MANAGING SPATIAL SUSTAINABILITY TRADE-OFFS: THE CASE OF WIND POWER

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Overview

Land-use decisions typically involve spatial sustainability trade-offs, e.g., between economic development and biodiversity conservation (e.g., Polasky et al., 2008). A prominent example is the deployment of wind energy, publicly supported to promote the energy transition and to mitigate climate change. Different sustainability criteria – e.g. the minimization of generation and system integration costs, the mitigation of adverse impacts on human health and ecosystems, distributive justice – may call for different spatial allocations of wind turbines (e.g., Drechsler et al., 2017; Eichhorn et al., 2017).

Against this background, our paper addresses the following overarching 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? Inter alia, we aim to understand whether there is a generally accepted ranking and definition of sustainability criteria to be used in this context. In this respect, we are also interested in the relative importance of arguments of efficiency (minimization of costs or impacts) and distributive justice (distribution of costs or impacts). Our insights are key to inform future renewable energy policy: spatial sustainability trade-offs are becoming ever more important with deployment levels of wind energy rising world-wide.

Methods

In order to analyze decision-making on the spatial allocation of wind power deployment, we developed game, and invited 30 stakeholders from politics, administration, business and science were invited to play the game. We chose a game over simple brainstorming or selection techniques to raise awareness about the complexity of the problem and stimulate the players' search for solutions which have fewer side effects according to their perception (Bots and van Daalen, 2007). The group exercise moreover helped to foster learning amongst stakeholders.

For the game, the stakeholders were divided into five groups. In each group, members of the different stakeholder categories were represented. Groups were asked to discuss and decide on the spatial allocation of wind power generation capacity across federal states in Germany to attain an energy target of 200 terawatt-hours annually. For this purpose, they were provided with information on the maximum generation capacity in each federal state (considering geographical and legal restrictions). In addition, they received state-level information on four sustainability criteria to be considered when taking their decisions: generation costs (measured by the state average of full-load hours as an indicator for the productivity of wind energy per installed capacity), system integration costs (measured by total state demand for electricity as an indicator for grid expansion cost), nature and landscape conservation (measured by relative shares of a combined indicator for the ecological and landscape conflict risk for the state), and distributive justice (deliberatively specified only vaguely). At first, a green field approach was applied and hence no information on the installed capacity of onshore wind power in each state was given. Information on the current level of wind power capacity for every state was then disclosed at a later point in time.

During the game, we were able to collect three types of data from each of the five groups: quantitative data on the chosen spatial allocations, reported rankings of the different sustainability criteria and qualitative data providing explanations for the distribution decision of the wind energy plants derived from the discussions during the game and the reflexive discussions afterwards. Quantitative data were further processed statistically to identify correlations with specific sustainability criteria. Discussions were transcribed to make them accessible for qualitative content analysis.

Results

Overall, the game led to heterogeneous group outcomes. While all groups assigned significantly positive deployment levels to the different federal states (minimum 3 Gigawatts per state), the actual levels differed distinctly between groups. In fact, the group ranges for capacities installed in individual states varied by 2-7 Gigawatts (amounting to up to 30% of the maximum potential capacity in some states).

A deeper look into the quantitative and qualitative data reveals that these observed variations can be explained by differences in the ranking of sustainability criteria across groups. The most decisive trade-off played out between the minimization of generation costs (calling for more capacity in the states with higher full-load-hours in the north of Germany) and the minimization of system integration costs (calling for more capacity in proximity to the demand centers in the south of Germany). A large degree of the variation across groups can be attributed to different rankings of these two criteria. In contrast, the nature and landscape conservation indicator played a minor role for the group outcomes. Most groups argued that this criterion cannot be considered meaningfully for the allocation of capacity across states, given that it is based solely on an aggregated state-level indicator (ecological and landscape conflict risks). Instead, nature and landscape aspects would need to be considered primarily when siting decisions are taken at the local level. Distributive justice was highlighted as an important criterion by all groups. Interestingly, however, three different concepts of distributive justice were used to different extents by the groups: equal distribution in absolute terms (same amount of capacity installed per state), distribution following a principle of equivalence (states with higher electricity demand should install more), and distribution following a principle of ability-to-pay (states with higher maximum potential capacity should install more). Hence, groups disagreed both on the ranking of sustainability criteria as well as on their precise definition and measurement.

Moreover, different opinions among groups were also related to the underlying assumptions about the future development of complementary infrastructures (grids, storage and demand, generation from other renewable and non-renewable energy sources). These aspects may also determine which spatial allocation of wind power generation is sustainable in the long-run. However, they were not addressed systematically within the game. Yet, group discussions revealed different expectations and consequently varying spatial choices.

Conclusions

The spatial allocations chosen by the groups partly varied both from the current allocation of wind power generation in Germany as well as from longer-term targets chosen by German federal states. Certainly, this deviation needs to be interpreted with care. On the one hand, it may point to the fact that so far, state decisions on wind power development have not only been driven by the selected sustainability considerations. In fact, state policy choices may at least partly be driven by the ability to externalize some costs of wind power deployment to other states. On the other hand, the deviation between the game outcomes and the real-world allocation may also be explained by the very fact that there is disagreement on the ranking of sustainability criteria between the experts joining the game and actual policy-makers.

Disagreement on the rankings of sustainability criteria strengthens the case for inclusive decision-making processes, e.g. multi-level and participatory governance approaches. In this context, it further illustrates the importance of transparency regarding both the selection and raking of sustainability criteria that underlie political decision making on wind power development. On a higher level, the diverging group outcomes and rankings of sustainability criteria also show that agreement on a centralized planning decision for wind power deployment in each state does not exist. Hence, coordination with and between federal states is necessary to sustainably reach national expansion targets.

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