BAY OF FUNDY TIDAL ENERGY: AN OPPORTUNITY FOR THE FUNDY REGION AND A CALL FOR SOCIOECONOMIC RESEARCH[1]

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The Bay of Fundy is rich source of tidal energy. Nova Scotia is turning its attention to this resource to reduce its reliance on coal and for economic development. Socioeconomic research is needed to help develop this nascent industry. The potential goes beyond green energy: with the involvement of universities, development of world-class expertise can be achieved.

As much opportunity as beauty lies within the shores of the Bay of Fundy. The energy from its world-renowned tides presents a unique opportunity to develop the technologies, industry and specialized knowledge that will not only provide clean electricity to the region but exportable expertise that is coveted around the world. The economic development opportunity for the rural communities located near the resource cannot be overstated, but the need to build capacity, while providing stewardship of the bay's ecosystem, adds significant complexity. Much research needs to be done in both the natural and social sciences for the development of a sustainable tidal energy industry in Atlantic Canada. This paper provides an overview of the work being done on tidal energy and the emerging socioeconomic issues that require research. These present both challenge and opportunity for business schools and business researchers to respond to help the nascent tidal energy industry in the Fundy region develop and become globally competitive.

Marine renewable energy includes wave energy, offshore wind energy, tidal barrages, lagoons and tidal in-stream energy conversion (TISEC) devises. In Nova Scotia, considerable attention is being given to TISEC. Nova Scotia has a tidal barrage in Annapolis Royal, commissioned in 1984. Though a mature technology, another tidal barrage is not likely to be developed in the Fundy region due to construction costs and environmental impacts. TISEC is believed to be less disruptive to the ecosystem than tidal barrages or lagoons (O'Rourke et al, 2010), though research on the potential impacts of TISEC devises is underway (Issacman & Lee, 2010; Tollit et al, 2011).

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In the Bay of Fundy, 100 billion tonnes of water ebb and flow each day. In the Minas Passage, a narrow 5-kilometer span between Cape Split, Kings County and Parrsboro, Cumberland County, the channeling of the water results in as much as 7,000 megawatts of extractable power, 2,500 MW of which could be extracted using TISEC devices with only a 5% change in the tides (Karsten et al, 2008). It has been estimated that over 300 MW of tidal-power generation could be developed in the Minas Channel (Electric Power Research Institute, 2008).[2]

In 2009, the Government of Nova Scotia committed to deriving at least 25% of the province's electricity from renewable sources by 2015 and 40% by 2020 (Nova Scotia Department of Energy, 2010). Part of the plan for achieving these goals is the implementation of feed-in-tariffs (FIT) - premium prices to be paid for electricity from renewable sources that reflect the higher cost of generation. In July 2011, the Nova Scotia Utility and Review Board introduced community feed-in-tariffs (ComFIT) that guarantee $0.652 per kWh for electricity generated from small-scale community tidal energy projects. (For contrast, the ComFIT for small wind power projects is $0.452/kWh and for large wind power projects $0.139/kWh). A known and stable FIT reduces the risk of renewable energy investments and will help Nova Scotia become a leader in small-scale tidal energy development. Three very rich tidal energy locations suitable for community-scale tidal projects are in the Petit Passage, Grand Passage and the Digby Gut in Digby County. There is limited capacity in the electrical grid there to take this electricity, however, which is one of the many infrastructure and logistics challenges a new tidal energy industry will face.

Also located in Nova Scotia is the Fundy Ocean Research Centre for Energy (FORCE) at Black Rock, near Parrsboro, Cumberland County. FORCE is a not-for-profit institute and test center for large, commercial-scale tidal in-stream technology. It will install submarine cables and a connection to the electrical grid as well as observation facilities. There are 4 berths available for commercial turbines to be situated and tested in the Minas Passage. The velocity of the water there, potentially the greatest anywhere, tests the limits of the technologies. FORCE is also facilitating full monitoring of currents, fish and marine mammals, debris, ice and other research to determine hazards to the environment and the turbines. Four consortia have been selected to test their turbines in these waters, all with quite different technologies. One turbine, belonging to the OpenHydro-NS Power consortium, was tested in 2010. It was found to be severely damaged when retrieved. OpenHydro believes the damage was caused by the currents in the Minas Passage, which they now believe to be considerably greater than originally estimated. Installation of the four test turbines, including a new OpenHydro unit, is planned for 2012-2013.

