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Research, Development and Demonstration: Challenges and Opportunities Atlantic Canada Opportunities Agency

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INTRODUCTION

The Atlantic Canada Opportunities Agency has asked SLR Consulting (Canada) Ltd., in partnership with Maxis Energy Solutions, to examine the current state of clean and renewable energy research, development and demonstration (RD & D) in Atlantic Canada and provide observations and advice that will assist the Atlantic Energy Gateway (AEG) initiative in the development of a strategy to facilitate and incent the progress of that sector.

Energy supply and security is a critical part of our society. In Atlantic Canada, the four provinces have very different energy resources and electrical energy generation mixes. As with much of the world, Atlantic Canada is moving toward a more diverse energy portfolio, and energy sources that produce less greenhouse gases emissions. Through this process, our region has an opportunity to capitalize on our resources and strengthen both our environmental stewardship and our economic standing.

The Atlantic Energy Gateway initiative is facilitating increased cooperation between the four Atlantic Provinces and encouraging the development of the Atlantic region's clean and renewable energy resources. As part of this effort, the AEG is engaged in the creation of a strategic and factual foundation with respect to the development of the region's clean and renewable energy potential.

The Atlantic region has natural resources that can yield significant, new and expanded clean energy sources, including tidal energy, hydroelectric power, wave energy, biomass sources, and wind power. The contributions that our scientific and technical communities are making to the development of clean energy are helping to advance clean energy initiatives around the world.

The AEG commissioned this study to gain a more complete picture of the clean and renewable energy RD&D activities in Atlantic Canada, both in terms of types of technologies being pursued, and the intellection and institutional resources present in the region. Based on this information, the AEG sought analysis and suggestions to help direct future strategies.

This report presents summaries of the current state of clean and renewable energy used in each of the four Atlantic Provinces and a summary of research and development capacity. Following from those sections of the report, a detailed review of four major projects is provided that leads to a discussion of the qualities of an effective RD&D project. Potential areas of regional cooperation are then presented, along with a series of policy considerations intended to support the AEG's clean and renewable energy development initiatives.

SECTION 1 REGIONAL DISCUSSION - CLEAN ENERGY GOALS AND PRIORITIES: BROAD AREAS OF SHARED INTEREST AND POTENTIAL COOPERATION

1.1 Newfoundland and Labrador

NL Background

In 2009, 97% of Newfoundland and Labrador's electricity was generated from hydropower, with the remainder derived from oil, diesel, natural gas and some wind. About 30% of the Province's GDP is related to energy, the highest percentage in the country, and NL exports three times more electricity than is used domestically.

With installed capacity of over 6,700 MW from 40 plants, most of which (>5,400) is generated at Churchill Falls (Labrador) (and sold to Hydro Quebec through a long-term agreement), NL can be viewed as Atlantic Canada's clean energy leader in terms of resource and electrical generation. Outside of hydro-electricity, Newfoundland and Labrador Hydro operates 1 oil-fired generating station, 4 gas turbine generating stations and 25 diesel-fired thermal plants. Newfoundland and Labrador Power operates gas turbine generating stations and diesel-fired plants (Canadian Centre for Energy). In addition to larger hydro facilities and its main grid, Newfoundland and Labrador Hydro provides electricity to rural "off grid" customers via small hydro and thermal diesel plants, many of which are located in isolated communities in coastal Labrador and southern Newfoundland (the Island).

One biomass plant with 15 MW of installed capacity, using bark, sludge and sawmill shavings, is located at Corner Brook Pulp and Paper, where a biomass cogeneration (combined heat and power) system has been in operation since 2003.

A total capacity of 54 MW of wind energy is installed in 2 wind farms at St. Lawrence (27MW) and Fermeuse (27MW), which is low in comparison to other Atlantic (and other Canadian) Provinces. Nalcor is engaged in an RD&D project at Ramea as part of a wind-hydrogen-diesel energy project. NL is known to have a significant wind resource, but development is limited due to an 80 MW limit on the amount of wind energy that can be integrated into the grid. Nalcor recommended the 80MW upper limit based constraints identified in a 2004 review, and are still applicable today as the power system has not substantially changed: These constraints are (from MHI Report):

