ENERGY POLICIES AND SOCIAL ACCEPTANCE OF SMALL WIND TURBINES

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WIND POWER IS a sustainable source of renewable energy with many benefits, including environmentally benign operation, an ability to generate and provide electricity in remote locations, and reduced fuel dependence. Wind power provides a reliable and competitive energy option, establishes employment opportunities by investing in new technology, and increases the diversity of the energy supply, which therefore contributes to better energy security.

Substantial interest exists for power generation by small wind turbine (SWT) units installed in residential and business zones. SWTs offer several advantages over other sources, such as generating power where it will be consumed, removing or reducing the need for dedicated land, and allowing existing structures to be dual-purposed as support structures (for example, omitting the need for a tower).

Despite extensive technical advances and demonstrated installations, various barriers to social acceptance remain for SWTs. Social acceptance requires three distinct components to be fulfilled: socio-political acceptance, community acceptance and market acceptance (Wüstenhagen et al.). Socio-political acceptance requires broad acceptance with implementation policies for all stakeholders; community acceptance requires local residents and authorities of projects to agree with site decisions; and market acceptance requires participation in the technology implementation by all stakeholders (Wüstenhagen et al.). This article examines social acceptance of SWTs through the alignment of incentives (socio-political acceptance) with community-level barriers to market acceptance. Examining the alignment between socio-political and community acceptance can provide insights into strategies to overcome barriers to market acceptance.

SOCIO-POLITICAL ACCEPTANCE BY FINANCIAL INCENTIVE PROGRAMS

Consider incentive programs to gauge socio-political acceptance of SWTs in Ontario, California and the United Kingdom (UK). Government legislation and incentives that are in line with concerns and barriers that limit increased social acceptance are necessary for additional market acceptance of SWTs. Social and environmental benefits can initiate SWT installations. However, financial incentives and support programs are required to ensure financial viability and market acceptance (Ek).

As a result of the *Green Energy and Green Economy Act*, the microFIT (micro feed-in tariff) Program was created in Ontario for renewable energy projects smaller than 10 kW. Eligible installations are grid connected, use a metering system and do not have a pre-existing Ontario Power Authority contract (excluding Renewable Energy Standard Offer Program contract holders because they can convert their contracts into microFIT contracts) (Ontario Power Authority).

The microFIT program offers 20-year contracts to homeowners, business owners, farmers, institutional managers and private developers at 11.5 cents/kWh for small wind projects. It is scheduled to be reviewed approximately every two years with 20 per cent of the contract price escalating with the Ontario Consumer Price Index. A 2014 target for microFIT procurement is 65.3 MW, which includes the unused capacity in 2013 of 15.3 MW (Ontario Power Authority).

Previously, California had a strong FIT program for SWTs that offered contracts for market-based, time-of-use tariffs that were calculated by the time of delivery and market price reference (California Energy Commission). However, as a result of Senate Bill 1018, the California Energy Commission has stopped the Emerging Renewables Program (California Energy Commission), leaving the federal *Energy Policy Act* of 2005 as the primary financial incentive for SWTs in California. Initially established for solar power and updated to include small wind power in 2008, the *Energy Policy Act* allows 30 per cent of small wind power costs to be claimed for a system that powers a residential unit.

To increase the installed capacity of renewable energy power generation, the UK initiated a feed-in-tariff scheme for most domestic technologies, including SWTs (Energy Saving Trust). Until March 31, 2014, the tariff rate is 22.23 p/kWh for a 20-year time period. Degression of the feed-in-tariff will commence on April 1, 2014, at a baseline of 5 per cent, although it will be dependent on usage rates.

COMMUNITY-LEVEL BARRIERS TO ACCEPTANCE

Compared to socio-political acceptance, community acceptance does not have a convenient measure and it is highly variable in different regions. This section considers technical and procedural factors that affect community acceptance, including site selection, capacity factors, efficiency, cost effectiveness, wind variability, economics and audio-aesthetics, as well as approval complexity, community engagement and legislative transparency.

TECHNICAL FACTORS OF COMMUNITY-LEVEL BARRIERS

Typically, SWTs have a lower efficiency and capacity factor than large wind turbines that are designed for optimal efficiency and installed in locations with steady, high-velocity wind conditions. SWTs have a lower installation height with reduced wind velocity, more wind turbulence from nearby flow obstructions, and less control and design complexity than large wind turbine installations. These factors contribute to the results of an investigation involving micro-wind turbines (James et al.), which suggests that only rural sites should be considered for micro-wind generation because the annual capacity factor for urban and suburban installations is less than 2 per cent, whereas rural sites are up to 8 per cent. The capacity factor is highly dependent on a turbine's control system. Turbines with active controls continuously alter the pitch of turbine blades as the wind speeds change. The added costs associated with active controls can limit their use in small installations. However, without active controls, the blade pitch remains constant and significantly reduces the turbine's capacity factor. Therefore, techniques to provide cost-effective control strategies are important to improve the technical effectiveness of SWT systems.

Due to wind intermittency, a SWT cannot continuously deliver power at its rated capacity. A common requirement is energy storage or backup generation capacity. Recent research (Ela et al.) has reported wind power can improve power system reliability by using active power control to help generation match the electrical draw on the grid. The high responsiveness of active-controlled wind turbines allows for quick modifications to the power-generation capacity as the load increases or decreases. Another benefit of SWTs is the ability to flatten the distribution variability by distributing power production over a wide area.

