NATURE CONSERVATION
AND RENEWABLE ENERGIES
Research at BfN

Federal Agency
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Conservation

IN PRACTICE

Nature and landscape conservation: GIS-supported scenarios for wind energy

The geographical distribution of the future expansion of onshore wind energy is one of the major controversial planning tasks. The new method funded by the Federal Agency for Nature Conservation enables the transfer of all aspects of nature and landscape conservation of relevance for wind power to a national GIS model for the first time. Thereby, an evaluation of different wind power expansion scenarios in terms of their risks of conflicting with nature and landscape conservation is possible. The analyses show that, for the 2035 target of roughly 270 TWh of energy from onshore wind turbines, there is considerable scope for expansion that is compatible with nature and landscape.

FOR

- Energy policy makers
- Energy scientists
- Nature conservation authorities
- Regional planners

NATURE CONSERVATION FACTORS

Biotic and abiotic factors as well as scenery and recreation

KEY WORDS

- Scenarios
- Strategic planning
- Wind energy
- Public consultation
- GIS models

Regional expansion scenarios for renewable energies have so far been based mainly on cost effectiveness and grid compatibility. These factors are easy to record in the planning procedures of the energy industry stakeholders. Biodiversity, ecosystem productivity and functionality and the conflicts resulting from these, on the other hand, have so far been integrated to varying degrees in higher-level planning processes. The criteria laid down in the Federal Nature Conservation Act (Bundesnaturschutzgesetz) to protect the “diversity, distinctiveness, beauty and recreational value of the landscape” are often neglected as factors in the expansion scenarios. The R&D project “Scenarios for the expansion of renewable energies” thus fills a gap for higher-level planning: it brings together energy industry aspects and the interests of nature and landscape conservation in a GIS model right at the strategic planning stage in order to identify potential areas for the expansion of wind energy that are compatible with nature and landscape. This is the first time that a method has been developed that can map the complex evaluation factors for assessing the nature and landscape compatibility of sites used for wind energy at a national level in spatially differentiated, GIS-supported scenarios, before detailed regional land use planning. The study, carried out for wind energy as an example, can also be applied to other renewable energies.

Conflicts with nature and species protection

The fundamentally new aspect of the method is the evaluation of the possible intensity of negative impacts on landscape quality in relation to wind power. Similarly, the assessment of the conflict risks with nature and species protection has been carried out for the entire country in a GIS model at an area and site-specific resolution that was previously impossible.

The starting point for the geographical evaluation is a new comprehensive catalogue of land categories available in GIS applications which are used as indicators for the spatially-determined type and intensity of potential conflict risks with nature, species and landscape interests. The catalogue reflects abiotic and biotic natural resources as well as landscape aesthetics and recreational value. These land categories were derived from the data on the features

of the area, land use and protected areas available for the whole of Germany. The R&E project collated, standardised and edited these data. In a consultative process with experts, 27 land categories were selected and a joint decision taken as to which protection factors and associated conflicts were to be represented. It was apparent that some land categories could represent several protection factors and therefore the associated potential conflicts.

The land categories used as indicators identify such factors as potential conflicts with species sensitive to wind power and go beyond the land categories e.g. nature conservation areas used to determine land potentials for wind energy in previous studies. Factors taken into account include ancient woodlands, permanent grassland, open spaces used for agriculture and FFH sites, Important Bird Areas and the areas adjoining them. A natural resource evaluation of the conflict risks for each of these land categories, e.g. construction and operation disturbances of specific bird species, mortality of bird species sensitive to collisions, degradation or alteration of biotopes and construction-related compaction of fragile soils. Finally, every land category has an ordinal ranking of the conflict risks they represent for both the individual natural resources and general features, covering five classes from very low to very high.

Land categories for conflicts with landscape conservation

The general features mean that the GIS model includes 24 additional land categories that represent the interests of landscape conservation. Evaluating the natural resource of landscape therefore includes aspects of diversity, distinctiveness, beauty, recreational value and naturalness – attributes that are recorded using standardised criteria and indicators, and integrated in the GIS-supported model of landscape evaluation. The analysis is based on a pilot study of the perception and evaluation of wind turbines in "representative landscapes" and the "Antizipativ-iterative Geo-Indikatoren-Landschaftspräferenzmodells (AIGILaP)" (anticipative-iterative landscape preference model geo indicators) derived from this. The R&D project takes account of e.g. the diversity of physical relief and areas that are not, little or highly exposed – e.g. ridges – and the increased visibility of the wind turbines that might be installed there.

ATTRIBUTE	CRITERION	INDICATOR
Diversity	▪ Diversity of use ▪ Diversity of physical relief	▪ Number of different use categories per unit area (1 x 1 km) ▪ Terrain Ruggedness Index (TRI)
Distinctiveness	▪ Distinctiveness of land use distribution ▪ Historic continuity	▪ Divergence of use distribution of a unit of land (1 x 1 km) from the use distribution of the associated cultural landscape type ▪ Rating of landscape change since 1996
Beauty		Presence of conservation areas (biosphere reserve, natural parks, landscape conservation area)
Recreational value	Potential suitability for recreation for a) Local recreation b) Distant recreation	▪ Diversity, distinctiveness, beauty and naturalness ▪ Distance to settlements ▪ Presence of protected areas (national park, nature park, biosphere reserve, German Green Belt)
Naturalness	▪ Perceived naturalness a) of land use b) in protected areas ▪ Presence of disturbance	▪ Perceived naturalness of use types ▪ Presence of protected areas (Fauna and Flora Habitat, European Bird Protection areas, nature reserves, national parks) ▪ Acoustic and visual disturbances