- *Water Management: Additional wind generation would cause less generation from hydro facilities and therefore more water would be spilled from reservoirs. For example, adding 20 MW to the upper limit of 80 MW, the amount of spillage would double from 9 GWh to 19 GWh on an annual basis.*
    - *Transmission grid security: Non-dispatchable generation could displace the demand from the hydro generation and cause the transmission network to be lightly loaded in certain areas resulting in an overvoltage condition. A small disruption to the system could cause widespread system disturbances.*
    - *Regional transmission issue: A possible overvoltage condition due to limited voltage control provided by wind generation.*

NL Clean Energy Goals

Components of Newfoundland and Labrador's "Energy Warehouse" are outlined in the 2007 Energy Plan entitled Focusing Our Energy. In terms of clean energy, "untapped potential also exists in other energy sources, such as wave and tidal energy, wood, peat, methane captured from landfills and solar energy in some areas."

NL's plans to advance the lower Churchill project are well known. The existing 5,428 MW (noted previously) has been generating power from Churchill Falls since 1971. Remaining potential sites for development exist at two locations on the lower Churchill River, known as the Lower Churchill Project (LCP). "The Lower Churchill Generation Project's two proposed installations,

Gull Island and Muskrat Falls, will have a combined capacity of 3,074 MW and can provide 16.7 Terawatt hours of electricity per year. That is enough to supply hundreds of thousands of households annually and contribute significantly to the reduction of air emissions from thermal, coal and fossil fuel power generation" (www.nalcorenergy.com). The Muskrat Falls Generating Station will have a capacity of 824 megawatts and annual energy production of 4.9 Terawatt hours. A transmission line interconnection will be made between Muskrat and Churchill Falls, and a 1,100 km long Labrador-Island Transmission Link will be constructed from Muskrat Falls to Soldiers Ponds in the eastern Newfoundland (Island), including a 30 km subsea crossing under the Strait of Belle Isle.

Power will be routed to Nova Scotia using existing lines, as well as a new Maritime Link from Bottom Brook, NL, to connect at Lingan, NS. The subsea link will be approximately 180 kilometres long and will have a capacity of 500 megawatts.

In terms of RD&D, "Barriers to development of hydro resources are not technical in nature" rather are more dependent on infrastructure and investment. "Transmission is a key enabler" and innovation can play a role.

NL Clean/Renewable Energy Priorities

Further to the objectives of this report, The Government of NL have taken steps to delve further into prioritizing efforts respecting clean energy technologies. In 2010, the Department of Natural Resources retained the consulting team of E4Tech, Orion Innovations and Wade Locke Economic Consulting to conduct a series of studies and provide recommendations for energy innovation priorities. Energy sources noted in the Energy Plan were reviewed, including crude oil, natural gas, wind, hydro, ocean, biomass, hydrogen, uranium, peat, geothermal, solar, power transmission, and energy efficiency & conservation. In short, nine priority themes across four energy areas were recommended for further road-mapping. With reference to clean energy the specific areas included:

- Onshore Wind – to address barriers impacting onshore wind innovation particularly related to icing, cold conditions, grid inflexibility/integration, and resource mapping
- Transmission – innovation to enhance power line de-icing capabilities with a focus on Labrador conditions
- Remote Energy – remote location power system technologies, with a focus on off-grid settings.

All energy sources underwent a screening based on a number of criteria. While not considered to be the highest priority areas, it is not to say that some of these energy types do not warrant further investigation. It is important to point out that the screening exercise was to determine whether or not to "carry forward" specific technologies for their further detailed innovation analysis. The criterion applied, however, allows general conclusions to be drawn as to the merits of committing resources toward certain energy types. With respect to clean energy technologies under review for this report, the consultants' reports concluded:

Table 1 – Newfoundland and Labrador Energy Source Screening

Energy Type	Sub-Type	Carry Forward for further innovation analysis?	Basis
Wind	Offshore Wind	Yes	Skills and resources are strong
	Small-scale wind	Yes	Some skills in applications engineering and resources are strong
	Novel wind concepts	No	NL capabilities not suited to innovation needs
Ocean	Wave	Yes	Required innovation may match local capabilities. Some local primary resource
	Tidal (instream)	Yes	Required innovation may match local capabilities. Some local primary resource
	Tidal (barrage)	No	No suitable sites particularly in comparison with other locations
	Novel (ocean thermal, osmotic)	No	Limited base to innovate and compete
Biomass	Feedstock supply	No	Limited innovation required. May (however) be an opportunity for provincial businesses
	Waste to energy	No	Modest resource level. Limited innovation base
	First generation biofuels	Yes	Fish oil as opposed to bio crops as a resource
	Lignocellulosic biofuels	No	Limited basis to innovate and compete
	Power generation	No	Technically mature. Limited innovation base
	Small scale heat	No	Technically mature. Innovation already dominated by others
	Large scale heat / CHP	No	Technically mature. Innovation already dominated by others
	Biogas and synthetic natural gas	No	No gas grid. Limited innovation base
Solar		No	Modest resource. Limited innovation base
Geothermal		No	No resource. Limited innovation need. No basis to innovate

