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Effects of spatial proximity to proposed high-voltage transmission lines: Evidence from a natural experiment in Lower Saxony

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ABSTRACT

Governments and energy operators are frequently confronted with opposition to the construction of new energy infrastructure and a lack of public support. This is also true for the planning of new high-voltage overhead transmission lines. In this context, a question of interest for policy makers and energy operators is how residents react when they realize that they may be affected by future transmission lines in close proximity to their homes. This study provides evidence of how local residents respond to the announcement of transmission line corridor route alternatives (TLCRAs). By means of a natural experiment, it estimates the causal effects of spatial proximity to proposed TLCRAs during the planning phase of an energy project. The results reveal that proximity significantly enhanced residents' risk perceptions with respect to landscape deterioration, property/house value reduction, and damages to human health. We also found that increasing proximity decreased residents' support for grid expansion and increased the likelihood of performing information seeking behavior and becoming a member of a local citizens' initiative. Finally, our findings suggest that the relationship between spatial proximity and the dependent variables are appropriately modeled by a distance decay function, showing that effects attenuate with increasing distance from the infrastructure site.

1. Introduction

In order to ensure a secure energy supply and to increase the share of renewable energy, new infrastructure for energy extraction, generation, storage, and distribution has to be constructed on a regular basis. Yet policy makers and energy operators frequently face problems when planning and operating new energy infrastructure, two of which are opposition to energy projects and a lack of support for them among the population. Previous research has already investigated the drivers of public support and opposition with regard to different types of energy infrastructure, such as wind farms (e.g., Devine-Wright and Howes, 2010; Wolsink, 2007; Warren et al., 2005); nuclear, gas, and coal-fired power plants (e.g., Ansolabehere and Konisky, 2009, 2014; Withfield et al., 2009); oil pipelines (e.g., Gravelle and Lachapelle, 2015); and high-voltage power lines (e.g., Devine-Wright, 2012; Soini et al., 2011).

One potential determinant of public support for and opposition to planned or operated energy infrastructure is persons' spatial proximity to them. The so-called 'proximity hypothesis' states that the closer people live to a controversial facility, the more likely it is that they will oppose it (Dear, 1992). Earlier studies have tested this hypothesis with respect to different kinds of energy technology. Some found negative proximity effects on residents' attitudes and perceptions (e.g., Warren et al., 2005; Swofford and Slattery, 2010; Johansson and Laike, 2007; Weiner et al., 2013) while others found positive or no effects at all (e.g., Gravelle and Lachapelle, 2015; Warren et al., 2005; Greenberg, 2009; Michaud et al., 2008; Priestley and Evans, 1996). Taken together, the evidence about the direction of proximity effects is unclear. Explanations for this variation in effects include the specific externalities of different types of energy technology (e.g., Ansolabehere and Konisky, 2009; Owen, 2006); site-specific economic, social, or geographic attributes; the stage of development of an energy project (e.g., Van der Horst, 2007; Warren et al., 2005); or project-specific implementation and participation policies (e.g., Devine-Wright, 2014).

In this study, we test the proximity hypothesis by using the example of power grid expansion, which is a necessary measure for the transition to low-carbon energy systems (e.g., Strunz, 2014). We believe this hypothesis may be applicable also in the context of planning new high-voltage transmission lines. A recent survey (forsa survey EEHH 2016[1]) found that almost half of Germans oppose plans to build transmission

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[1] Results can be downloaded at http://www.erneuerbare-energien-hamburg.de/de/service/downloads.html?page_c27=3&file=files/eehh-website/upload/eehh/general/downloads/public/sonstiges/Ergebnisse%20forsa-Umfrage%20EEHH%202016.pdf (last visit: July 4, 2017).

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lines close to their homes, suggesting that there is the potential for active opposition to arise when new transmission lines are planned in close proximity to residents' homes. Moreover, the energy project we investigate in this study was in the planning stage of development when the data was collected. It has been suggested that proximity to (proposed) energy infrastructure may lead to strong responses by local residents particularly within this stage (Van der Horst, 2007). Additionally, the geographic distribution of costs and benefits of energy infrastructure is suggested to play a crucial role for public perceptions of energy technologies and opposition to them (Gravelle and Lachapelle, 2015; Cohen et al., 2016; Van der Horst, 2007). These costs and benefits are oftentimes unequally distributed across different distance from infrastructure sites (e.g., Schively, 2007; Van der Horst, 2007). In case of transmission lines, societal costs and benefits of grid expansion are usually widely dispersed, whereas some specific costs like property/house value reductions occur only at the local level. Finally, as regards physical impacts, "proximity to energy infrastructure increases the likelihood of having contact with its negative aspects (such as sights or sounds) or its health or environmental hazards" (Gravelle and Lachapelle, 2015, p. 101), which is also true for power lines.

