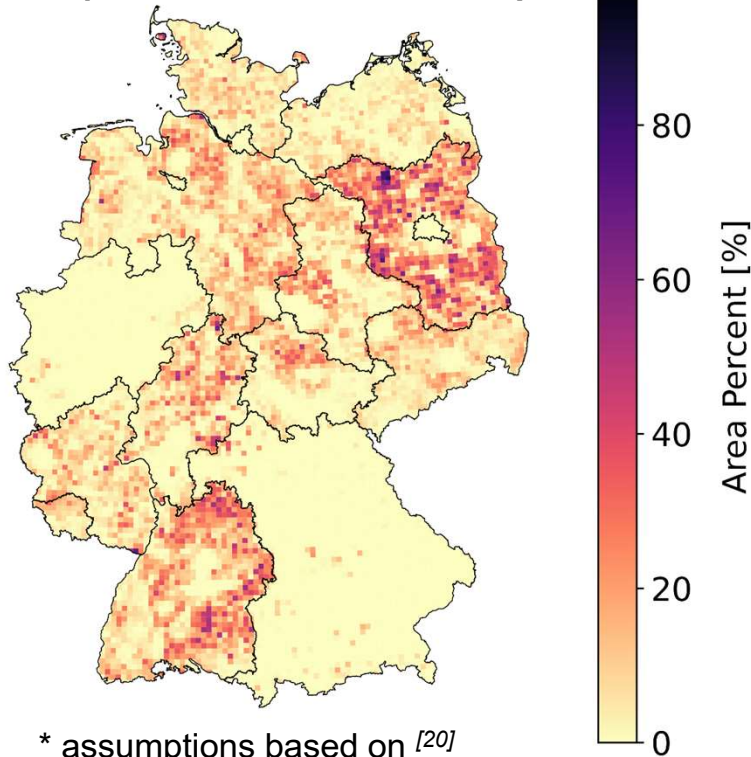
- Exclusion of not usable areas with open-source-tool GLAES [6]
 - Identification of land usage based on high resolution land usage datasets [7-19]
 - Exclusion of 44 criteria
 - Consideration of residential buildings for entire Germany
 - Placement of turbines on eligible areas with GLAES [6]:
 - Distance between turbines: 8D* and 4D* in prevailing and transverse wind directions
 - Reference turbine: 4.7 MW (Wind-class IEC IIIB)
- Calculation of legislation and nation-wide scenario
- Examination of sensitivities which have influence on acceptance and legislation

* Rotor diameter



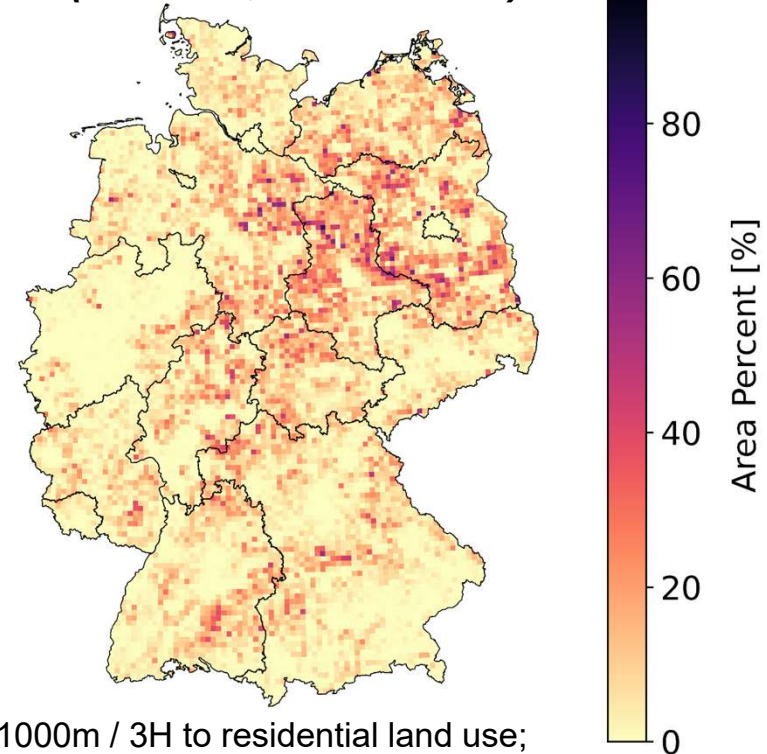
Inequalities of Current Legislation

Federal state legislation*
(385 GW, 6.9 Area-%)



