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"Wind energy is not an issue for government": Barriers to wind energy development in Newfoundland and Labrador, Canada

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ABSTRACT

Despite having amongst the strongest potential for wind energy development (WED) of any jurisdiction in North America, the Canadian province of Newfoundland and Labrador (NL) remains dependent on fossil fuels for economic activity, government revenue, as well as electricity generation. The study is a comprehensive assessment of barriers to renewable energy development in NL, with a focus on wind energy. While NL is chosen as the primary case study, the study's theoretical breadth provides insights for other renewable energy (RE) development and policy contexts as well. Seventeen semi-structured expert interviews were conducted with respondents from academia, community groups, government, and the private sector. An analytical framework was employed and directed content analysis was utilized. A large majority of expert respondents (65%) classified the current state of WED in the province as 'unfavourable'. In total, 19 unique barriers were identified; the most significant barriers to WED were found to be political (71% of respondents), economic (65%), as well as related to lack of knowledge and agreement (53 and 41%, respectively). The study demonstrates that there is no single barrier to the development of RE sources; as such, comprehensive policy solutions comprised of financial, educational, legislative, and consultative components are required.

1. Introduction

Carbon-intensive fuel sources continue to prevail as the world's leading supply of energy. Coal, oil, and natural gas supply approximately 82% of the global primary energy needs according to the International Energy Agency (IEA, 2015). The Intergovernmental Panel on Climate Change ([IPCC] 2007) has concluded that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level". Furthermore, the most recent IPCC report (IPCC, 2014) states that "it is extremely likely (with 95–100% certainty) that human influence has been the dominant cause of the observed warming since the mid-20th century", most significantly, due to the burning of fossil fuels in transportation, generation of electricity, and operation of homes and businesses.

Research suggests that in order to maintain the atmospheric carbon concentration target of 450 ppm, global emissions must be reduced by up to 50% compared to 1990 levels. This implies emissions reductions in developed countries of 60–80% by 2050 (Weaver et al., 2007). Many researchers have promoted the idea of developing renewable energy sources as a means to achieve emissions reduction targets (Muis et al., 2010). However, many barriers to renewable energy development remain (Mey et al., 2016; Richards et al., 2012; Krupa, 2012; Jagoda et al., 2011; Musial and Ram, 2010; Sovacool, 2009; Oikonomou et al., 2009; Reddy and Painuly, 2004; Jagadeesh, 2000).

Newfoundland and Labrador (NL), Canada's most easterly province, serves as the case study for the current research. Despite having substantial renewable energy potential, the province remains dependent on the production and consumption of fossil fuels. For example, in 2009, oil royalties accounted for 31% of the provincial governments total revenue (Canadian Association of Petroleum Producers, 2010). As such, fluctuating oil prices severely impact the NL economy; for every dollar drop in the yearly average price of a barrel of oil, the provincial treasury loses approximately $30 million in revenue (Bailey, 2014). A single oil-fired power plant, the 490 MW Holyrood Thermal Generating Station, provides upwards of 30% of the provinces electricity needs on an annual basis (Department of Natural Resources, 2012). Furthermore, approximately 25 off-grid communities in the province rely exclusively on diesel generators – consuming over 15 million litres

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of diesel fuel annually (Jones, 2010). While the province relies on large-scale hydroelectric power for approximately 65% of its electricity, not including the 824 MW Lower Churchill Project (Muskrat Falls) currently under construction, a considerable body of research suggests that large-scale hydroelectric developments have significant ecological and social impacts (Jackson and Barber, 2016; Rosenberg et al., 1995).

Conversely, the province has amongst the strongest potential for wind energy development of any jurisdiction in North America (Government of NL, 2007). For example, Fisher et al. (2009) have calculated that on an annual basis, NL is theoretically capable of producing 117 times the amount of its 2006 electricity demand through wind energy. Barrington-Leigh and Ouliaris (2017) have concluded that “[NL] could generate almost 20% of Canada's 2010 energy demand by making use of only 25% of its high potential [wind development] area” (p. 21). NL's Department of Natural Resources (2005) provides a conservative estimate of 5000 MW of wind energy available for development. Despite this significant potential, NLs 55 MW of installed wind energy capacity is ranked last amongst Canada's provinces (Canadian Wind Energy Association [CWEA], 2015). There are few studies analyzing NL's fossil fuel dependence or wind energy potential. Existing research in a NL context concentrates solely on engineering aspects or the technical feasibility of renewable energy development (Fisher et al., 2009; Blackler and Iqbal, 2006; Jewer et al., 2005; Khan and Iqbal, 2004), despite the fact that numerous non-technical barriers to renewable energy exist (Zhao et al., 2016a; Owen, 2006; Beck and Martinot, 2004; Reddy and Painuly, 2004).

In the study, barriers to renewable energy development in NL are explored with a focus on wind energy. The research method involved a series of 17 semi-structured/open-ended expert interviews. Expert respondents were drawn evenly from academia, government, the private sector, and environmental non-governmental organizations (ENGOs). The research was organized using Trudgill's AKTESP framework (1990), which focuses on agreement, knowledge, technological, economic, social, and political aspects of wind energy development. The study argues that transitioning to renewable sources of energy in the province of NL is a complex and difficult process – often impeded by several individual and interrelated barriers. Comprehensive policy solutions involving consultative, educational, legislative, and financial components are needed in order to encourage the transition to renewable energies. The results of this research will assist policymakers and other relevant stakeholders in making informed energy-related decisions and in targeting future research and development efforts.

The paper is organized as follows. First, the paper includes a brief literature review of relevant technological innovation literature, and a discussion of the data collection and analysis processes. Secondly, the paper overviews the data collected, followed by a full discussion and interpretation of the results. Finally, the paper includes a short conclusion – which includes limitations, recommendations for future research and policy implications.