To summarize, outside of hydro developments, the Province recognizes potential in the areas of: (1) onshore wind including large conventional turbines, as well as small scale wind; (2) harsh environment transmission; (3) marine energy technologies of offshore wind, wave, and tidal energy; (4) smaller scale first generation biofuels for local use, and; (5) recognizes a business opportunity in feedstock supply of forest related biomass. Additionally, and further to small scale wind and biofuels, the province is focussed on their application at (6) remote off-grid power

systems. Caution is noted respecting marine energy technologies in that the province does possess innovation resources and capabilities, however, NL is not likely to be a suitable location for deployment. The opportunity for NL lies in the provision of services to innovators from outside NL who may wish to make use of NL skills and facilities. Consequently, analysis and prioritization within marine energy technologies is less important than the development of an appropriate service- export plan.

Current and Future Projects of Interest: Potential Areas of Regional Cooperation

The resource of Newfoundland's, and primarily Labrador's, rivers offers the province the regionally unique ability to develop hydro-electric power, and in turn provides the province with clean electricity generation. Regional cooperation respecting transmission from NL to the other Atlantic Provinces and beyond is occurring now between NS and NL. As noted earlier, hydro developments are major industrial projects and do not represent RD&D.

The availability of this wealth of clean energy source has negated the need for NL to move forward with the development of other forms of clean energy, primarily onshore wind. The Province already exports most of its produced electricity, and has ample power supply to meet the needs of NL residents. In discussions with representatives of NL's Department of Natural Resources, it was suggested that the link with NS will enable the export of Labrador hydro power, but will additionally provide the means to add island based wind power, primarily for export. As well, there is clearly a medium to long term plan to develop Labrador onshore wind power, also for export, on a large scale.

NL Power's Ramea Wind Energy Project to assist in addressing the needs of off-grid communities, is consistent with NL priorities. It is highlighted as an example of regional (albeit limited) cooperation, and is summarized in Section 3 later in this report. The Province has provided funding for NL Hydro for the Coastal Labrador Alternative Energy Study to identify alternative energy sources for coastal communities now serviced by diesel generators. The primary focus includes wind and small scale hydroelectricity. Work includes hydro site identification, wind prospecting, transmission requirements, and other elements. Another area of focus, as evidenced by current road-mapping efforts overseen by DNR and NL Power/Hydro, is aimed at addressing the challenges of extreme harsh environments on wind turbines and transmission.

While not specifically RD&D, interesting discussions were also held respecting NL's abundant forest based biomass and the promising commercial potential of wood pellets, where three local companies are producing pellets for export. Unlike the three other Atlantic Provinces, where extensive land is privately owned, much of Newfoundland and Labrador's forest resource is held in crown lands. Moreover, NL's land mass has minimal agricultural development when compared to most of the Atlantic Canada region, so forest related would be the only source for biomass.

Areas of regional interest and potential cooperation, in which the experiences of the other three Atlantic Provinces might benefit NL, and the region as a whole, intuitively lies in: onshore wind;

small hydro; the effects of cold/snow/ice on wind turbine performance; small wind technologies; storage and integration technologies, and; forest based biomass and wood pellets.

1.2 New Brunswick

NB Background

NB Power's generating fleet has a total capacity of 3811.4 MW, consisting of hydro (888.1 MW), nuclear (660 MW), thermal (1738.4 MW)and combustion turbine (524.9 MW) sources. In addition, New Brunswick has 260 MW capacity of natural gas, 260 MW of wind, 294 MW of biomass, and 148.4 MW of biogas, and 2.4 MW supplied through net metering, giving an overall capacity of 4516.7 MW.