* assumptions based on [20]
and expert-based corrections

Nation-wide exclusions**
(403 GW, 7.3 Area-%)



** 1000m / 3H to residential land use;
forests not excluded; see appendix

- Large variation between federal states' legislation lead to big differences in potential capacity
- Only 0.4% and 0.3% of area available in Bavaria and NRW^x with current legislation
- Nation wide exclusion show that potential could be distributed more evenly

^x North Rhine-Westphalia

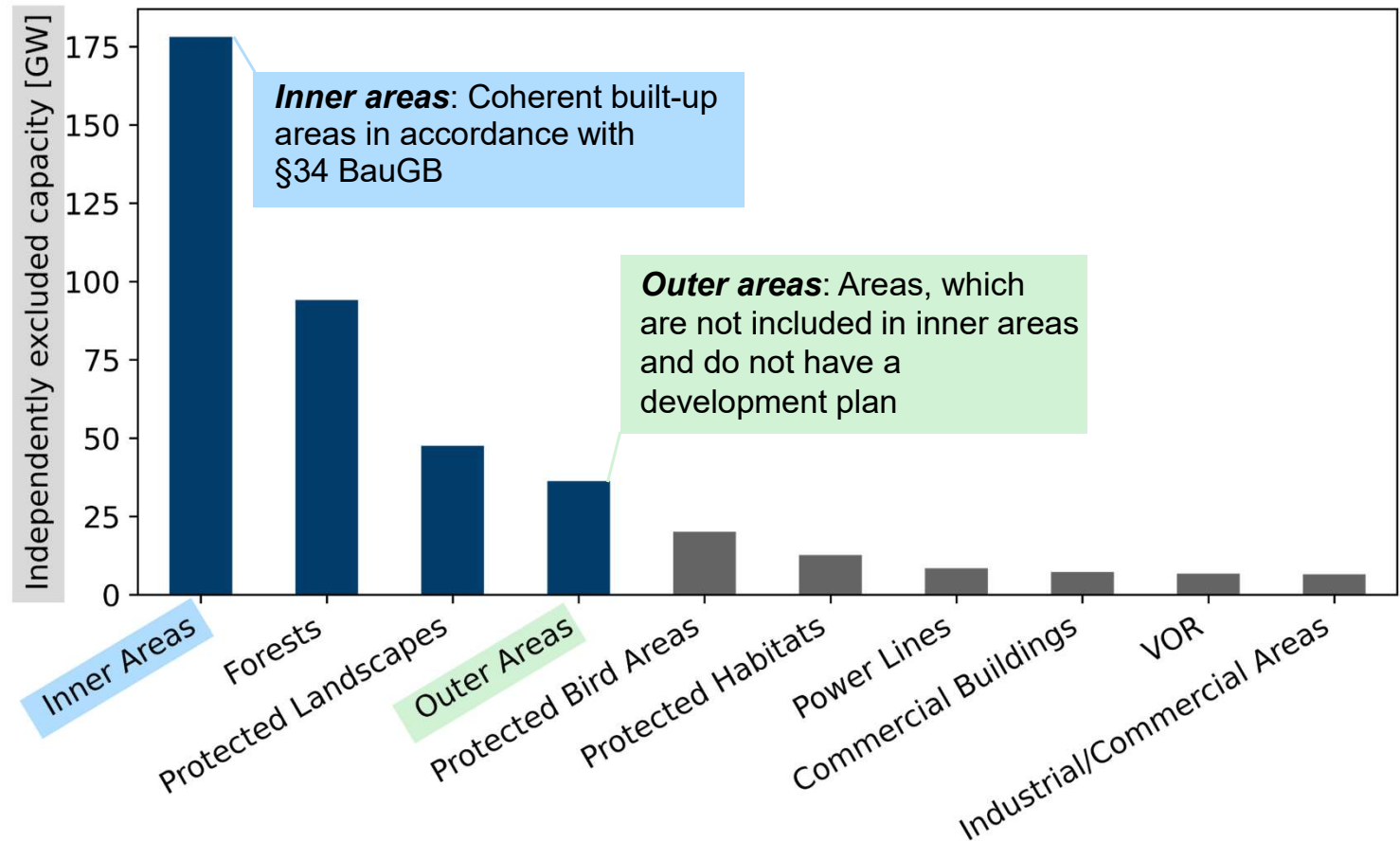
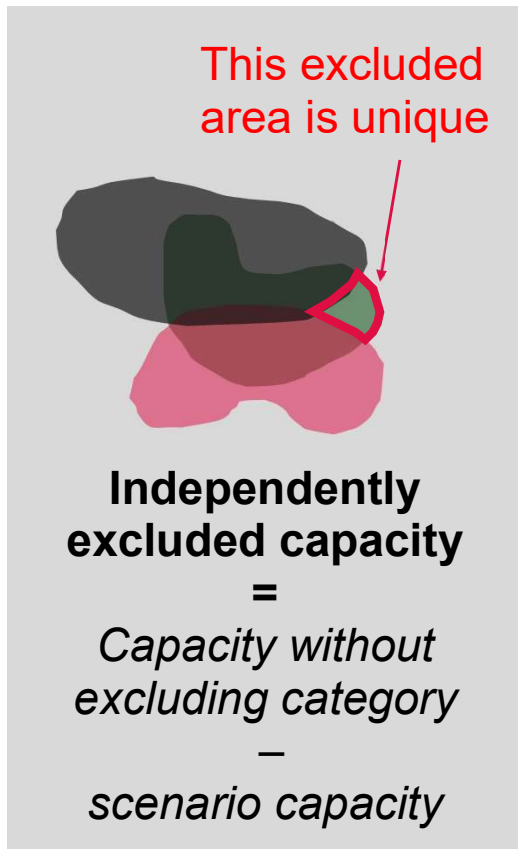
[20] Fachagentur Wind an Land, „Überblick Abstandsempfehlungen und Vorgaben zur Ausweisung von Windenergiegebieten in den Bundesländern“. 2021.