2. Literature review

There are many theoretical frameworks appropriate for analyzing the development and diffusion of technical innovations systems [TIS]; these include, but are not limited to, the national innovation systems framework (Nelson, 1993; Lundvall, 1992), the technological innovation systems framework (Edquist, 1997; Freeman, 1987), and the socio-technical regime theory (Smith et al., 2005; Geels, 2004). It is beyond the focus of this article to provide an in-depth understanding of these theoretical frameworks; however, it is important to acknowledge that the various transition theories mentioned above “analyze the development and diffusion of new technologies by examining the actors of a particular technological regimes, the networks through which they interact and the institutions that set the framework under which technological transition takes place” (Eleftheriadis and Anagnostopoulou, 2015, p. 154). These theories explain the success or failure of a TIS on the basis of structural components – consisting of (1) actors from the public and private sectors such as firms, government, research bodies, and advocacy groups, (2) the networks where they interact, and (3) relevant institutions (norms, regulations, and laws) (Eleftheriadis and Anagnostopoulou, 2015). The systems function concept has also been proposed to study the diffusion of TIS (Bergek et al., 2008; Hekkert et al., 2007; Negro et al., 2007); here TIS are investigated using a set of specific functions including: entrepreneurial activities/experimentation, knowledge development and diffusion, guidance of the search, resource mobilization, market formation, and legitimization and development of positive externalities. The barriers to transformation can be identified by analyzing each specific function (Eleftheriadis and Anagnostopoulou, 2015).

Bergek et al. (2008) explain that for an emerging TIS, there are considerable uncertainties in identifying structural components; for example, it may be difficult to identify relevant actors, networks are typically underdeveloped and/or informal, and there may be a lack of TIS-specific institutions (p. 414). Furthermore, these authors argue that identifying structural components forms the basis for analyzing TIS in the previously mentioned set of functions. It is rather difficult to identify structural components in NL's emerging wind energy sector, suggesting that these frameworks may not be the most appropriate for the current investigation. As previously discussed in Section 1, NL is ranked last amongst Canada's provinces in installed wind energy capacity. As such, there is a limited number of firms, government agencies, NGOs, or research bodies, directly involved in the development or diffusion of wind energy in the province. Further complicating matters, the provincial government has enacted legislation (*Bill* 61) which maintains a monopoly over power production and distribution in the province to the two existing electrical utilities (47th General Assembly, First Session, 2012).

Due to the difficulty in identifying/analyzing the structural components (actors, networks, institutions) involved in NL's emerging wind energy sector, the research project sought a broader analytical framework which would enable an understanding of barriers to wind energy development in the province. The research drew on a methodology successfully implemented by researchers in a similar Canadian jurisdiction; Richards et al. (2012) implemented Trudgill's (1990) ‘AKTESP’ Analytical Framework in their investigation of barriers to large-scale wind energy development in Saskatchewan. Saskatchewan's energy sector maintains similar characteristics to NL's, in that it is highly dependent on the consumption of fossil fuels, and possesses significant untapped wind energy potential (SaskPower Environmental Programs, 2009; SES, 2007). Electricity generation in both provinces is dominated by a single Crown energy corporation (SaskPower and Nalcor/NL Hydro, respectively). Similar to NL, Saskatchewan ranks third last amongst Canada's provinces in installed wind energy capacity (CWEA, 2015). These common factors and successful implementation by Richards et al. (2012) suggests that the AKTESP Framework would be useful in explaining barriers to renewable energy diffusion in NL. Furthermore, the ‘AKTESP’ Framework has proven its versatility in helping to explain a diverse array of environmental challenges, including Amazonian deforestation (Trudgill, 1990), cumulative effects assessment (Piper, 2001), cultural landscape conservation (Selman, 2004), and public resistance to solar energy (Haw et al., 2009).

Trudgill (1990) identified six major groups of barriers to achieving a better environment: agreement, knowledge, technological, economic, social perception, and political will **(**Fig. 1**).** Trudgill (1990) argues that if there is a barrier along the framework (i.e. key actors disagree on the problem at hand, inadequate knowledge exists to understand the problem, technological solutions are underdeveloped, solutions are not economically viable, the solution lacks social acceptance, or there is a lack of political will to pursue a solution, etc.), environmental solutions may not be achieved. The study implements Trudgill's (1990) ‘AKTESP’ framework for analysis in order to organize and analyze empirical evidence and to guide the discussion of barriers to

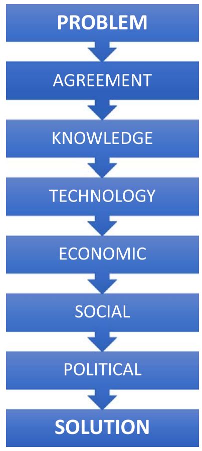

Fig. 1. AKTESP Group of Barriers (Adapted from Trudgill, 1990).

WED in NL. While the study focuses on NL, its theoretical breadth will provide insights for other renewable energy development contexts as well.

2.1. Data collection and analysis

Experts' perception regarding barriers to WED in NL was explored through semi-structured/open-ended interviews. Interviews consisted primarily of open-ended questions, designed according to Trudgill's 'AKTESP' analytical framework. Upon completion of the interviews, respondents were given an opportunity to speak to any barriers to WED in the province outside of the AKTESP framework.

Expert interviews were conducted between September 1, 2015 and January 15, 2016. Expert sampling was employed; in order to provide a balanced perspective, participants were recruited evenly from the following four categories: academics, government, ENGOs, and the private sector. Selection criteria included a minimum of two years' experience working in a related field (renewable energy development/ energy policy), appropriate knowledge of NLs energy sector, and the ability to communicate in English. Of the 34 experts invited to participate, 17 expert respondents ultimately participated in the study (Table 1). All interviews were digitally-recorded and manually transcribed by the primary researcher.