New Brunswick is in the unique position of being electrically connected to PEI, NS, New England (Maine), Quebec, and in the near future Newfoundland and Labrador. These connections provide New Brunswick with the ability to access electricity from numerous sources, and to be able to move to markets electricity from NB and from regional neighbouring provinces.

NB's Department of Energy released ***The New Brunswick Energy Blueprint*** in October of 2011. It provides a "long term vision and a three year action plan to work toward the objectives" of: low and stable energy prices; energy security; reliability of the electrical system; environmental responsibility, and; effective regulation. The Plan provides a comprehensive list of 20 government actions for the energy sector for the next three years. In general, the approaches contemplated by the NB government include:

- restructuring NB Power to promote greater efficiency and transparency in its operations
- achieving greater efficiency of energy use
- enhancing NB's ability to transition away from fossil fuels and towards stable priced fuel generation to reduce market risk
- ensuring NB energy markets are efficient and well regulated
- working towards more inter-governmental cooperation in terms of policies and projects
- optimizing strategic advantages in regional energy markets
- fostering innovation and improved energy technologies
- an on-going commitment to public, stakeholder and New Brunswick First Nations dialogue regarding energy issues, opportunities, challenges and solutions

NB Energy Goals

New Brunswick currently derives 28 percent of its in-province electricity demand from the clean energy sources of wind, biomass and hydro. It will create a new Renewable Portfolio Standard requiring NB power to increase this to 40 percent by 2020. It is noted in the plan that renewable energy imports such as hydro power from Quebec and Newfoundland and Labrador will be eligible under certain conditions. With the Point Lepreau nuclear station back on line this year, an added 35 percent will come from non-emitting energy, resulting in a total of 75 percent of NB's electricity demand coming from non-emitting or renewable energy sources.

Noted earlier, the NB Energy Blueprint provides a comprehensive list of 20 government actions for the energy sector. These specific actions fall under the following headings:

1. Reintegration of NB Power
   - Amalgamate NB Power group into a single vertically integrated crown corporation.

2. Electricity market and New Brunswick System Operator
   - Review electricity market policies. Implement appropriate structural and operational changes, including the dissolution of the NB System Operator and migration of the system operator functions back to NB Power.

3. NB Power – debt management plan
   - NB Power is to implement a debt management plan, allowing it to reduce debt and create shareholders equity.

4. NB Power – regulatory oversight and Integrated Resource Plan
   - NB Power operations will be subject to regulatory oversight and review, and will be required to present an Integrated Resource Plan every three years, and a Financial Forecast annually to the NB Energy and Utilities Board (EUB), or as directed by the EUB.

5. Regional electricity partnerships
   - Pursue regional electricity agreements, joint ventures and partnerships where there are positive commercial outcomes for NB Power and defined benefits for New Brunswick ratepayers.

6. Smart grid technology and innovation
   - Expand the network of smart grid stakeholders and partnerships and work with existing and new smart grid pilot projects.

7. Large Industrial Renewable Energy Purchase Plan (LIREPP)
   - Bring qualifying large industrial companies' electricity costs in line with their Canadian competitors by implementing a LIREPP.

8. Renewable Portfolio Standard (RPS)
   - Increase the Renewable Portfolio Standard to a minimum of 40 percent of NB Power's in-province sales by 2020.

9. Future development of renewable energy resources
   - Support local and First Nations small scale renewable projects
   - Integrate current and future wind generation in the most cost effective and efficient manner.
   - Support promising solar, bio-energy and other emerging renewable energy technologies.

10. Wood based biomass resource
    - Develop and implement supporting policies to optimize the energy output from wood based biomass resources with a specific focus on pellets.

11. Energy and climate change
    - Develop the key energy components for the 2012 – 2020 New Brunswick Climate Change Action Plan.

12. Electricity efficiency plan
    - Utilities, in conjunction with Efficiency NB, will be required to prepare a three year electricity efficiency plan.

13. Energy efficiency building code standards
    - Minimum efficiency standards will be required for new building construction by adopting national standards.
    - The New Brunswick Building Code Act will be amended to create the authority to do so.

14. Energy efficient appliances and equipment
    - Upgrade the list of regulated appliances and equipment under the *Energy Efficiency Act*.

15. Natural gas distribution rates
    - Review the natural gas rate structure and distribution network with the objective of achieving a cost-based rate structure and improve access to natural gas across the province.