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IEK-3: Techno-Economic Systems Analysis

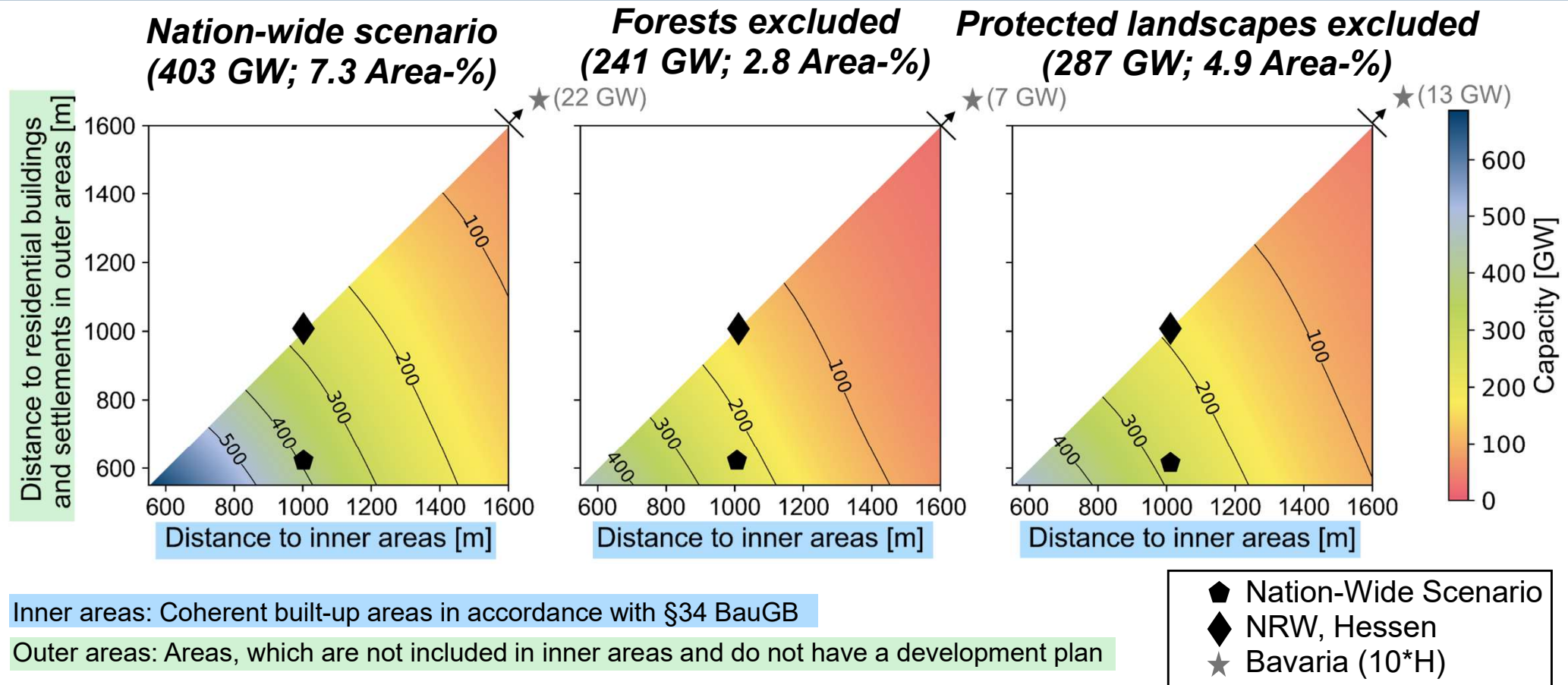
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Sensitivity of Exclusions



- **Inner areas, forests, protected landscapes, and outer areas** most influential criteria
- **Outer areas** not as influential because of lower buffer distance and large interaction with inner areas

Impact of Residential Land Use

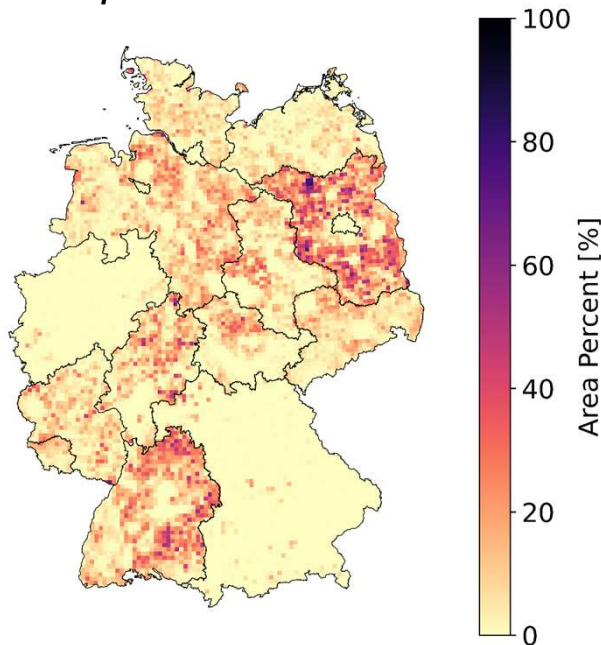


- Distances to residential buildings frequently discussed in public and politics
- Highly sensitive regarding buffer distances
- Leverage for capacity potential in Germany