The primary form of data analysis applied in the study was a form of content analysis known as 'directed content analysis' (Zhang and Wildemuth, 2009; Patton, 2002). It is a form of qualitative content analysis in which initial coding starts with theory or relevant research findings. In this case, transcripts were coded according to the AKTESP framework for analysis; Version 11.1.1 NVIVO for Mac software was employed in data analysis, to assist in organizing, managing, and coding qualitative data in a more effective manner.

3. Results

All 17 expert respondents were asked to classify the current state of WED in NL as either 'favourable', 'unfavourable', or 'not sure'. A large majority of expert respondents (65%) classified the current state of WED in the province as 'unfavourable', the classification 'favourable' was chosen by 29% of respondents, and 'unsure' was chosen by one respondent ($<$ 1%).

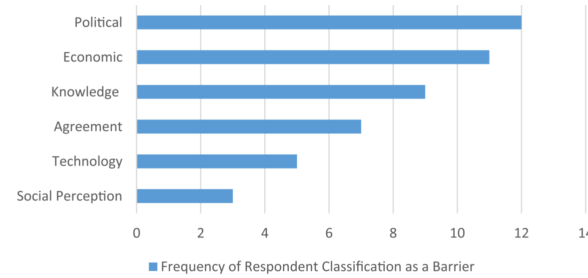

Fig. 2. Barrier identification (n = 17).

Each category of the 'AKTESP' framework was explored individually throughout the interviews. Upon completion of each category, respondents were asked to respond either 'yes, no, or unsure' to the question "Does category x represent a barrier to wind energy development in NL?" Results to these structured questions are presented in Fig. 2.

Respondents classified the 'political' and 'economic' categories as the leading barriers to WED in the province (71% and 65% of respondents, respectively), while a small majority (53%) classified 'knowledge-related' issues as barrier. A minority of respondents (41%) classified the 'agreement' category as a barrier to WED, while a small number of respondents classified the 'technology' and 'social perception' categories (29% and 18%, respectively) as barriers. While this may suggest that the 'technology', and 'social perception' categories are not the most pressing barriers to WED in NL, according to the expert respondents, it is noted that numerous themes were developed within each category **(**Table 2**).**

4. Discussion

The following sections discuss the themes developed in data analysis, and relate these themes to the existing literature.

4.1. Political barriers to wind energy development in NL

Expert respondents most frequently classified the 'political' category as a barrier to WED in NL (71% of respondents). Political themes developed in data analysis are explored in this section

4.1.1. Role of NL's utilities – Lack of utility acceptance

Much of the discussion with regards to political barriers to WED concentrated on the role of NL's public utilities, Nalcor Energy and NL Hydro. Some researchers have argued that 'lack of utility acceptance' is a common barrier to renewable energy development or the idea that new, proven, cost-effective technologies may still be perceived as risky by utilities and other stakeholders if there is little experience with them

Table 1
Research participants by target group (n = 17).

Private sector (n = 5)	**Academics (n = 4)**	**ENGOs (n = 4)**	**Government (n = 4)**
Executive, Utility Scale Wind Company	Energy Economist	Director of ENGO (Atlantic Canada Focus)	Executive, Provincial Crown Corporation
Executive, Small-Scale Wind Company	Electrical Engineer (Policy Focus)	Chairperson of NL ENGO (Conservation Focus)	Director, Energy Related Portfolio
Executive, National Wind Energy Association	Electrical Engineer (Systems Focus)	Executive of NL ENGO (Energy Focus)	Director, Natural Resources Related Portfolio
Executive, Regional Industry Association	Energy Economist / Former Public Servant	Executive of Canadian ENGO (Energy Focus)	Manager, Crown Energy Corporation
Manager of Private Energy Utility			

Table 2
Barriers to wind energy development in NL according to the 'AKTESP' framework.

Agreement	Knowledge	Technology	Economic	Social	Political
Disagreement over potential for economic benefit	Energy Illiteracy	Wind intermittency	Cost competitiveness	'NIMBY' phenomena	Lack of utility acceptance
Approach to development: 'mega-project' mentality	Siloed knowledge	Icing of turbines	Insufficient demand/lack of export capacity	Noise impacts	Lack of policy/political will
	Lack of expert capacity/ educational programs	Spilt energy at existing reservoirs	Fossil fuel subsidies and externalities		Preference for 'energy status quo'
		Strength of wind speeds			Inadequate public consultation
					Legislative barriers

in a new application or region (Zhao et al., 2016a; Heymann and Barrera, 2013; Beck and Martinot, 2004).

Respondents argued that due to governmental mandates, public utilities are inherently conservative institutions which may prevent them from adopting new technologies such as wind energy. As stated by a private-sector respondent,

> "By their nature, utilities are very conservative entities; their role is to make sure that the lights come on every time we need them… sometimes, we might have to push our utilities to be more cutting edge in terms of new technology and to bring our electricity system into the 21st century".

A prominent area of debate amongst respondents was whether or not NL's public utilities have helped to facilitate, or constrain WED. For example, a private-sector respondent stated, "In this province, the Crown Corporations were set up to develop energy – and that does not include wind power". Another ENGO respondent stated "it is impossible to get any information out of them [about wind energy]". Conversely, some respondents believed that the utilities were actively supporting WED, as a government respondent stated "As a Crown Energy Corporation – we are one of the ones who went forward and actually solicited wind development here in the province. We have stepped up, along with ACOA [Atlantic Canada Opportunities Agency] … and we are spending significant capital on advancing [wind energy] research".

If other key stakeholders view the public utilities as a barrier to WED, this may hinder them from collaborating with the utilities to pursue any type of WED – including research, development, and future investment.

4.1.2. Lack of policy and political will

Previous research has established that lack of supportive energy policy and lack of political will are often barriers to renewable energy development (Elliott, 2013; Wizelius, 2007; Martinot and McDoom, 2000). Zhao et al. (2016b) demonstrate how incentive policies of the Chinese government played a critical role in triggering the rapid growth of the domestic wind energy industry.

