



# Hidden repowering potential of non-repowerable onshore wind sites in Germany

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## ABSTRACT

Feed-in tariff funding will cease by 2025 for more than 70% of the currently installed onshore wind turbines in Germany. For many wind turbines, the feasibility of repowering from a regulatory point of view is unknown; that is, a complete replacement of the old wind turbines with new, modern, and more efficient models. In Germany, restrictive regulations regarding the required minimum distances of wind turbines from residential and other protected areas may impede repowering, thereby rendering a site non-repowerable. Many of these wind turbine sites are well-established in terms of their acceptance by the local population. Our analysis shows that the potential of non-repowerable but well-established locations with more efficient technology at the same height is almost twice that of the sites qualified for repowering via higher wind turbines. The latest legislation of the German federal government prescribes minimum distances of 1,000 m between a wind turbine and the nearest residential buildings. This will slow down the expansion of onshore wind energy in Germany and decrease its contribution to climate neutrality. This study quantifies the nationwide effects of restrictive legislative minimum distance regulations on repowering potential by means of a developed geographic information system that utilizes highly detailed settlement structures.

## 1. Introduction

By the end of 2030, the feed-in tariff funding from the German Renewable Energy Sources Act (EEG) will expire for more than 16,000 onshore wind turbines, which equals approximately 22 gigawatt (GW). For more than 70% of these wind turbines, the funding will stop by 2025. In Europe, as many as 61,000 turbines will reach their end of life or feed-in tariff funding by 2030, which equals 73 GW. Accordingly, operators of affected turbines are increasingly facing the decision of whether to further extend the lifetime of a wind turbine or to decommission it. The third option is to repower the wind turbine, which involves a complete replacement of the old wind turbine with a new, modern, and more efficient wind turbine model at the same site.

In some cases, it is economically viable to extend the operational life of an onshore wind turbine (Stetter et al., 2020a). However, this strategy is only temporary and will not drive onshore wind development and contribute significantly to the German energy transition. German policymakers have set a target to produce its nationwide energy from 100% renewable resources by 2050. To date, onshore wind energy has already featured the highest share of renewable energy in Germany (Umweltbundesamt, 2020). To meet the politically agreed energy transition goals, wind energy must supply at least 26.5% of the

electricity generated by 2030. In absolute terms, this equals an annual electricity yield of 150 TWh/a from onshore wind and an installed capacity of up to 75 GW by 2030 in Germany (Gerbert et al., 2018). Onshore wind energy can contribute to this goal by repowering old turbines or new greenfield projects.

However, restrictive regulations regarding the required minimum distances to residential and other areas may impede both expansion types. The latest legislation of the German federal government prescribes a minimum distance of 1000 m between a wind turbine and the nearest residential buildings (Bundesregierung, 2019). Regarding the repowering of old turbines, a non-repowerable site is defined as a wind turbine location that does not comply with current German distance regulations; e.g., it does not maintain the specified minimum distance to settlements. Consequently, an old wind turbine cannot be replaced with a new, modern, and more efficient wind turbine model at the same site. This will particularly affect small-to medium-scale turbines at sites that were built closer to residential areas in the 1990s and the early 2000s.

New greenfield projects are capable to drive expansion targets. This requires identifying green fields that comply with the current German distance regulations. There are two major issues in onshore

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