

# Chances and limits of multi-objective optimization when siting renewable energies considering the 'Sustainable Development Goals' (SDGs)

Jessica Weber<sup>1</sup>

<sup>1</sup>Berlin Institute of Technology (TU Berlin), Straße des 17. Juni 135, 10623 Berlin

## Motivation

In the process of **securing land for renewable energies** areas have been excluded through consistent negative planning (e.g. buffers to settlements, excluding landscape protection areas). However, this also led to discussions about the remaining areas and **whether energy and climate policy goals can be achieved** in the future. In the case of onshore wind turbines (WT) in particular, **trade-offs** with nature conservation, forest protection and emission control, for example, have not only led to long procedural times, but also to a sharp decline in the construction of new WT and the replacement of WT of previous generations, both of which are necessary from a climate protection and energy security point of view.

- The aim of the PhD project is to explore a solution model that supports decision makers and stakeholders in a **multi-criteria planning approach** to identify **sufficient areas** for the energy transition, which currently fail due to a 'wicked problem' - i.e. the **negotiation and balancing of sustainability trade-offs** - in the course of predominantly negative planning.
- For this purpose, **ecological, economic and social effects** are to be considered in the search for locations for wind energy and ground-mounted photovoltaics (referring to the SDGs), thus also allowing for potential welfare effects.
- In particular, the project discusses how a **multi-criteria (sustainability) planning approach** can better support **'positive planning'**, i.e. if the achievement of concrete, regionalized and cumulative development targets for renewable energies is just as 'fair' as excluding planning criteria.

## Approach

Cumulative dissertation (2021-2023):

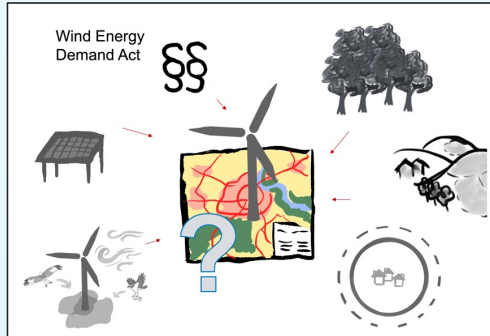
- Can area-wide positive planning approaches allow for a swifter target orientation in developing wind energy? (Fig.1 – No. 1)
- Can MCDA serve ex post to indicate winners and losers in sustainability dilemmas? A case study of marine spatial planning in Germany (Fig.2 – No. 2)
- Is there room for two? - A multi-criteria scenario framework to model the energy-species-land nexus footprint for regional renewable energy planning (Fig.3 – No. 3)
- Gridlock in compromise, or is multi target optimization in planning renewable energies possible? A stakeholder case study using scenario-MCDA (in preparation) (No. 4)

Figure 1 consists of a grid of icons and text boxes. The icons represent various aspects of planning and stakeholder interaction. The text boxes contain the following points:

- (+) Overall energy targets would be spatially contextualized to the lower planning level and not kept vague
- (-) The success for WT development depends on the ambitions of high-level stakeholders, and risk of adequate balancing and social acceptance
- (+) A common planning strategy at high-level could enable transparency on the achievement of targets
- (-) Identifying low-conflict areas by making compromises still needs to be tackled
- (+) Placing energy targets in a spatial context could create an incentive of expectation on municipalities and strengthen local responsibility for onshore wind energy (Swedish case)
- (-) Municipalities might be overwhelmed with the tasks to allocate wind energy areas
- (+) Allowing flexibility in demand assessment and adjusting the planning approach may provide for responsive and adaptive planning
- (-) Energy demands need to be translated into sufficient areas, also portraying normative convictions
- (+) Inter-agency coordination of energy quantity targets with tools for tackling trade-offs may prevent a post-political planning approach from being adopted
- (-) The will to work multidisciplinary is needed
- (+) Consolidating the discussion towards high-level approaches for onshore wind energy
- (-) Adjusting planning systems could lead to a small time lag in wind energy planning as well

Fig.1: Can area-wide positive planning approaches allow for a swifter target orientation in developing wind energy?

- Chances and limits of positive planning approaches (case study of onshore wind energy planning in Sweden, and offshore wind energy in the German Exclusive Economic Zone (EEZ))
- Positive planning refers to a target-oriented adaptation, when regionalized development targets are addressed as 'fairly' as restrictive specifications, the steering impetus evolves by met targets



## Multi-Criteria Decision Making (MCDA)



### Ex ante MCDA

- ❖ Support for decision-making, generating information and transparency using (inter- and transdisciplinary) multiple criteria, aggregation and criteria ranking techniques

### Ex post MCDA

- ❖ Tracing back decision making, understanding dynamics, learning for future planning using (inter- and transdisciplinary) multiple criteria, aggregation and criteria ranking techniques

Figure 2 is a table with four columns: Environmental criteria, Social criteria, Economic criteria, and Shipping. Each column lists various criteria and their associated values.