Similarly, the study revealed that there is an apparent lack of policy support for WED in NL. As a private sector respondent argued, "Our province is the only jurisdiction in Canada that does not have a feed-in-tariff, a net-metering policy, or some other policy tool to get [renewable] energy onto the grid". A utility representative stated: "In the absence of a clear policy [on net-metering, feed-in-tariffs, etc.], the Crown Energy Corporation has probably held back on wind energy". With regards to political will, a government respondent stated that "wind energy is not an issue for government… no one is knocking on our door about wind generation".

While the province has recently announced a framework net metering program (Department of Natural Resources, 2015), it is questionable whether the policy will support the development of any substantial amount of wind energy. As a government participant stated, "net metering is going to make absolutely no difference to electricity in the province". An academic participant explained that the net-metering policy will only allow for a cap of five megawatts of small-scale renewable energy development, and "that will be a barrier, because five megawatts is nothing".

Respondents suggested that existing WED targets demonstrate a lack of government support. As an academic participant stated, "In the initial energy plan, they imposed a limit of 80 MW of wind energy. They have since completed full detailed studies, and they simulated that 300–400 MW of wind energy can easily be injected into the grid". This is consistent with the existing literature, as the provincial energy strategy maintains a technical and economic limit of 80 MW of wind energy (Government of Newfoundland and Labrador, 2007), while more recent technical analysis indicates that an additional 300 MW will be feasible by 2035 (Hatch, 2012). Despite the new information revealing the potential for additional development, the targets for WED have not been updated.

4.1.3. Preference for 'Energy Status Quo' – Preoccupation with lower churchill project and offshore oil development

In this study, as well as others, a preference to 'continue the [energy] status quo' was found to represent a barrier to renewable energy development (Michelsen and Madlener, 2016; Verbruggen et al., 2010). As a government respondent in this study stated: "It is a cultural thing, [wind energy] has never been contemplated here. Government is behind the curve; it does not lead the curve". The respondent also added, "hydroelectricity in the province started with the paper mills, and we have been there ever since. We have got hydro[electricity]; why do we need anything else?". Furthermore, a government respondent argued that because the province's remote communities already have an existing diesel system – there is little need to provide new generation sources.

For example, the Lower Churchill Project may be impeding the development of other sources of energy, due to the government's and public utilities' preoccupation with the project. As a government respondent stated, "Nalcor will look at wind energy after Muskrat is built, everything is currently dedicated to Muskrat Falls". A utility representative stated, "We have a mandate to do economic development of wind energy, but right now, the focus is clearly on executing projects that we already have in hand". An academic participant explained that "all government resources, all policies, are focused on one project. It got approved, work is being done, and now they are not willing to discuss any other [energy] sources".

Along the same vein, a number of participants believed that the provincial government's preoccupation with offshore oil development was to the detriment of WED. As an ENGO representative stated, "Offshore oil and gas development really preoccupies the political system", and "within that context, there has just been no room for other renewables to be given any sort of consideration". An academic participant explained that most research funding has been directed towards oil development: "With all the funding going into petroleum research, there was a bit of a pull [away from wind energy] there".

4.1.4. Inadequate public consultation regarding energy policy decisions

A lack of consultation by the regional governments of relevant stakeholders has previously been established as a barrier to the development of renewable energy (Nasirov et al., 2015; International Renewable Energy Agency, 2012). According to United Nations Environment Programme (2005), at the policy development level, meaningful stakeholder participation in decision making and monitoring processes is the most reliable way to maximize benefits and prevent negative impacts from an energy policy. Limited expert and public consultation in NL may have negatively affected WED in the province.

As an ENGO representative stated, "Public consultation is not a big priority with the Newfoundland government... that is one of our impediments to innovation – we do not have [proper] consultations with people who are experts in the field". A private-sector participant stated, "There is no consultation – they [the provincial government] go out of their way not to consult", also adding, "there is a broken consultation process, they have a viewpoint, that we [the provincial government] know best".

A number of participants argued that wind energy was given inadequate consideration as an alternative to the Lower Churchill Project – during Public Utility Board (PUB) hearings - when determining the 'least cost option' to meet the province's future energy needs. An ENGO representative argued,

> "When the Public Utilities Board was asked to take a reference study into the Lower Churchill Project... there were only two [alternatives] put on the table for consideration. One was interconnection with Muskrat Falls, [and the other was] the continuation of thermal and small hydro development. There was very little attention given to wind [during the study]".

4.1.5. Legislative Barriers: Monopoly in Electricity Market

As established by previous researchers, legislative barriers are often an impediment to renewable energy development (Beck and Martinot, 2004; Oikonomou et al., 2009). Beck and Martinot (2004) explained that in many jurisdictions, power utilities still control a monopoly on electricity production and distribution. Under these restrictions, independent power producers are unable to invest in renewable energy facilities and sell power to the grid, or to third-party users. Furthermore, Zhao et al. (2014) demonstrate the necessity of open and market-oriented environments and policies to the development of the Chinese wind energy industry chain.

Existing legislation has direct effects on the development of renewable energy sources in the province. For instance, *Bill 61* gives an exclusive right to existing utilities to supply, transmit, distribute, and sell electricity to residential consumers on the island portion of the province (47th General Assembly, First Session, 2012). As a private sector respondent characterized the legislation, "Grid tied power [from independent producers] is illegal in Newfoundland".

Most participants believed that the monopolistic nature of the electricity generation and distribution sectors in the province has inhibited WED. As a wind developer in the province stated,

> "In the rest of North America, power production is a competitive undertaking.... There is competition between various players to produce electricity at the lowest price possible. In Newfoundland, there is no competition – it is a monopoly that Nalcor has and controls all decisions related to energy".