In sum, all of these reasons speak in favor of applying the proximity hypothesis in the context of transmission line siting. In this study, we investigate how spatial distance to proposed transmission line corridor route alternatives (TLCRAs) of a grid expansion project in Northern Germany affects local residents' risk perceptions, their public support for grid expansion, and specific kinds of behavior.[2] Although exact power line routes are not defined at the stage of planning of the energy project under study, TLCRAs were proposed and the spatial affectedness of local residents was on the horizon. Our study estimates causal proximity effects by means of a natural experiment. We are thus capable of providing relatively strong evidence of how residents feel and behave when they realize that grid extension may directly affect them. Because research on proximity effects in the context of transmission lines is sparse, our study contributes to filling an existing gap in the literature.

Our article is organized as follows. First, we present our theoretical approach and formulate research propositions. Subsequently, we present information about the setting in which the data of our study were collected and describe our research design and the methods used. Finally, we present and discuss the results as well as the limitations and implications of our findings.

2. Theory and research propositions

When investigating proximity effects in the context of energy infrastructure placement, one should be aware of the fact that proximity to energy infrastructure is not merely a measure of spatial distance but serves as a proxy for different physical, economic, and social processes. In this section, we discuss this issue, present our research propositions, and outline our approach for modeling the relationship between spatial proximity and the dependent variables.

2.1. Spatial proximity as a proxy variable

First of all, investigating the effects of proximity to existing or planned energy infrastructure means investigating physical aspects like sounds/noise, visual impacts/sights, impacts on vegetation and wildlife, and (electromagnetic) radiation (e.g., Sumper et al., 2010; Furby et al., 1988). In the case of transmission lines these physical impacts are usually most severe in close proximity to the energy site and attenuate with distance from them, which is why spatial proximity serves as a proxy for them. Furthermore, spatial proximity to energy infrastructure can be used as a proxy for the economic impacts of the energy infrastructure (e.g., Van der Horst, 2007). For example, as Gravelle and Lachapelle (2015) point out, the construction of the Keystone XL pipeline was expected to create economic benefits at the local community level by generating construction jobs. In the case of transmission lines, economic costs for local residents may occur in form of property/house value reductions very close to the infrastructure site and, again, attenuate with increasing distance (e.g., Jackson and Pitts, 2010). Both the physical and the economic impacts of energy technologies are in turn major determinants of residents' risk perceptions. Therefore, spatial proximity not only serves as a proxy for physical and economic impacts but also for residents' perceived risks (Van der Horst, 2007), which are often more important in terms of public opposition than actual risks (Cain and Nelson, 2013).

Furthermore, the distance to energy infrastructures serves as a proxy for social processes (Gravelle and Lachapelle, 2015). It has been proposed that not only the physical but also the 'social distance' to infrastructure facilities may play an important role in explaining public perceptions to energy projects (Devine-Wright, 2005). Following from this idea, social influence measures such as the opinions of significant others (e.g., family and friends), social networks (e.g., local environment and animal protection associations), the local media, and the activities of local authorities might affect residents' personal salience of an energy project and hence their perceptions of it (Devine-Wright, 2005). Moreover, attitudes toward energy technologies are shaped by prevailing social norms (Cain and Nelson, 2013; Huijts et al., 2012). Thus, residents' attitudes and behaviors are likely to be influenced by what they believe is accepted by others within their community.

There is some evidence that all of these social processes are correlated with spatial proximity to an energy infrastructure. For example, it is argued that increased media coverage of events is related to the spatial proximity to these events, which may lead to an increased awareness by media viewers of the environmental risks of an energy infrastructure in close proximity to the facility (Gravelle and Lachapelle, 2015). Moreover, the activities of local authorities are oftentimes very intense and visible in areas close to planned facilities, which may also increase residents' awareness of the issue. An enhanced awareness of energy projects in areas close to the project site may further lead to increased social interactions among residents, for example in the context of events, social networks, local action groups, or simple everyday conversations. Such social interactions may not only directly stimulate the development of perceptions, attitudes, and behaviors, but also indirectly in that they reinforce or change prevailing social norms regarding the energy project. Yet it is unclear whether social processes support or oppose the proximity hypothesis. We believe that either is possible, depending on whether local media reports are benevolent or critical about the planned project, whether local authorities support or oppose the project (e.g., Battaglini et al., 2012), and on the dynamics of social interactions among residents.

Finally, the concept of 'place attachment' (Devine-Wright, 2009; Devine-Wright and Howes, 2010) states that "residents of a given community become attached to a place and its landscape characteristics, which in turn becomes part of the identity of residents. This creates a key link between individual perception and social interaction: a person's "sense of place" is determined in large part by the meaning a community attaches to a particular place" (Cain and Nelson, 2013, p. 207). In case of transmission line siting, residents living in close proximity to the planned facility are thus presumably more likely to oppose the project in order to prevent disruptions to sense of place than residents living farther away. Therefore, we consider spatial proximity also as a proxy variable covering the impacts of residents' place attachment.

[2] In the course of our research, we also investigated proximity effects on three additional variables, namely 'being informed about grid expansion', 'perceived subjective affectedness', and 'awareness level'. The according effect estimates are not included in this article but are available upon request.