Evaluation of different expansion scenarios

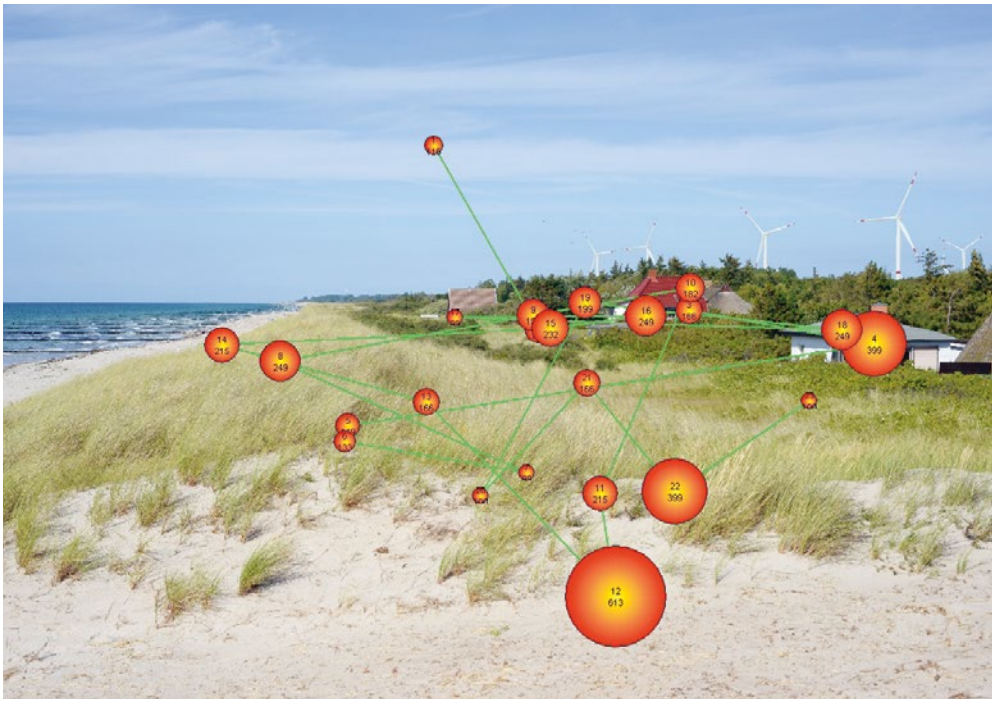
The spatial differentiation of conflict risks provides the key to a detailed spatial analysis of wind energy from the viewpoint of nature and landscape conservation. The analysis is carried out in a 25 x 25 metre grid. At each point on the grid the GIS model stores the land categories used as indicators for nature and landscape conservation interests that apply there and the conflict risk classes they give rise to. It also stores the energy industry background data: the basic suitability as a site for wind turbines, the wind abundance and its proximity to potential consumers.

Using these parameters the project team used the GIS model to produce several scenarios of geographical distribution for the expansion of onshore wind energy. The existing stock of wind turbines was not included in the model. The only fixed criterion for the scenarios is an anticipated reasonable share of the onshore wind energy in the gross energy consumption in 2035. The scenarios vary in the chosen sites for the turbines: Scenario A concentrates the turbines at particularly efficient sites with high amounts of wind (wind abundance); in contrast scenario B is more decentralised and takes account of the proximity to consumers in the site selection.

The GIS model illustrates in detail which and how many sites are occupied with the different nature conservation conflict risks. In addition, the scenarios in the GIS model also allow an alignment to the most nature-compatible distribution by including the nature conservation conflict risks in the site selection. An analysis of the scenarios enables recommendations to be derived for the national distribution of wind energy expansion that can feed into political, strategic and planning decisions at national level. Specific suitable sites cannot and should not be identified at this level at this stage.

Perception psychology study of landscape quality

As “beauty is in the eye of the beholder” and not in the terrain data, the analyses produced by the GIS model AIGILaP were accompanied and checked using a perception psychology study on the perception and evaluation of wind turbines. The pilot study comprised an online survey of the public and an eye-tracking experiment in-



Scenario A “efficiency”
Number of turbines: 18,040
Target quantity of energy: 269 TWh
Average conflict risk per turbine: 4.43
Total conflict risk: 79,995

Scenario B* “Nature conservation / efficiency / proximity to consumption”
Number of turbines: 23,788
Target quantity of energy: 269 TWh
Average conflict risk per turbine: 3.04
Total conflict risk: 72,326

Statements on the perception of the landscape can support planning processes even in the early stages. The eye tracking shows the key areas of perceptions: the upper number indicates the sequence, the lower one the fixation time in milliseconds.

cluding a qualitative public opinion poll on the individual perception of selected representative landscapes of relevance in the wind power context. The results – for example, the importance of how noticeable wind turbines are in monotonous landscapes in terms of the sensitivity of a landscape – were used to optimise the GIS model.

The step to planning practice

The step to lower-tier planning practice is covered by the follow-up project "Simulation of the spatial distribution of renewable energy systems in sample regions: impacts of the expansion of renewable energies on nature and landscape." The project, running from 2020–2021, analyses the national evaluation results through a comparison with the results of selected regional plans and examines which adaptations are required in order to optimise the GIS model so that the results are more plausible at regional level. The follow-up project can therefore make a contribution to improving the attention to nature conservation interests at the strategic level but also produce a more efficient way of taking account of nature conservation interests at the regional level.

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LINKS

- www.th-owl.de/landschaft
- www.lenne3d.com

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