According to Brennan (2008), local electricity distribution and long-distance electricity transmission retain scale economies and other natural monopoly characteristics that impede any substantial competition. However, electrical generation and marketing sectors lack the same scale economies as distribution and transmission – and may benefit from increased competition. Conversely, a limited number of respondents in this study believed that due to the high quality of the provinces wind resources – competition for additional long-distance transmission capacity may be economically viable and beneficial in the province.

4.2. Economic barriers to wind energy development in NL

Expert respondents classified the 'economic' category as the second most frequent barrier to wind energy development in NL (65% of respondents). The economic themes identified by data analysis are explored in this section.

4.2.1. Cost-competitiveness of wind energy

Much of the debate in the published literature regarding renewable energy sources is whether or not they are cost-competitive with conventional generation technologies (IEA, 2015); (Ueckerdt et al., 2013). Similarly, much of the debate in this study focused on the cost-competitiveness of wind energy. In cases where wind is more expensive than other generation sources, this is a clear economic barrier, as wind energy would not be able to compete on the market. Each respondent in the study was asked to estimate the cost of electricity by various generation sources in the province, the competiveness of wind against these sources is explored below.

Utility-scale wind energy in NL ($0.07–$0.14/kWh) cannot currently compete with the spot market prices for natural gas generation ($0.03–0.06/kWh). An additional disadvantage of wind competing on the spot market is that wind energy has to be consumed when it is produced – which may mean receiving unfavourable prices for exported electricity. As a utility representative explained, "You take the spot market prices whenever the [wind] turbine is turning", also adding: "With hydro projects... when market prices are going up, we turbine the energy. When the market prices are down, we hold it back. We do not have that ability with wind projects, you are a price-taker – period". Utility-scale wind energy cannot compete with existing large-scale hydroelectricity projects ($0.02–0.045/kWh) in the province. As stated by a private sector participant, "The existing hydroelectric power in Newfoundland [sic] is just about free".

Respondents suggested that wind energy is cost competitive with oil-fired thermal generation in the province ($0.10–0.19/kWh). As a government respondent stated, "The economics are (sic) pretty clear; wind is cheaper than Holyrood or oil". The figures imply that small-scale wind ($0.1–0.18/kWh) applications are competitive with diesel-generation in NL's remote communities (upwards of $1.00/kWh). As an academic participant explained, "In remote communities, the cost of [diesel] generation is very high" and "If they installed wind turbines, that would reduce their equipment [consumption of fuel] – then it will make [economic] sense".

Respondents argued that wind energy is cost-competitive with other forms of newly-built renewable energy. For example, onshore wind energy is either competitive or less expensive than power from the Muskrat Falls project ($0.08–0.165) currently under construction. As a utility representative stated, "It [wind energy] is cost competitive with other forms of renewable energy: solar, geothermal, biomass, and hydro".

4.2.2. Insufficient demand in the province – Limited access to export markets

Similar to the findings of others (Mirza et al., 2009), insufficient local demand for electricity was found to be a barrier to WED. For example, in 2012, peak demand on the Newfoundland's interconnected system was 1581 MW, while the total generating capacity was 1958 MW (Department of Natural Resources, 2012a). If there is no demand for additional electricity in the province, participants suggested it is uneconomic to build additional wind generation capacity.

Building transmission capacity is costly and is often cited as a barrier to WED (Zhao et al., 2016a; Mills et al., 2009). For example, Mills et al. (2009) found that the median cost for building transmission capacity for wind power was $300/kW, or approximately 15% of the cost of building a wind project. Similarly, the cost of transmission was found to be a barrier to WED in NL; as a private sector respondent stated, "Transmission costs money; it is very expensive, especially for an island like Newfoundland". For example, the Maritime Link being built as part of the Lower Churchill Project with export capacity of 500 MW, will cost $1.56 billion (Emera, 2015) – which is approximately $3120/kW, or roughly 156% of the cost of building a wind project (Mills et al., 2009).

There was substantial debate regarding how the Maritime Link would affect the prospects for WED in NL. For example, a utility representative stated, "The Muskrat Falls project and the associated transmission… will interconnect the island of Newfoundland with the North American grid… which will change the business case for wind quite dramatically". Conversely, an academic participant argued that of the 500 MW capacity on the Maritime Link, approximately 340 MW is already dedicated to Nova Scotia and the broader spot market, meaning there is limited spare capacity for WED.

4.2.3. Fossil fuel subsidies and externalities

Similar to the findings of many researchers (Whitley and van der Burg, 2015; International Institute for Sustainable Development, 2014; Ouyang and Lin, 2014), the study found that existing fossil fuel subsidies and the failure to internalize the negative externalities of fossil fuels may be inhibiting WED, as this affects the competitiveness of renewable energies (which tend to have significantly lower external costs) (European Commission, 1995). For example, the IEA (2014) estimated that in 2013 the fossil fuel sector received $548 billion in subsidies, compared to only $121 billion for the renewable energy sector – creating an uneven economic playing field.

An ENGO respondent stated, "We need to bring wind energy and other renewables onto a level playing field with fossil fuels, which benefit from billions of dollars of subsides annually. Fossil fuels also benefit from existing infrastructure which is predicated on their use".

A primary area of concern were subsidies that support diesel plants in the province; the subsidies distort the cost of electricity generation from fossil fuels, and negatively affect the competitiveness of renewable energy sources. A utility representative explained that in some jurisdictions across Canada, rate-payers and governments are subsidizing electricity rates from remote diesel plants to the order of 90–95%. For example, in 2003 in NL, diesel customers in the province paid only 26% of actual electricity costs, while rural interconnected customers paid 64% of actual costs (Department of Mines and Energy, 2003).

4.3. Knowledge barriers to wind energy development in NL

Expert respondents classified the 'knowledge' category as the third most frequent barrier to WED in NL (53% of respondents). The knowledge themes developed in data analysis are explored in this section.