The cost effectiveness of SWTs is highly variable, with rated capacity and wind conditions. For all turbines less than 100 kW, the Canadian Wind Energy Association (CanWEA) reports that the most cost-effective turbines are less than 1 kW and the least cost-effective are 1 to 10 kW turbines (CanWEA). Greater than 1 kW, the cost effectiveness decreases by approximately 310 per cent, and then improves as size increases.

Several studies identified audio-aesthetic impact to be the most important factor of community acceptance, with more influence than risks to wildlife and habitat, noise or shadow flicker (Wüstenhagen et al.). SWTs in residential and business sectors require additional attention to audio-aesthetic barriers compared to larger installations that are placed in remote locations. Smaller and lower-capacity turbines need more installations than a large turbine to produce the same power output, which can increase the audio-aesthetic impact if not carefully regulated. Also, the local community is affected by the audio-aesthetic impact of SWT projects without receiving financial benefits and the relative increase of audio impact can increase at night with the decrease in ambient noise.

PROCEDURAL FACTORS OF COMMUNITY-LEVEL BARRIERS

Perceived procedural fairness for a proponent installing a turbine and the local community is required to increase social acceptance of SWTs, which includes planning permission and approval complexity, community engagement and transparency, among others (Jobert et al.). A community is more likely to accept a result if the process that determined the outcome is perceived to be fair. A complexity and capacity for community input on the approval process within SWT legislation is an important procedural factor. A relatively simple process with reasonable timelines while maintaining perceived fairness, trust and transparency can increase community acceptance and the quantity of SWT installations. Community members should be able to trust industrial and government stakeholders, including local authorities, utilities, turbine manufacturers and contractors to ensure adequate acceptance. Open communication of SWT projects, incentives and legislation can improve perceived procedural fairness. Conversely, ineffective communication, inaccurate perceptions and lack of relevant SWT knowledge can deteriorate community acceptance by creating misconceptions and mistrust among the community (Jobert et al.).

MARKET ACCEPTANCE AND GROWTH TRENDS

The market trends of SWTs provide insight into the alignment of socio-political legislature and incentives with community-level barriers in Ontario, California and the UK. Globally, SWT market size increased from $156 million in 2008, to $609 million in 2012, and is predicted to rise to $3 billion by 2020 (Verma). Regional statistics of SWTs are typically unavailable and most manufacturers cannot report data by region (American Wind Energy Association). Therefore, as presented in Table 1, the installed capacity of SWTs for Ontario and California is examined with country-specific data.

All three countries are exhibiting promising growth in SWTs. Recent changes in legislation for SWTs in the UK have greatly accelerated their installation rates. In 2012, the UK had the largest

TABLE 1. SWT TRENDS IN INSTALLED CAPACITY

	Number of new units	New capacity [MW]	Total installed capacity [MW]	Total electricity consumption [GWh][4]
Canada[1]				
2009	3140	3.0		
2008	2294	2.3	12.6	536,054
United States				
2009[2]	9800	20.3		
2008[2]	10,500	17.3	100[1]	3,872,598
2012[4]			216	
United Kingdom				
2009[3]	3280	8.62		
2008[3]	3453	7.26	≈30[1]	345,798
2012[4]		50	118	

[1] Canadian Wind Energy Association

[2] American Wind Energy Association

[3] Central Intelligence Agency

[4] Verma

*Data from UK and US include all wind power with a capacity up to 100 kW and Canadian data includes systems with a capacity up to 300 kW.

increase (50 MW) worldwide in SWT installed capacity (Verma). Until the recent changes in California's incentive programs, Ontario, California and the UK had similar incentive programs with unique requirements for implementation of SWTs. The *Green Energy and Green Economy Act* provides a clear process for implementing SWTs in Ontario; however, it neglects community barriers by excluding a method for community input on the approval process, which can increase community opposition. Before cancellation, California's financial incentives allowed communities to establish an ordinance within the guidelines of the California Government Code, which helped to create high levels of community acceptance. In the UK, a method for community input on the approval process is excluded; however, financial incentives are provided for an on-grid and off-grid SWT installation that includes significant benefits for a wide variety of SWT applications and increases the quantity of effective locations.

The cost effectiveness of SWTs is an important factor for social acceptance (Ek). During this period of rapid growth, it's important that cost-effective systems with low audio-aesthetic impact are installed to maintain high levels of social acceptance. Yet, none of the three jurisdictions investigated in this paper place an emphasis on selecting suitable sites and ensuring high-quality engineering practices with suitable power coefficients, capacity factors and audio-aesthetic impacts for the installation locations. Implementing legislation to ensure cost effectiveness while maintaining a straightforward approval process can help to increase the social acceptance of SWTs.

CONCLUSIONS

The incentive programs and supporting legislation show high levels of socio-political acceptance for SWTs in several jurisdictions; however, community-level barriers are challenges to more widespread implementation. The alignment between socio-political incentives and community-level barriers is an important element to maximize the potential and ensure appropriate market acceptance. A suitable alignment between the cost of installed capacity, audio-aesthetic impact and a relatively simple approval process within the SWT legislation can facilitate further growth in installed capacity. Σ

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