Environmental criteria	Social criteria	Economic criteria	Shipping
Capacity of OWP needed for energy transition (at 8 MW/km <sup>2</sup> ) (1)	Military training areas (25)	Wind energy in military areas (29)	Priority area shipping (31)
Priority area wind energy (2)	Passability for (touristic, research, military) boats at OWP (26)	Sand and gravel extraction and hydrocarbons (30)	Temporary priority area shipping (32)
Reservation area wind energy (3)	Archaeological sites (27)	Future arctic routes (34)	Temporary reservation area shipping (33)
Conditional priority area wind energy (4)	Fixed deconstruction of OWP (28)	Safety and ease of shipping (35)	Aquaculture (36)
Conditional reservation area wind energy (5)			Fishery areas (37)
Wind energy in foreign areas (6)			(Active and/or passive) Fishery in areas for wind energy (38)
Wind energy in areas for bird migration (7)			Fishery in nature conservation areas (39)
Wind energy in areas for harbor porpoises (8)			Pipelines for hydrogen (40)
Wind energy in areas for loons (9)			OWP connection lines and grid connection (41)
Wind energy in areas for nature conservation (10)			Area of potential Fehmarnbelt crossing (42)
Wind energy in areas for research (11)			(Future) plants for energy production (43)
Area for bird migration (12)			Areas and starting places for aerospace (44)
Priority areas loons (13)			
Reservation areas loons (14)			
Good environmental status according to MSFD in target setting (15)			
Ecosystem approach according to MSFD in target setting (16)			
No uses of the sea for 50% (17)			
Sediment relocation and erosion (18)			
Heavy metal release of OWP in 25 years (19)			
Refuge and nursery areas for fish species at OWP (20)			
Nature conservation area (21)			
Shipping in nature conservation areas (22)			
Military training in nature conservation areas (23)			
Applying mitigation measures (24)			

Fig.2: Can MCDA serve ex post to indicate winners and losers in sustainability dilemmas? A case study of marine spatial planning in Germany\*

- Sustainability criteria shifted in weights in the spur of moment during planning stages, with nature conservation goals apparently being deferred in the process
  - Ex post MCDA might allow for reviewing the potential policy dynamics of planning processes, learning for future processes
- \*OWP = Offshore Wind Parks

## Conclusions (preliminary)

- Frequent planning approaches may not give equal weight to climate protection and renewable energy concerns at lower planning levels ('negative planning') (No. 1)
- Planning might also be understood as executing official decision-making, meaning that a transparent planning process that is open to change may become increasingly important for democratic planning decisions (No. 2)
- Multi-criteria scenarios allow quantification of objectives/criteria and transparent negotiation (democratic planning mandate) (No. 2, 3)
- Multi-objective optimization involves combining scenarios and adjusting levers, i.e. criteria, to minimize impacts on protected areas from all sides (No. 3)

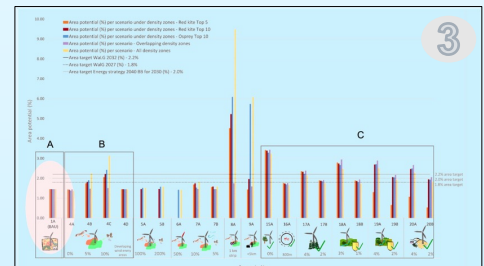
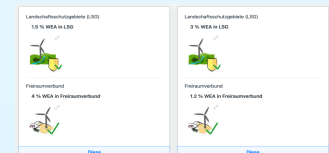


Fig.3: Is there room for two? - A multi-criteria scenario framework to model the energy-species-land nexus footprint for regional renewable energy planning

- Where should wind energy be sited; which land uses/objectives/criteria should be prioritized, or set back?
- Is wind energy needed in forests to meet the wind energy spatial targets of the Wind Energy Demand Act, for example?
- What would be the 'least intrusive' approach to wind energy development?

## Next steps: Gridlock in compromise?

Is an added value of multi-criteria planning tools recognized in practice?  
 Are there boundaries between siloed institutions, i.e. is multi-objective optimization possible?



## Contact

M.Sc. Jessica Weber  
 j.weber@campus.tu-berlin.de



## References

1. Can area-wide positive planning approaches allow for a swifter target-orientation in developing wind energy? – submitted
2. Weber, J.; Köppl, J. Can MCDA Serve Ex-Post to Indicate 'Winners and Losers' in Sustainability Dilemmas? A Case Study of Marine Spatial Planning in Germany. *Energies* 2022, 15, 7654. <https://doi.org/10.3390/en15207654>
3. Weber, J., Steinkamp, T., Reichenbach, M., 2023. Competing for space? - A multi-criteria scenario framework to model the energy-biodiversity-land nexus for regional renewable energy planning on a German case. Preprint. <https://www.researchsquare.com/article/rs-2599221/v1>