4.3.1. Energy illiteracy: Inadequate knowledge and understanding about wind energy

In this study, as well as in other research (Moore et al., 2013; DeWaters and Powers, 2011; Bittl et al., 2009), inadequate 'energy literacy' was found to be an impediment to the development of sustainable sources of energy.[1] As stated by Moore et al. (2013) "an informed or literate public is critical for the long-term conservation, management, pricing and use of increasingly scarce energy resources" (para. 1). If key stakeholders lack knowledge about energy sources, and widespread misinformation exists about certain technologies (i.e wind), this may hinder its development and public support as a source of energy in the province.

Most participants suggested that the general public and relevant stakeholders in the province possess inadequate knowledge and understanding about energy sources. As an ENGO respondent stated, "I think most people are too busy to delve into the issue [of energy supply] deeply". More bluntly, when asked about energy literacy in the province, a government respondent stated, "I do not think the general public has a clue".

A great deal of misinformation seems to exist in the province surrounding wind energy in particular. For example, a utility representative stated, "Some people think wind energy is cheap, some people think that it is expensive. I have heard all sorts of stories; but I don't think people understand what it is"; this respondent also added: "I have heard so many myths about why we can, or cannot, do wind projects. It has led me to believe that the general public is not well informed".

Similarly, an ENGO representative stated, "People believe that wind energy is [too] intermittent or unreliable… or that the wind is too strong for the wind turbine's blades… these comments were coming from [key decision-makers], these [individuals] are not very knowledgeable".

4.3.2. Siloed knowledge

In this study, as well as in others in the fields of energy policy and resource management (Scobie, 2016; Mitchell, 2005), 'siloed knowledge' has emerged as a barrier to effective environmental action.[2] Scobie (2016) concluded that the "silo effect" contributes to an unwillingness to share information between key-stakeholders with similar mandates, and as a result decision-makers often lack credible data when formulating policy. Zhao et al. (2016b) demonstrate how poor communication amongst the government, wind power developers, and energy utilities, represents a barrier to wind energy planning and development in China.

For example, there was substantial debate regarding the level of research conducted in the province to support WED. Many participants argued that there was a lack of research to support wind energy. An ENGO representative stated, "[the provincial government] has not done any research on wind in thirty years", a private sector representative stated, "the research is completely inexistent", and an academic participant stated, "At Memorial University, or anywhere else, there is very little research going on [regarding wind energy]".

Conversely, other participants contended that there was a high level of research taking place. As a utility respondent stated, "There is sufficient research taking place from a technical perspective" and "there is a lot of investment in wind industry research [from their company] … a lot of research and collaboration with government on understanding wind resources in isolated communities". An academic respondent stated, "There is significant research being conducted; there is quite strong interest, and reasonable research funding".

While a number of utility and academic representatives stated that they were aware of a substantial amount of technical research, the fact that other key stakeholders (ENGOs, private-sector actors, and academics) were unaware of these efforts, suggests that the existing research has occurred in "research siloes" and has not been properly disseminated. This has resulted in the disconnect between various parties, concerning knowledge of ongoing wind energy research.

4.3.3. Lack of expert capacity, trained professionals, educational programs

Previous research has established that a general lack of expert capacity, trained professionals, and educational programs represents a

[1] Dewater and Powers (2011) state that 'energy literacy' includes an individual's broad content knowledge about energy sources, as well as affective and behavioral characteristics.

[2] Mitchell (2005) defines the 'silo effect' as "the separation of responsibilities among resource-management agencies as well as their inability or unwillingness to consider their mandate relative to those of other organizations" (p. 1340).

barrier to renewable energy development (Zhao et al., 2016a; Jennings and Lund, 2001).

Similarly, in this study, it was found that educational and training opportunities in renewable energy development, and specifically WED, are limited in NL. Participants generally believed that renewable energy training at the postsecondary level is limited or non-existent in the province. One academic explained, "[at our provincial university] we give some introduction to wind engineering and renewable energy systems" and "I don't think there are any courses [in the provincial college system] that deal with wind turbines, or renewable energy systems". A private-sector actor stated "There are no graduate programs concentrating on alternative energy in the province… many of the graduate students in [environmental] fields, do not study wind energy – because there is a lack of [research] opportunities here".

4.4. Agreement barriers to wind energy development in NL

A minority of expert respondents classified the 'agreement' category as a barrier to WED in NL (41% of respondents). The "agreement" themes identified by data analysis are explored in this section.

4.4.1. Disagreement over potential for economic benefits

Similar to the findings of other studies, there was substantial debate amongst wind energy proponents and opponents regarding the potential economic benefits of WED (Blum et al., 2013; Caspary, 2009; Jacobsson and Johnson, 2009). If decision-makers do not see wind energy as a viable source of economic development, it may prevent them from creating policies which support the development of the industry.

Many respondents were optimistic about wind energy's potential economic benefits. As an ENGO respondent stated, "A benefit of developing a local wind industry in Newfoundland and Labrador is that it could employ a bunch of people and help generate local prosperity". Similarly, a private sector respondent stated, "The immediate benefit of [WED] would be big time employment" and "If we got one big local [wind turbine/component] manufacturer here in Newfoundland… we would be looking at 2500 full-time jobs". Conversely, a number of respondents were not optimistic about WED's potential economic benefits. As a government respondent stated, "There is very little economic benefit, jobs, labour, or GDP created from wind energy".

Experience in neighboring jurisdictions suggests that WED does create substantial economic benefits (Union of Nova Scotia Municipalities, 2015; Gipe and Murphy, 2005). However, an area of contention is related to job creation; according to Gagnon et al. (2009), the majority of job creation benefits occur during the construction phase of wind projects. However, job creation benefits need to be kept in perspective by comparing energy sources. Kammen et al. (2004) conclude that "overall, the renewable energy industry generates more jobs per megawatt-hour than the fossil fuel based industries (mining, refining and utilities)" (p. 12). Sastresa et al. (2010) suggest that the renewable energy sector generates 1.8–4 times more jobs per MW than conventional sources.

