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Austria's wind energy potential – A participatory modeling approach to assess socio-political and market acceptance

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HIGHLIGHTS

- Including social barriers could reduce Austria's wind potential from 92.78 to 3.89 TWh
- Costs for attaining a 20% wind energy share vary by 20% between the scenarios
- Socially acceptable wind area potential ranges from 0.1 to 3.9% of Austria's total area
- Excluding forest areas lowers the maximum wind energy potential by 45%

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ABSTRACT

Techno-economic assessments confirm the potential of wind energy to contribute to a low carbon bioeconomy. The increasing diffusion of wind energy, however, has turned wind energy acceptance into a significant barrier with respect to the deployment of wind turbines. This article assesses whether, and at what cost, Austrian renewable energy targets can be met under different expansion scenarios considering the socio-political and market acceptance of wind energy. Land-use scenarios have been defined in a participatory modeling approach with stakeholders from various interest groups. We calculated the levelized cost of electricity (LCOE) for all of the potential wind turbine sites, which we used to generate wind energy supply curves. The results show that wind energy production could be expanded to 20% of the final end energy demand in three out of four scenarios. However, more restrictive criteria increase LCOE by up to 20%. In contrast to common views that see local opposition against wind projects as the main barrier for wind power expansion, our participatory modeling approach indicates that even on the level of key stakeholders, the future possible contribution of wind energy to Austrian renewable energy targets reaches from almost no further expansion to very high shares of wind energy.

1. Introduction

In recent years, several studies have explored wind energy potentials at different scales: global (Hoogwijk et al., 2004; Lu et al., 2009), European (EEA - European Environment Agency, 2009; McKenna et al., 2015; Resch et al., 2008) and national and regional (Gass et al., 2013; Grassi et al., 2012; McKenna et al., 2014; Schallenberg-Rodríguez and Notario-del Pino, 2014; Winkelmeier et al., 2014). Recent studies on Austrian wind energy potential have assessed the realizable potential until 2030 assuming current policy support schemes and a constant rate of new installations (Winkelmeier et al., 2014) and the optimal level of feed in-tariffs for attaining renewable energy targets for wind (Gass et al., 2013). All of these studies conclude that the technical wind energy potential exceeds the current electricity consumption. Thus, the potential contribution of wind energy to a renewable low carbon energy system will not be limited by its physical availability, but by ecological, spatial and social restrictions and the amount of intermittent wind generation that can be economically integrated into the power system.

In Austria, wind energy contributed to approximately 6% (3.64 TWh) of the electricity demand in 2014 (E-Control Austria, 2014; OeMAG, 2015). The eco-electricity act of 2012 defined a goal of 6 TWh wind production in 2020, which is equivalent to approximately 10% of the electricity demand in 2014. For 2030, the

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EU reference scenario for transport, energy and greenhouse gas (ghg) emissions (Capros et al., 2013) projects that Austrian wind energy production could rise to 13.4 TWh. This would equal 17.5% of the electricity consumption in 2014. Wind integration costs are not likely to represent a major barrier to reach this share as previous studies have shown that integration costs remain moderate for wind penetration rates of up to 20% (Georgilakis, 2008). However, at high wind energy shares of 40%, integration costs can reach the same magnitude as generation costs and thus become a major economic barrier to a large-scale deployment of wind energy (Ueckerdt et al., 2013).

The most important limitations to tapping the full technical potential of wind energy are ecological, spatial and social barriers. These restrictions have been considered in previous assessments either by defining suitability factors for certain land use categories or by excluding protected areas. Hoogwijk et al. (2004) excluded nature reserves and defined suitability factors for different land use-categories. McKenna et al. (2014) followed a similar approach – however, additionally, they exclude several protected areas and defined buffer zones to nature reserves and national parks. Previous studies for Austria do not consider variations in the suitability of different land use categories, but only exclude Natura 2000 areas (Gass et al., 2013) or both Natura 2000 areas and protected sites that are listed in the Common Database on Designated Areas (CDDA) (Winkelmeier et al., 2014).

The importance of including social barriers in wind potential assessments is acknowledged by several studies (EEA - European Environment Agency, 2009; Gass et al., 2013; McKenna et al., 2014). However, none of them have considered the opinions and preferences of decision makers and key stakeholders regarding the future development of wind energy. Therefore, the analysis may not be very robust as social barriers may hamper wind energy deployment and constrain techno-economic potentials. Future research should therefore integrate social aspects into spatial explicit analyses of wind power potential (Gass et al., 2013) and account for social barriers and costs (McKenna et al., 2014). A recent assessment for the German federal state of Baden-Württemberg takes into account socio-economic constraints by considering landscape aesthetical aspects (Jäger et al., 2016).