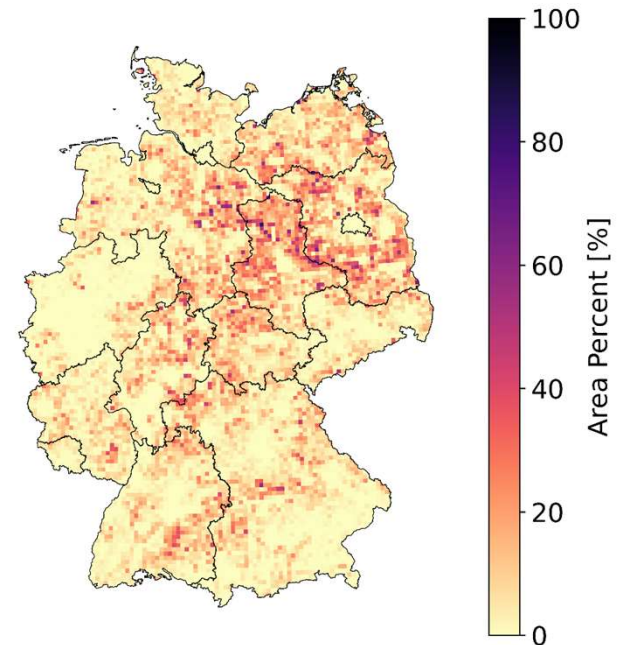
Conclusions

- Large inequalities between federal states' legislation in Germany
- Nation-wide application of legislation in Bavaria and NRW might not be sufficient when compared to different energy system studies
- Largest leverage on capacity potentials with distances to residential land use, forest exclusion, and protected landscapes exclusion
- Interdependency between parts of legislation have to be considered

Federal state specific scenario



Nation-wide scenario



Thank you for your attention!

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References

- [1] *Bundes-Klimaschutzgesetz (KSG)*. 2021. Accessed: Jan. 05, 2021. [Online]. Available: <https://www.gesetze-im-internet.de/ksg/KSG.pdf>
- [2] D. Stolten, P. Markewitz, T. Schöb, and L. Kotzur, "Strategien für eine treibhausgasneutrale Energieversorgung bis zum Jahr 2045. (Kurzfassung)," Forschungszentrum Jülich GmbH, Jülich, 2021. Accessed: Dec. 22, 2021. [Online]. Available: https://www.fz-juelich.de/iek/iek-3/DE/Documents/Downloads/transformationStrategies2045ShortStudy.pdf?__blob=publicationFile
- [3] J. Brandes *et al.*, "Wege zu einem klimaneutralen Energiesystem - Die deutsche Energiewende im Kontext gesellschaftlicher Verhaltensweisen - Update November 2021: Klimaneutralität 2045," Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg, Nov. 2021.
- [4] G. Luderer, C. Kost, and D. Sörgel, "Deutschland auf dem Weg zur Klimaneutralität 2045 - Szenarien und Pfade im Modellvergleich," Potsdam Institute for Climate Impact Research, 2021. Accessed: Nov. 03, 2021. [Online]. Available: https://publications.pik-potsdam.de/pubman/item/item_26056
- [5] Bundesministerium für Wirtschaft und Klimaschutz (BMWK), *Entwurf eines Gesetzes zu Sofortmaßnahmen für einen beschleunigten Ausbau der erneuerbaren Energien und weiteren Maßnahmen im Stromsektor (EEG 2023)*. 2022. [Online]. Available: https://www.bmwi.de/Redaktion/DE/Downloads/Energie/04_EEG_2023.pdf?__blob=publicationFile&v=8
- [6] D. Severin Ryberg, Leander Kotzur, and Detlef Stolten, [GitHub Repository] *Geospatial Land Availability For Energy Systems (GLAES)*.
