THE OPPORTUNITY COSTS OF ENVIRONMENTAL EXCLUSION ZONES FOR RENEWABLE ENERGY DEPLOYMENT

Paul Lehmann, Leipzig University, Faculty of Economics and Management Science,
Ritterstraße 12, 04109 Leipzig, Germany
Helmholtz Centre for Environmental Research – UFZ, Department of Economics,
Permoserstraße 15, 04318 Leipzig, Germany
Phone: +49 341 9733614, E-mail: lehmann@wifa.uni-leipzig.de

Philip Tafarte, Leipzig University, Faculty of Economics and Management Science

Overview

Exclusion zones are the most common policy instrument to address environmental impacts of human land-use. With the rising use of renewable energy sources (RES), such land-use restrictions have also been increasingly used to steer the deployment of wind parks and solar photovoltaic (PV) systems towards areas and sites with lower impacts on local residents and wildlife. A prominent example of environmental exclusion zones are setback distances for wind turbines which aim at reducing local disamenities for residents living nearby, such as noise emissions, shadowing, or losses in landscape aesthetic quality. They are in place in many European countries, the United States, and Canada (Aidun et al., 2021; Dalla Longa et al., 2018; Watson et al., 2012). Other types of environmental exclusion zones ban RES deployment on sites which are considered as ecologically valuable and vulnerable, such as forests or peatlands, or as particularly scenic (Bunzel et al., 2019; Cowell and de Laurentis, 2021). All these instruments have in common that they exclude deployment in legally defined zones, and allow for deployment elsewhere.

In terms of efficiency, environmental exclusion zones are ambiguous. On the one hand, they may generate benefits by reducing the externalities of RES deployment, e.g. on wildlife or residents living next to installations. However, environmental exclusion zones also bring about opportunity costs. They may shift RES deployment to sites with higher market and non-market costs (other than the ones addressed by the exclusion zone). For example, implementing setback distances to settlements may help reduce disamenities for local residents. However, they may also imply that generation costs increase (if less windy sites have to be used), and that impacts on wildlife are aggravated (if the abundance of wildlife increases with the distance to settlements). This paper aims to understand and quantify the drivers determining the opportunity costs related to environmental exclusion zones for RES deployment more thoroughly. While several previous studies quantify opportunity costs of environmental exclusion zones (e.g., Delafield et al., 2023; McKenna et al., 2021; Salomon et al., 2020), the underlying drivers are still poorly understood.

Method

We analyze a setting in which environmental exclusion zones are implemented on top of a tender scheme promoting RES deployment. Tender schemes are currently the most prominent RES policy worldwide (Grashof, 2021). They basically imply that sites for RES deployment are chosen to minimize generation costs for a politically set RES generation target. We first use a simple analytical model to understand drivers of opportunity costs of environmental exclusion zones. Subsequently, we also provide a numerical illustration for the opportunity costs of environmental exclusion zones which are implemented for wind power deployment in Germany. The numerical illustration builds on a spatially explicit optimization model using GIS data for more than 100,000 potential wind turbine sites in Germany. Using this model, we analyze the opportunity costs of two types of environmental exclusion zones: setback distances to settlements and forest bans. Our model allows us to determine opportunity costs in terms of both market costs (generation costs) as well as a variety of non-market costs (local disamenities, impacts on landscape aesthetic quality, impacts on wind power-sensitive birds as well as impacts on general ecological conflict risks).

Results

Using our analytical model, we suggest that opportunity costs of environmental exclusion zones can be decomposed into a substitution effect and an output effect. The substitution effect arises because adopting an exclusion zone shifts deployment from excluded to allowable sites. This substitution effect will be positive (increasing opportunity costs) if allowable sites chosen under a tender scheme have higher marginal costs, and negative otherwise. We show that a particularly strong positive substitution effect can be expected if marginal costs are very heterogeneous in space, and if they are negatively correlated in space with the exclusion zone and RES productivity. In addition, an output effect arises. If environmental exclusion zones exclude relatively productive RES sites, more sites will be required to attain the RES generation target. We show that the output effect is strictly positive and increases with spatial heterogeneity in RES productivity, spatial correlation between RES productivity and the exclusion zone, the stringency of the exclusion zone, and the ambition of the RES generation target.