In the 1990s, the social acceptance of wind energy was largely neglected due to the high level of general public support for renewable energies (Wüstenhagen et al., 2007). With the expansion of wind energy, negative externalities such as visual impact, noise and effects on wildlife and ecosystems became much more pronounced (Horbaty et al., 2012). This resulted in growing opposition against specific wind energy projects and a growing recognition of social acceptance in the scientific literature. Several authors have conceptualized the social acceptance of wind energy (Batel et al., 2013; Bidwell, 2013; Horbaty et al., 2012; Sovacool and Lakshmi Ratan, 2012; Wüstenhagen et al., 2007) and renewable energy technologies in general. We follow Wüstenhagen et al. (2007) in their definition of social acceptance. They contributed to clarify the understanding of social acceptance by differentiating between three aspects of social acceptance: socio-political, community and market acceptance.

The focus of this research paper is to assess socio-political and market acceptance, as defined by Wüstenhagen et al. (2007). Community acceptance, which involves issues of procedural and distributional justice and trust are not assessed, as acceptance in those terms can hardly be derived from an assessment on a national scale such as ours. Wüstenhagen et al. (2007) frame socio-political acceptance as the acceptance (or lack of acceptance) of technologies and policies by the public, important stakeholders, and policy makers. The focus of market acceptance is on consumers and investors and includes aspects such as the distribution of costs and benefits (Horbaty et al., 2012). The public, as confirmed by many surveys (Eurobarometer, 2006; Wunderlich and Vohrer, 2012), is generally in favor of wind energy generation (if asked about wind energy in general - and not about particular projects in the neighborhood). However, important stakeholders, e.g., from the environmental sector, partly oppose wind energy due to external effects with respect to birds, bats, wildlife, and visual impact, while other groups, such as wind park developers and operators, have a strong interest in deploying more wind turbines.

In Austria, four out of nine federal states have defined suitability and exclusion zones for wind energy to reduce conflicts with local communities and to create more predictable framework conditions for investors. However, the legal status, applied approaches and criteria to define those zones vary greatly among the federal states. Structurally, political oriented top-down and bottom-up processes are used in the regulatory process for wind turbine installation in Austria; exclusion and suitability zones are defined top-down by the federal states, while the actual designation of areas for the construction of wind turbines is the responsibility of the municipalities. Consultation processes with civil society were organized in the top-down definition of suitability zones, e.g., in Lower Austria, but there is no general, coherent process for defining those zones and, consequently, conflicts arise after definition. Additionally, the economic impact in terms of higher system costs due to different criteria is, in general, not evaluated at that level.

Our specific aim was therefore to empirically employ the concept of social acceptance and to assess, in particular, the socio-political and market acceptance of wind energy in Austria and also to report the economic consequences in terms of installation costs for the whole country. For that purpose, we applied a participatory modeling approach to develop a criteria catalogue that considers techno-economic, environmental and socio-political restrictions. Together with an expert oriented stakeholder group from different fields of interest, we defined spatial and topological restrictions, minimum distances to settlements and infrastructure and the suitability of different protected and forest areas. The results provide a bandwidth for suitable areas for wind energy generation and the corresponding wind energy potentials that are acceptable by key stakeholders and decision makers. The contribution of wind energy to the energy system in 2030 is assessed by assuming a bandwidth for the end energy demand in 2030. Additionally, we calculate the wind energy potential and the costs for attaining renewable energy targets with the existing suitability and exclusion zones that have been defined by the Austrian federal states.

The paper is structured as follows: first, we describe our participatory modeling approach and the data and model that were used to calculate the socio-political and market acceptable wind energy potential. We then present the results with respect to the different area scenarios and identify the key parameters that determine the wind potential. Finally, we discuss the results and highlight major policy implications.

2. Methods

As outlined in the introduction, we frame the analysis of our wind power potentials with the social acceptance concept as proposed by Wüstenhagen et al. (2007). In particular, we focus on socio-political and market acceptance. The first category, i.e. socio political acceptance, is addressed by deriving land availability scenarios in cooperation with stakeholders. Acceptance of the public and important stakeholders is reflected in those scenarios. The second category, i.e. market acceptance, also relies on those scenarios as important market actors defined the availability of land for new projects as fundamental. Additionally, we apply a