- [7] © Bayerischen Landesamts für Umwelt (LfU), "Bayerischen Landesamts für Umwelt (LfU) - Wasserschutz." 2021. [Online]. Available: www.lfu.bayern.de
- [8] © Bundesamt für Naturschutz (2021), "BfN-Datensatz." 2021.
- [9] © Landesamt für Umwelt Rheinland-Pfalz, "Landesamt für Umwelt Rheinland-Pfalz - Wasserschutz." 2021.
- [10] © Landesanstalt für Umwelt Baden-Württemberg (LUBW), "Daten- und Kartendienst der LUBW - Wasserschutzgebiete." 2021. [Online]. Available: <https://udo.lubw.baden-wuerttemberg.de/public/index.xhtml>
- [11] © WasserBLlck/BfG und Zuständige Behörden der Länder, 2020, "BfG-Datensatz." 2020. [Online]. Available: <https://www.geoportal.de/Metadata/52d1b6ab-31c7-491b-96c8-be22a31d7313>
- [12] Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), "Informationen zu deutschen Seismometer-Stationen." [Online]. Available: https://www.bgr.bund.de/DE/Themen/Erdbeben-Gefaehrdungsanalysen/Seismologie/Seismologie/Seismometer_Stationen/Stationsinfos/d_stationen_node.html
- [13] Copernicus Programme, "European Digital Elevation Model (EU-DEM v1.1)." 2016. [Online]. Available: <https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1>
- Zenodo, 2020. doi: [10.5281/ZENODO.1122558](https://doi.org/10.5281/ZENODO.1122558).
- [14] Geobasisdaten: © GeoBasis-DE / BKG (2021), "Amtliche Hausumringe Deutschland (HU-DE)." 2021.
- [15] Geobasisdaten: © GeoBasis-DE / BKG (2021), "Digitales Basis-Landschaftsmodell (Ebenen) (Basis-DLM)." 2021.
- [16] OpenStreetMap contributors, "Open Street Map." 2021. [Online]. Available: <https://www.openstreetmap.org/>
- [17] Overpass Contributors, "Overpass Turbo," 2022. <https://overpass-turbo.eu/>
- [18] UNEP-WCMC, IUCN, "The world database on protected areas." 2016. Accessed: Oct. 22, 2021. [Online]. Available: <https://www.protectedplanet.net/23>
- [19] Geobasisdaten: © GeoBasis-DE / BKG (2020), "Verwaltungsgebiete 1:250 000 (VG250)." 2020. Accessed: Jul. 05, 2021. [Online]. Available: <https://gdz.bkg.bund.de/index.php/default/verwaltungsgebiete-1-250-000-ebenen-stand-01-01-vg250-ebenen-01-01.html>
- [20] Fachagentur Wind an Land, "Überblick Abstandsempfehlungen und Vorgaben zur Ausweisung von Windenergiegebieten in den Bundesländern". 2021.

