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Public receptiveness of vertical axis wind turbines

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ABSTRACT

Most of the scholarly focus to date has been on large horizontal axis rather than vertical axis wind turbines. It may be possible to improve the efficiency of vertical axis wind technology by deploying turbines in clusters. There might also be advantages to deploying vertical axis turbines at a smaller scale in urban or suburban areas and in places where the risk of bird damage is highest. Would these features increase public acceptance of new wind turbine installations and possibly open up new areas for wind energy development?

We conducted a public opinion poll in California to examine public receptiveness. We used experimental design to assess the willingness to accept vertical axis turbines in certain urban settings. We find that the visual differences between the vertical and conventional wind turbines did not matter very much in any of the hypothetical settings in which we placed them. However, the prospect of killing fewer birds registered strongly with our survey respondents, though it could be outweighed by concern for cost. We also show that certain segments of the population, particularly those who are more educated, may be open to a more extensive deployment of vertical axis turbines in urban communities.

1. Introduction

The extensive deployment of wind energy in many parts of the world has taught us a great deal about public attitudes towards wind turbines. Public understanding about wind energy in the United States remains superficial (Klick and Smith, 2010). While some members of the public are unalterably opposed to wind turbines for ideological or aesthetic reasons (Devine-Wright, 2004; Padersen and Larsman, 2008; Johansson and Laike, 2007; Ellis et al., 2007), the views of many others depend on various qualifications such as how close the wind farm facility is to their home (Jones and Eiser, 2010; Swofford and Slattery, 2010), its likely impact on birds (Drewitt and Langston, 2006; Smallwood and Thelander, 2008), the level of turbine noise and its impact on health (Bolin et al., 2011; Salt and Kaltenbach, 2011), the perception of shadow flicker (Eltham et al., 2008), the concern for spoiled scenery (Devine-Wright and Howes, 2010), community ownership (Warren and McFadyen, 2010), or perceived need for wind power (Devlin, 2005). Some of these objections have been met by siting wind farms in remote places and away from environmentally sensitive areas, while others have been met by technological advances (e.g. noise reduction). Nonetheless, as new developments may disrupt pre-existing emotional attachments and threaten place-related identity processes (Devine-Wright, 2009; Pasqualetti, 2011), wind farm proposals still encounter many objections from citizens and stakeholder groups, even in places where the majority of citizens are committed to meeting the challenges of climate change (Bell et al., 2005).

Most of the scholarly focus to date has been on large horizontal axis rather than vertical axis wind turbines. Vertical wind turbines have been less popular for various reasons, but especially because they have been less reliable than horizontal axis turbines, and current commercially available versions do not produce as much energy per unit as the horizontal turbines (Gipe, 2004). It may be possible to improve the efficiency of vertical axis wind technology, e.g. by deploying turbines in clusters (Dabiri, 2011). There might also be advantages to deploying vertical axis turbines at a smaller scale in urban or suburban areas and in places where the risk of bird damage is highest. Would these features

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increase public acceptance of new wind turbine installations and possibly open up new areas for wind energy development? The goal of this study is to test these propositions in order to give an old technology a new look, and see whether vertical wind technologies might be an underutilized option.

Our data is drawn from a California sample. California is particularly relevant since it has ambitious state goals for reducing greenhouse gases but at the same time has encountered problems in deploying new wind farms due to public concerns about siting and impact on wildlife. In the sections that follow, we set out some hypotheses about why the public might prefer vertical to horizontal axis turbines and tested them with an experimental public opinion survey design. We also use this experimental design to assess the willingness to accept vertical axis turbines in certain urban settings. In general, we find that the visual differences between the two types of turbines did not matter very much in any of the hypothetical settings in which we placed them. The prospect of killing fewer birds registered strongly with our survey respondents, though it could be outweighed by concern for cost. We also show that certain segments of the population, particularly those who are more educated, may be open to a more extensive deployment of vertical axis turbines in urban communities.

2. Vertical axis wind turbines

In contrast to horizontal axis wind turbines, in which a set of airfoil blades rotate around a horizontal axis like a propeller, vertical axis wind turbines are characterized by blade rotation around an axis perpendicular to the ground. This design obviates the need for a mechanism to orient the turbine in the direction of the oncoming wind, which enables the turbine to function in complex wind conditions such as those that are prevalent close to the built environment. It also facilitates installation of the generator and other components closer to the ground, potentially simplifying operations and maintenance. Current commercially available implementations of the vertical axis design use a simple permanent magnet generator to create electricity, which eliminates the need for a gearbox or other complex mechanical transmission as is found in conventional horizontal axis wind turbines.