4.4.2. Approach to development: Megaproject mentality vs. small-scale energy projects

A number of researchers have documented a government preference for large-scale energy projects as opposed to small-scale renewable energy developments (Liu et al., 2013, p. 5; Shirley and Kammen, 2015). Furthermore, previous research has found that over reliance on capital and energy intensive mega-projects is not compatible with climate change mitigation strategies (Winkler and Marquand, 2009). In this study, it was suggested that a historical reliance on and government preference for mega-projects may be a barrier to small-scale renewable energy developments, including wind power.

Many participants were critical of the mega-project approach to development, as one ENGO respondent stated, "The mega-project mentality is a barrier to wind… we cannot bring ourselves to believe that if you just build a whole bunch of small projects, you will create way more jobs, and generate more money in the economy". Another ENGO representative stated, "If your attitude is "big is better", then you will prefer things like massive hydro projects. If you are more community-minded, and you want to see each little community prosper, then you think smaller projects like small wind and hydro".

Roberts (2016) examined a recent report by the Atlantic Provinces Economic Council (APEC) suggesting that major-project spending (capital investments greater than $25 million) is particularly dominant in NL compared to other jurisdictions. The report concluded that of the $13.3 billion that was projected to be spent on major projects in Atlantic Canada in 2015, more than $8 billion was spent in NL.

4.5. Technical barriers to wind energy development in NL

A limited number of expert respondents (29%) classified the 'technical' category as a barrier to WED. This may suggest that technical issues are not the most pressing barriers to WED in NL. The following technical themes have been identified by data analysis and are explored in this section.

4.5.1. Wind intermittency

Similar to the findings of other reports (Zhao et al., 2016a; Musgrove, 2010; Logan and Kaplan, 2009), participants in this study acknowledged that due to intermittency of wind energy, and without large-scale energy storage (which is prohibitively expensive), the technology is not suitable as a 'base-load' energy source. While wind's intermittency does create added expenses and complexity for an electricity system, it is important to note that these integration costs do not become significant (5–10% of wholesale prices) until wind energy accounts for 15–30% of the capacity in a given system (Logan and Kaplan, 2009).

Some respondents were more conservative with regards to feasible wind penetration levels in NL; for example, a government respondent stated, "10% wind energy is a rule of thumb, although it does not always work". Other participants were more optimistic, a private sector actor stated, "you need to start discussing energy storage when you are reaching 35% of wind penetration on the grid". However, wind penetration levels are currently less than 3% in NL, suggesting that much more wind energy could be integrated into the existing system and that the effects of intermittency are not yet an insurmountable barrier.

4.5.2. Icing of turbines

Previous research has established that, in harsh environments, icing of wind turbines and blades causes measurement and control errors, power losses, mechanical and electrical failures, as well as safety hazards (Parent and Ilinca, 2011). However, most respondents in this study acknowledged that icing is not an insoluble challenge in NL. As a wind operator in the province stated, "Icing is a problem that is a bit more specific to Newfoundland, because of the Atlantic air front and the very humid condition… it is a small barrier, but you can account for it in [system planning]". Another private sector participant stated, "with state-of-the-art technology, wind turbines will only shut down [from icing] when temperatures reach below −30C".

Participants generally believed that icing is a site-specific issue; for example, a utility respondent referred to a provincial icing study, which found that 10–15% of wind energy would be lost due to icing in particular areas of the province; with areas to avoid including the Bonavista Peninsula and the northeast Avalon. To compare, a private sector respondent referred to a Pan-Canadian wind energy study, where average losses for icing were calculated as 8%.

4.5.3. Spilt energy: Implications of existing electricity system

A unique technical constraint for integrating additional wind energy onto the provincial grid is termed "spilt energy" – or, essentially, lost energy at the province's existing hydroelectric reservoirs. As a utility respondent stated,

> "When you start adding more wind beyond the amounts we already have on our system... we increase the likelihood of spill at our existing hydro dams". So if we add a kilowatt hour of wind, and we spill the equivalent of a kilowatt hour of water, we have not made any positive impact on the electricity system".

Respondents referred to a technical document issued/published by the province's Crown Energy Corporation (Newfoundland and Labrador Hydro, 2004). A government actor stated, "It set a cap at 80 MW, and it explained that if you go above 80 MW of wind on the island... you are spilling water when you need to be storing water". In 2012, a new study was completed to determine how much additional wind power could be added, economically and technically, to the system. The study concluded that by 2035, approximately 300 MW of additional wind generation would be feasible. However, the decision to proceed with the Lower Churchill project may affect this analysis, as Newfoundland and Labrador Hydro (2012) stated that "additional wind was not incorporated in the Interconnected Island case. However, wind could be built for export and this option will be analyzed at a later date" (p. 17).

4.5.4. Strength of wind speeds

A small number of respondents expressed concerns that wind speeds were too strong in the province for commercially available turbines. As an academic participant stated, "We have a harsh environment... when the wind blows strong and gusty all the time, it may not be appropriate for technology in terms of turbines that have been developed". Despite these concerns, the majority of respondents held a different position. For example, an academic participant stated:

> "Wind speeds are not too strong [in NL]; our average wind speed is about 6.25 m/s (meters per second). If you look at Scotland, their annual average is 7.5 m/s, so our wind speeds are not that high" and "When it comes to variance [or gustiness], that is also not significant... commercially available wind turbines can easily handle up to 30 or 45 m/s, with survival rates of 50 m/s – so this is not an issue".

Molina and Alvarez (2011) suggested that the typical survival speeds for commercial wind turbines are 145 km/h to 260 km/h, while the most common survival speed is 215 km/h. For comparison, the Department of Natural Resources (2011) suggests that much of the province has average wind speeds of between 25 and 35 km/h at 50 m above the ground. For the windiest areas of the province, along the south and west coast, very strong gusts of wind between 120 and 140 km/h are common (Heritage Newfoundland and Labrador, 2016). The available data suggests that provincial wind speeds are not a technical barrier to WED.