Appendix: Exclusions Nation-Wide Scenario

Criterion	Dataset	Distance	Criterion	Dataset	Distance
Airfields	[15]	1500 m	Inner areas	[15]	1000 m
Airports	[15]	6000 m	Lakes	[15]	100 m
Biosphere (core zones)	[8]	0 m	Military	[15]	0 m
Biosphere (Development zones)	[8]	Not excluded	Mineral extraction	[15]	0 m
Biosphere (Maintenance zones)	[8]	Not excluded	Mixed usage	[15]	2H
Birds protected areas (SPA)	[18]	300 m	Motorway	[15]	40 + R
Border	[19]	100 m	National park	[18]	300 m
Buildings commercial	[14]	2H	Nature park	[8]	Not excluded
Buildings health treatment	[14]	1000 m	Nature reserve (NSG)	[18]	300 m
Buildings mixed usage	[14]	3H	Outer areas	[15]	3H
Buildings residential	[14]	3H	Power lines	[15]	100 + D
Camping	[15]	3H	Primary roads	[15]	20 + R
Cemetery	[15]	0 m	Protected landscapes	[18]	Not excluded
D-VOR	[17]	10000 m	Railways	[15]	100 + D
Farmland	Not excluded	Not excluded	Ramsar	[18]	Not excluded
FFH	[18]	300 m	Recreational	[15]	0 m
Forests	[15]	Not excluded	Regional roads	[15]	R
Grassland	Not excluded	Not excluded	Rivers	[15]	100 m
Historical	[16]	1000 m	Secondary roads	[15]	R
Industrial/Commercial	[15]	2H	Seismic station	[12]	1000 m
			Slope >17°	[13]	0 m
			Stream	[16]	0 m
			VOR	[17]	15000 m
			Water protection (I&II)	[7,9,11]	50 m