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Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany

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ABSTRACT

The rapid expansion of renewable energy sources (RES) in many European countries brings about transmission grid expansion requirements. While the transition towards RES-based energy systems is largely perceived positively in general, locally both RES and grid expansion are often confronted with a lack of public acceptance. Using Germany as a case study, we analyse public acceptance of energy infrastructure and its main drivers on local vs. national levels. For this purpose, we conducted a nationally representative survey. Our results show that, on a national level, the acceptance of RES is very high and there is also a high acceptance of grid expansion if it helps to increase the share of RES in the system. In terms of local acceptance problems that may arise for most considered technologies, concerns about landscape modification turn out to be the main driving factor. Moreover, the distance between places of residence and places of energy infrastructure construction is crucial. While acceptance or rejection of technologies will never be entirely tangible or explicable, we find the explicability of rejections to be lowest for new technologies. Finally, age and education turn out to be the most relevant socio-demographic variables determining the participants' acceptance.

1. Introduction

There is little dissent that greenhouse gas emissions need to be reduced globally to combat climate change and that the decarbonisation of the energy sector is a basic prerequisite in this context [1]. In Europe, emissions are planned to be reduced to 80–95% below 1990 levels by 2050 and the decarbonisation of the energy system shall mainly be realised by energy efficiency achievements and by transforming the current system into a system based on renewable energy sources (RES). In 2050, more than two thirds of gross final European energy consumption shall be provided by RES, with an even higher share for the electricity system [2]. While the public's general attitude towards most RES technologies and RES-based energy systems is rather positive according to different surveys (e.g., [3,4]), the rapid expansion of RES in many European countries brings about local challenges concerning acceptance. On the one hand, the continuous displacement of conventional power generation through RES technologies periodically leads to local acceptance problems (see e.g., [5–8]) in spite of the positive attitude towards RES-based systems on a higher level (see e.g., [3,9,10]). On the other hand, since many of these new power generating facilities will be located far from the load centres (in particular new wind parks), an expansion of the transmission grid is necessary to meet the resulting transport capacity requirements. Grid expansion projects, however, face acceptance problems too (see e.g., [11–14]). Because of such recent experiences, particularly on a local level, it has been suggested increasingly often to consider public acceptance as a new key dimension of energy policy (see e.g., [1,15–17]). In a nutshell, the understanding as well as consideration of acceptance are undoubtedly key for energy planning. Moreover, the level of public support and acceptance seems to decrease with decreasing abstraction – from global emission reduction and decarbonisation goals over national and regional energy policy directions (e.g., towards RES-based energy systems) to the local

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implementation and expansion of RES and grid technologies.

Overall, we are therefore interested in understanding how well the energy transition is accepted on different levels of abstraction, on which level acceptance problems begin to arise and what the main drivers for people's attitudes are on these different levels. We particularly seek to answer the following research questions:

1. To which extent is the energy transition as a whole supported and how much do people agree with the overall direction of RES energy policies?
2. How does the acceptance of power systems on a national level differ from the local acceptance of individual power technologies?
3. What are the main factors driving local acceptance of energy technologies?
4. How does the subjective overall valuation of technologies differ from subjective impact assessment of these technologies w.r.t. tangible criteria, and how do these differences vary across technologies?
5. How strongly should different objectives be weighted in decisions related to national or local energy policy, and how important do people rate their subjective valuation/acceptance in comparison to traditional objectives of energy policy, namely economic impact, environmental sustainability and security of supply?
6. To which extent are the answers to the above questions related and are they related to socio-demographic characteristics?