4.6. Social barriers to wind energy development in NL

A small number of expert respondents (17%) classified the 'social' category as a barrier to WED, suggesting that social issues regarding WED in NL are not significant. The following social themes were identified by the data analysis and are explored in this section.

4.6.1. NIMBY phenomena

Substantial literature has been published on the 'NIMBY' phenomena (Wizelius, 2007; Wolsink, 2000; Devine-Wright, 2011), or more generally, on local opposition to an energy project when built within property owners' near vicinity. A small number of respondents expressed concern that 'NIMBYism' opposition would be a factor in NL, as an academic respondent stated "Look what happens with cell phone towers [in the province] – with opposition to radiation, magnetism, and noise. If it is close to a relatively populated area, you will find the same reaction to a wind farm".

In contrast, most respondents believed that due to abundant availability of Crown land in NL, and the ability to build wind projects away from residential areas, 'NIMBYism' is not a barrier in the province. As a government respondent stated, "There is (sic) tons of Crown land out there... so [wind energy] is not encroaching on people. Support for wind energy is very high". Furthermore, a wind developer in the province stated, "[NIMBYism] is almost opposite in Newfoundland. We [have] only received positive support".

4.6.2. Noise impacts

Researchers have identified the perception of turbine-induced health impacts from noise as a determinant of wind energy opposition (Baxter et al., 2013). Similarly, some respondents in this study expressed concern about wind turbine noise. As an academic respondent stated, "Depending on the size of the [wind] turbine, if you are close to it on a windy day, noise levels could be 60–70 dB or higher". An ENGO respondent captured the sentiment when they stated, "Wind turbines do make noise; I would not want to live across the street from one".

However, most respondents believed that noise issues can be overcome with proper technology and siting of turbines. As explained by an academic participant, "Large wind turbines should be at least two kilometers away from people's homes [to avoid noise impacts]". A government respondent explained that in Ramea, which hosts a small-scale wind energy project, "I have never heard a negative comment about the wind turbines... they are actually right next to town". This is consistent with the findings of the Council of Canadian Academies (2015), who concluded that available scientific evidence can only establish a causal relationship between exposure to wind turbine noise and annoyance.

5. Conclusion and policy implications

Despite having abundant renewable energy resources, the Canadian province of NL remains dependent on fossil fuels for regional economic activity, government revenue, and electricity generation. By applying an analytical framework in implementation of expert interviews, the study set out to conduct a comprehensive assessment of barriers to WED in the province.

The study suggests that political impediments are the most pressing barrier to WED in NL; primary issues include the role of NL's public utilities, lack of supporting policy and regulation from provincial government, a preference for the 'energy status quo', inadequate public consultation, and existing legislative barriers. Economic barriers also ranked highly in the study; central issues included the cost-competitiveness of wind energy, insufficient demand in the province and inadequate access to export markets, as well as existing fossil fuel subsidies and externalities. Knowledge-related barriers were prevalent in the study as well; obstacles included inadequate energy literacy, siloed knowledge, as well as a lack of expert capacity and educational programs. A minority of respondents suggested that agreement, technological, and societal issues were a minor barrier to WED in NL. This is not to say that these barriers do not exist, but the study suggests that these issues may not be as pressing as other categories of barriers.

The main limitation of the study is that it relied on self-reported data from respondents. We addressed this bias by including equal numbers of respondents from academia, NGOs, the private sector, and government. Furthermore, only respondents with adequate experience and knowledge in NLs renewable energy sector were invited to participate in the study. An additional limitation of the study was time restrictions. Barriers to renewable energy are constantly evolving –

technology develops, political realities change – as such, our study only provided a snapshot of the current state of barriers to wind development in NL. However, the theoretical depth of the study should make the findings relevant for NL and other jurisdictions over time.

A number of areas have been identified in the study and are recommended as future areas of research: (1) There is a need to compare mega-projects and small-scale energy developments as an approach for sustainable economic development, (2) There is a need to assess the current state of the provincial sustainable development curriculum – potential research questions may include ‘how effectively are the province's schools teaching/preparing youth for sustainable development?’, and ‘which post-secondary education programs could contribute to the building of a green-economy in the province?’, (3) The export of electricity from renewable sources presents a substantial economic opportunity for the province – there is a need for economic analyses of potential export options as well as transmission costs, (4) how does ‘siloed-knowledge’ manifest itself within the public service of the province – what are the consequences of this?

A number of policy implications can be drawn from the current study, including:

(1) There is no single barrier to the development of renewable energy sources and many barriers exist outside of the technical realm. As such, renewable energy research and possible policy solutions need to be interdisciplinary and incorporate broader social-science aspects.
(2) Lack of public and expert consultations may result in sub-optimal energy related decisions. Therefore, policymakers are encouraged to conduct full assessments of potential energy alternatives, based on in-depth expert and public consultation.
(3) Even if significant investments are made in renewable energy research and development, this may not be a useful exercise if conducted in ‘research siloes’. Policymakers should encourage sharing of results, and broader knowledge mobilization efforts, within various government departments/institutions, and with other key academic, community, and business stakeholders.
(4) While education and awareness have previously been identified as important energy policy tools, it may not be ideal for these efforts to be conducted by government actors as they are typically the least trusted source of energy-related information. Policymakers should finance and support independent/expert individuals or organizations in the development of renewable energy related educational tools for best results.
(5) Unpriced negative externalities of fossil fuels, including environmental damage and public health costs, create an economic disadvantage for renewables. As such, policy efforts need to be made to bring renewable energy onto a level economic playing field with conventional energy technologies (including carbon pricing mechanisms, renewable energy subsidies, etc.).

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