Our numerical analysis reveals that opportunity costs in terms of higher generation costs are relatively small for most exclusion zone scenarios studied. This is primarily due to the fact that the output effect is small and the substitution effect is absent for this cost criterion. Our numerical simulation yields the most substantial opportunity cost effects for non-market costs. We find that the disamenity costs of attaining a wind power generation target are reduced (i.e., opportunity costs are negative) if moderate setback distances are adopted, as one may expect. In these cases, the positive output effect is more than offset by a negative substitution effect. Interestingly, though, very restrictive setbacks may produce overall positive opportunity costs, i.e. increase the disamenities of a attaining a generation target. This is because the output effect becomes extremely large, and sometimes even the substitution effect turns positive. This result thus stands in sharp contrast with the objective of mitigating disamenities which policy-makers usually pursue by implementing setback distances. Moreover, very restrictive setbacks also produce opportunity costs in terms of higher impacts on nature and landscape conservation. With respect to forest bans, our analysis highlights substantial opportunity costs in terms of higher disamenities. These are particularly high if wind power deployment is excluded from all forests. Finally, we find that both setback distances and forest bans may reduce the spatial generation potential for wind power deployment significantly. Overall, our analysis thus suggests that opportunity costs of environmental exclusion zones may be substantial and have to be balanced carefully with expected benefits from applying this policy instrument.

Conclusions

Our analysis does not mean to dismiss environmental exclusion zones in general. Instead, it emphasizes the importance to properly understand possible opportunity costs (e.g., higher disamenity costs due to forest bans), and compare them with possible benefits (e.g., protection of ecosystem services provided by forests) when implementing exclusion zones. Interestingly, however, our analysis also reveals a case where an environmental exclusion zone appears to be an inappropriate instrument of environmental policy. Very restrictive setback distances may in fact increase the total disamenity costs produced by wind power deployment – contrary to the policy objective pursued by this instrument. In addition, our analysis points towards using more differentiated exclusion zone approaches, – e.g., setback distances differentiating between the size of settlements, or forest bans differentiated by the type of forest. Differentiating exclusion zones may help to attain environmental policy objectives at lower opportunity costs. More generally, our analysis may also strengthen the case for using alternative policy instruments to exclusion zones to mitigate environmental impacts of human land-use. Alternatives may include permitting processes which carry out environmental impact assessments for each site individually – or market-based approaches which internalize non-market costs and benefits of siting decisions by respective pricing schemes. Analyzing how such policy instruments compare to environmental exclusion zones may be a promising avenue for further research. Certainly, such comparative assessment will also have factor in that such policy instruments may be much more cumbersome to implement administratively than simpler environmental exclusion zones.

References

Aidun, H., Marsh, K., McKee, N., Welch, M., 2021. Opposition to renewable energy facilities in the United States. Sabin Center For Climate Change Law, Columbia Law School, New York.

Bunzel, K., Bovet, J., Thrän, D., Eichhorn, M., 2019. Hidden outlaws in the forest? A legal and spatial analysis of onshore wind energy in Germany. Energy Research & Social Science 55, 14-25.

Cowell, R., de Laurentis, C., 2021. Understanding the effects of spatial planning on the deployment of on-shore wind power: insights from Italy and the UK. Journal of Environmental Planning and Management, DOI: 10.1080/09640568.09642021.01987866.

Dalla Longa, F., Kober, T., Badger, J., Volker, P., Hoyer-Klick, C., Hidalgo, I., Medarac, H., Nijs, W., Politis, S., Tarvydas, D., Zucker, A., 2018. Wind potentials for EU and neighbouring countries: Input datasets for the JRC-EU-TIMES Model. Publications Office of the European Union, Luxembourg.

Delafield, G., Smith, G.S., Day, B., Holland, R., Lovett, A., 2023. The Financial and Environmental Consequences of Renewable Energy Exclusion Zones. Environ. Resource Econ., https://doi.org/10.1007/s10640-022-00749-z.

Grashof, K., 2021. Who put the hammer in the toolbox? Explaining the emergence of renewable energy auctions as a globally dominant policy instrument. Energy Research & Social Science 73, Article 101917.

McKenna, R., Weinand, J.M., Mulalic, I., Petrovic, S., Mainzer, K., Preis, T., Moat, H.S., 2021. Scenicness assessment of onshore wind sites with geotagged photographs and impacts on approval and cost-efficiency. Nature Energy, https://doi.org/10.1038/s41560-41021-00842-41565.

Salomon, H., Drechsler, M., Reutter, F., 2020. Minimum distances for wind turbines: A robustness analysis of policies for a sustainable wind power deployment. Energ. Policy 140, 111431.

Watson, I., Betts, S., Rapaport, E., 2012. Determining appropriate wind turbine setback distances: Perspectives from municipal planners in the Canadian provinces of Nova Scotia, Ontario, and Quebec. Energ. Policy 41, 782-789.