Much research is underway in the natural and applied sciences on tidal energy. In the Minas Passage, research in being done to model the potential amount of energy extractable from the currents (Karsten et al, 2007), characterize baseline physical and biological site characteristics and assess the potential near- and far-field effects of tidal turbines on sediment dynamics, current flows and fish, marine mammals and benthic habitat in the Minas Basin (Isaacman & Lee, 2010; Tollit et al, 2011). Engineering research is ongoing on the designs and efficiency of the in-stream

[2] At peak usage (coldest winter day), Nova Scotia uses 2,300 MW of electricity. A megawatt is sufficient to power approximately 750 homes.

energy conversion technologies by turbine developers. Small- and medium-sized turbines have been tested and deployed in rivers and tidal areas around the world such as in the Race Rocks Ecological Reserve, British Columbia, Yukon River and Cook Inlet, Alaska, Cobscook Bay, Eastport, Maine, and Orkney, Scotland.

The Need for Socioeconomic Research

Though much more work in the natural and applied sciences needs to be done, attention is turning to socioeconomic questions of how to sustainably bring the energy to market and how to garner local economic benefit from it, particularly by the predominantly rural communities located near tidal resources and most affected by the activity. Being an ocean region, the provinces around the Bay of Fundy have a great deal traditional knowledge and experience with the waters. There are also businesses with relevant skills, knowledge and facilities from having served the fishery, shipbuilding, off-shore oil and gas, and Canadian Forces' Halifax naval base, such as marine services and supplies, metal fabrication, engineering, as well as accounting, legal services, and so on. However, the supply chain is thin at best and many gaps exist. The availability of appropriately skilled workers and specific expertise is also insufficient. For the Fundy region to optimally benefit from development of tidal energy and world-class expertise, local sourcing of services and products is important (Porter, 1998). Capacity building is needed to support this new industry.

Other large socioeconomic issues are community acceptance and engagement, socioeconomic costs and benefits to the community (Centre for Sustainable Energy, 2005), regulatory policies and governance (Holburn et al, 2009; O'Rourke et al, 2010). Jacobson and Delucchi (2011, 2011a) maintain the barriers to meeting the world's energy needs from water (and wind and solar) are primarily social and political rather than technological or economic. There are many jurisdictions in the world that have wrestled with community engagement and impacts while developing wind energy and other renewables, Denmark and Germany being among the most effective (Centre for Sustainable Energy, 2005).

The development of wind energy over the past 20 years provides substantial experience and analysis to draw upon. It is a relatively mature industry, compared to in-stream tidal energy. In some aspects, wind energy is more difficult (community acceptance, ecological effects) and in others, simpler (technological, installation, maintenance, worker safety). Still, many of lessons learned developing the wind energy industry are useful starting points for the research needed in the tidal energy industry (Canadian Wind Energy Association, 2011; Centre for Sustainable Energy, 2005; Holburn et al, 2009).

Topics for Study

Below is a sampling of the challenges faced by the emerging tidal industry that would benefit from socioeconomic research:

- Capacity building - Communities located near tidal resources are predominantly rural and remote, without the needed skills and infrastructure. How can capacity be built to support the development of a new industry?
- The impact of tidal energy development on other users of the waters - How will fishers, commercial marine interests, recreational users, tourist operations (i.e. whale watching tours), First Nations communities be affected? How can opposing interests be met?
- Managing change – There will be disruption of community life around construction, operation and maintenance of the tidal energy devices, construction of infrastructure, etc. How is the tension between preserving the natural beauty and way of life and harnessing the power resolved?
- Local economic development - How can the local community most benefit from the employment, leases, taxation, tourism, education, development of job opportunities for young people in trades and knowledge industries, and service industry opportunities?
- Analysis of the supply chain - Companies must provide products and services to one another to ultimately bring electricity to consumers. What skills and services are needed, what are there already, and what are the gaps? How do we fill the gaps? What roles do suppliers to our existing fishing, oil & gas, shipbuilding, construction industries play in this new tidal energy industry? How do they transition from serving these industries to also serve an emerging one? (CanmetEnergy, 2011; Scottish Government-Marine Energy Group, 2009)
- Competing in a global industry – Other countries also realize there are first-to-market spoils in this emerging industry. How do we manage the strategic development of a tidal energy industry to be more effective, more quickly?
- Gaining of community support – What are the best methods of engaging the community for mutual benefit, thereby reducing the delays, costs and risks of developing the industry?
- Government legislation and consents - What permitting is necessary, how should the approval processes be streamlined to not create undue delays that increase the risk and cost to the project developers? What are the jurisdictional conflicts between the provinces and the federal government of the Bay of Fundy? How should are these best resolved to allow the tidal energy industry to develop?
- Occupational safety and standards, certifications for workers – Working where the tidal energy is the greatest poses many occupational risks.
- Development of intellectual property and export of systems knowledge - How do companies retain valuable private knowledge while still sharing information to advance the development of this renewable energy?
- Risk and risk-mitigation - Beyond design, construction, and commissioning risks, there are supply chain and completion risks, commodity price volatility, weather, health and safety, energy yield, loss of equipment, plus a plethora of other risks (International Energy Agency-RETD, 2011). Mitigation of these is important for developers and for obtaining financing.
- Financing - Finding capital at the various stages (design, testing, implementation, commercialization, etc.) is a barrier at present. Government grants and incentives help at some stages, venture capital will participate much later. Banks are reluctant to participate until the technology is relatively mature. Through the process, there are funding gaps. Also, what methods of financing are most appropriate?

- Economic evaluation – How will these investments be valued, taking into account staged investments, economies of learning, opportunities to export knowledge or systems, real options valuation (Denny, 2009).
- Economic development – What will be the benefits, such as jobs created (direct, indirect and induced), tourism, energy security, economic rents (Boettceher et al., 2008; Canadian Wind Energy Association, 2011; Sustainable Energy Authority Ireland, 2010). What will occur during the construction phase and what will continue during the operation and maintenance phase?
- Making it economical - Increasing efficiencies and competition to reduce costs so tidal energy can become competitive with other renewable resources (International Energy Agency-RETD, 2011). How can these be realized?

Studies on some of the socioeconomic issues surrounding tidal energy have been commissioned by the federal and provincial governments. At the time of this writing, several important reports are soon to be released: the Canadian Marine Renewable Energy Technology Roadmap (Ocean Renewable Energy Group), Dalhousie Oceanographer Dr. Bob Fournier's recommendations to the Province of Nova Scotia on marine renewable energy legislation, and a Nova Scotia government-commissioned study of the infrastructure that is in place to support the development of marine renewable energy.

Summary

Skilled tradespeople and knowledge workers are needed, as is an engaged research community, for the development of a sustainable world-class industry to be realized in the Fundy region. Business school researchers from all functional areas are needed to apply their domain knowledge to the research needs that abound in the nascent tidal energy industry. Efforts have been made around the world to develop wind, wave and tidal resources but little academic research has been done on the impacts and best practices. The economic development opportunity for the Fundy region, especially in struggling rural farming and fishing communities, is potentially large. The development of tidal energy should be sustainable not only economically but environmentally and socially, objectives that are often discordant, making the need for research even greater.

Research and education are vital components in the successful development of a new industry (Porter, 1998). In addition to research related to tidal energy, college and university courses are needed to train and educate a workforce for tidal energy and excite students about tidal energy career opportunities in the region. Tidal energy is both an opportunity and challenge for universities and colleges in the Fundy region that is worth taking up.

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