The overall simplicity of the vertical axis wind turbine design should present a commercial advantage in terms of cost and the range of wind conditions in which the technology could be deployed. However, the development of vertical axis wind turbines has significantly lagged behind horizontal axis wind turbines since the mid-1980s, when horizontal axis turbines became the industry standard due to their higher efficiency of power conversion and better record of reliability. The past decade has seen a resurgence of interest in the vertical axis wind turbine platform, in part due to new research showing the possibility of improved overall wind farm performance from favorable aerodynamic interactions between closely spaced vertical axis turbines (Dabiri, 2011, 2014; Araya et al., 2014; Brownstein et al., 2016). This is in contrast to the reduced performance of horizontal axis turbines when placed in proximity within a farm (Hau, 2005). The data in Dabiri (2011) support the possibility of increasing the footprint power density from 2 to 3 W/m^2 for horizontal wind turbine farms to 20–30 W/m^2 for vertical wind turbine farms. The number of turbines involved in either scenario is proportional to the individual unit power. Current large horizontal wind turbines are typically 2–3 MW individually, whereas the vertical wind turbines would be 5–50 kW (0.005–0.05 MW) individually. The hub height deficiencies can be compensated by the increase in turbine efficiency due to collective behavior (e.g. Brownstein et al., 2016). In addition, the vertical wind turbine start wind speed is lower than that of the horizontal turbine.

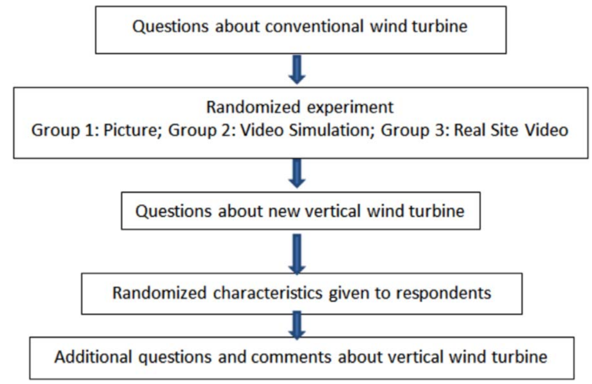

Fig. 1. Research design and embedded experiments.

An increased awareness of avian impacts from horizontal axis wind turbines has also encouraged the exploration of vertical axis wind turbines as a more environmentally-friendly alternative. Indeed, the lower operating speeds of the vertical-axis wind turbine blades, their different visual signature, and their typical implementation at lower heights than horizontal axis wind turbines suggest that they should have a more limited impact on birds and bats. Anecdotal evidence supports this view; however, controlled studies of avian impacts of vertical axis wind turbines have not been conducted to date.

3. Public opinion and technology preferences

Public opinion research has repeatedly shown that there are important limitations in what the public knows and cares about. In the area of economic policy, for instance, voters tend to react more to perceived conditions than to specific arguments about the merits of monetary versus fiscal strategies (Fiorina, 1981; Kinder and Kiewiet, 1981). Or when faced with choices about taxes and expenditures, many people lack the basic facts about which programs are the most expensive or have inconsistent views about what they are willing to pay for the services they believe that the government should provide (Converse, 1962). Hence, one might be skeptical about whether public input is valuable when it comes to choosing between different strategies and technologies for generating more alternative energy.

However, when energy technologies have tangible effects on people's lives or on their immediate environment, public attitudes can be more definitive and strongly held. At the same time, permitting procedures at the state and federal level for new energy facilities have been democratized, giving individual citizens, neighborhood groups, NGOs, and the like many opportunities to weigh in on the decision of whether and how to site new utility-scale thermal, solar, or wind turbine energy facilities. This in effect has given groups organized around specific wildlife causes such as protecting birds the ability to delay or hold up the permitting processes of new wind turbine deployments over possible bird deaths. If this problem is not addressed, it could limit the supply of an important source of alternative energy.

We can divide the determinants of public attitudes about wind turbines into three categories. First, there are factors that do not hinge on any specific features of technical design. These include climate skepticism and partisan polarization. Climate skeptics and those who support fossil fuels for partisan reasons are more likely to be unalterably opposed to new wind facilities, regardless of any new design features or carefully planned siting decisions. Political scientists have