There are many studies focussing on the acceptance of different energy technologies. Several authors have conceptually studied and defined acceptance in relation to energy technologies [3,8,13,18–20]. Further details are provided in Section 2.1. Moreover, the acceptance of RES as a whole has been analysed in literature [7,21]. Focussing on individual technologies, Van der Horst [4], Guo et al. [6], Bell et al. [10] and Wolsink [22] studied the acceptance of wind energy whereas Battaglini et al. [11], Devine-Wright [13], Ciupuliga & Cuppen [14] and Cotton & Devine-Wright [23] study the acceptance of grid infrastructure. Moreover, Devine-Wright [5] analyses the acceptance of a tidal wave energy project and Gross [24] investigates the acceptance related to geothermal energy. We wish to note that the acceptance of energy technologies is a field with a large and fast growing literature. Therefore, the above selection of related work cannot be comprehensive and is, to some extent, subjective of course. While the research referred to above provides detailed and valuable insights on the acceptance of individual energy technologies, our focus is on understanding acceptance and its drivers across technologies and scales – inevitably leading to a loss in detail in relation to individual technologies. Scheer et al. [25] emphasise that considering individual technologies is not sufficient for designing and implementing future energy policies and promote an approach based on generation portfolios. While we are supportive of this statement, we extend their approach in our research, inter alia, by adding a perspective on power grid expansion and infrastructure technologies since the grid and its expansion play a crucial role in future RES-based energy systems as outlined above.

With their ongoing energy transition to RES, Germany provides a particularly good use case to analyse these questions [26]. According to the German Renewable Energy Sources Act ("Erneuerbare-Energien-Gesetz", EEG), the RES share of gross electricity generation shall amount to at least 80% by 2050. In order to meet this target, a large amount of additional RES generators, in particular wind turbines and photovoltaic (PV) modules, will need to be integrated into the existing power system and, as a result, the power grid capacities will need to be increased strongly. We therefore conducted a large nationally-representative online survey in Germany to find answers to the research questions set out above.

The remainder of this paper is structured as follows. In Section 2, we define public acceptance for this paper in order to avoid ambiguity (Section 2.1). Moreover, we provide a brief summary of the survey design and structure (Section 2.2) and an overview of the methods used for our analysis (Section 2.3). In Section 3, we present the results. In Section 4, we discuss and interpret the results before we conclude the paper in Section 5. Appendix 1 provides further details concerning the structure and questions of the survey.

2. Material and methods

While it seems to be a common understanding that a lack of public acceptance may hinder RES as well as grid expansion, the term acceptance is used in a wide variety of circumstances. Because the specific understanding and interpretation of the term strongly affects the choice and design of methods for its elicitation, we first seek to define and delimit our usage of the term within this paper (Section 2.1). Subsequently, we describe the survey design and structure (Section 2.2) before providing a short overview of the methods we make use of in our analysis, including a brief selection of preference elicitation methods from the field of multi-criteria decision analysis (MCDA, Section 2.3).

2.1. The term acceptance

On a general level, acceptance can be understood as an active or passive approval of a certain technology/product or policy. Different sub-categories of acceptance have been introduced in literature. For instance, Wüstenhagen et al. [3] distinguish between socio-political acceptance (social acceptance on the broadest level), community acceptance (particularly referring to siting decisions of energy projects involving local authorities and residents) and market acceptance (closely related to the market adoption of innovations or products). Schweizer-Ries [19] differentiates between a *valuation* dimension (adoption vs. rejection) and an *action* dimension (passive vs. active) resulting in four quadrants in her acceptance model. For instance, a positive valuation may be expressed through either active or passive acceptance/behaviour. Focussing on technology acceptance, Schumann [20] distinguishes between different forms depending on the type of technology under consideration. For "product and everyday technology", acceptance is disclosed by (active) purchasing behaviour. This type of acceptance partly corresponds to the market acceptance described by Wüstenhagen et al. [3]. For "work technology", the active use of a technology or product (e.g., software technology) by the employees of a company reveals its acceptance. For both "product and everyday technology" as well as "work technology", acceptance is shown by an active behaviour. For large-scale technologies, including most energy technologies, the passive approval or tolerance of those concerned (e.g., as they live in the area) imply the acceptance according to Schumann [20], whereas it is not necessary for those concerned to become active or to have a positive attitude towards the technology. While the definition by Schumann [20] is in line with that by Schweizer-Ries [19] in that acceptance may include passive as well as active behaviour, it differs in that Schweizer-Ries [19] does not consider a negative attitude with a passive behaviour as acceptance. While for large-scale energy technologies, an active approval is often not easily possible for "normal" citizens, this topic has also been a subject of research in individual studies (see for instance Hampl & Wüstenhagen [27],