16. Petroleum products pricing
    - Perform a comprehensive review of the Petroleum Products Pricing Act and Regulations for the purposes of ensuring its continued effectiveness in achieving the objectives of petroleum price stability, while ensuring the lowest possible price to the consumed without jeopardizing the continuity of supply.

17. Energy and Utilities Board
    - Restructure the Energy and Utilities Board to consist of exclusively full time members.

18. Office of the Public Energy Advocate
    - Establish and appoint a full time public energy advocate to replace the system of ad hoc appointment of public interveners.

19. Energy literacy, education and skills development
    - Develop an energy sector workforce development strategy
    - Pilot an energy certificate program
    - Implement an energy lit, education and awareness campaign.

20. Energy research and development
    - Develop and implement a New Brunswick energy sector research and development strategy supporting the adoption of emerging clean energy technologies.

NB Current and Future Projects of Interest: Potential Areas of Regional Cooperation

The NB Energy Blueprint notes that the province's electricity system is well-positioned to serve its needs for many years, and that "no significant capital expenditures to replace or refurbish current electrical infrastructure are expected over the next decade." Clearly, demand side management, energy efficiency, and the role of smart grid technology, is a high priority for NB utilities and the NB government.

Consistent with this priority, NB is a key player in the PowerShift Atlantic smart grid pilot project. PowerShift is further described in Section 3. Briefly, it is a regional demonstration project, using

pilot programs with residential and commercial customers, focused on finding more effective ways of integrating wind energy into the electrical system in the Maritime Provinces. Smart grid innovations enable homes and businesses to better manage energy consumption.

NB supports continued regional cooperation where it benefits the province, and mentions the Atlantic Energy Gateway (AEG) Project as being a “launching pad for detailed discussions and studies of potential benefits of regional electricity cooperation, including enhanced system integration, expanding clean and renewable energy sources, and regional transmission planning.” initiative in its Blueprint. It is believed that NB “could take on more intermittent renewable electricity sources, such as wind and solar energy, if such capacities were backed up and balanced by larger regional generation and load base.”

New Brunswick has been successful in integrating and balancing significant wind power in to the electrical system. The intermittent nature of wind, however, often leads to missed opportunities respecting cost savings from out-sourced energy purchases, and sales. New Brunswick’s next phase of renewable energy development will focus on smaller scale projects with a particular emphasis on non-intermittent sources such as wood based biomass. Wind energy will continue to be integrated, but in “measured and manageable stages.”

Competitive Requests for Proposals will be undertaken for small scale renewable projects, and a portion will be set aside for First Nations Projects. RFP approaches in NB, and NS, as well as the Large Industrial Renewable Energy Purchase Program (biomass and river hydro), appear to have potential for more regional cooperation and information sharing regarding approaches, success, challenges and a range of other related issues.

Given the interest in biomass in all four Atlantic Provinces, another area of potential regional cooperation may be built on New Brunswick interest in advancing biomass and wood pellets. NB’s Blueprint outlines a number of initiatives including: resource mapping; wood pellet industry research, best-practices (standards, QA/QC, certification, etc); and district heating & cogeneration applications and practices. Specifically the Blueprint notes that the U.S. Pellet Fuels Institute is developing standards for the U.S. Environmental Protection Agency. It points to “an opportunity for New Brunswick to lead in the development and expansion of (the) pellet industry by adopting pellet standards, possibly in conjunction with other Atlantic Provinces.

In summary, areas of shared regional interest might include: smart grid technologies and other issues related to demand side management; wind balancing and integration; smaller scale renewable energy developments – biomass, small hydro, wind; community, First Nations, and large industry involvement, and; biomass and wood pellets.

1.3 Prince Edward Island

PEI Background

Having no fossil fuel, nuclear or hydroelectric resources of its own, Prince Edward Island relies primarily on imported energy for transportation, electrical and heating needs. The PEI Energy Corporation is responsible for pursuing and promoting the development of energy systems and

the generation, production, transmission and distribution of energy, in all its forms, on an economic and efficient basis. In February 2012, PEI's total energy mix comprised 77% petroleum products, 13.5% electricity and 9.5% biomass. Petroleum products are used primarily as transportation fuel and for home heating. Wind resources supply roughly 18% of the electricity demand with the remainder tied primarily to fossil fuel and nuclear power imported from New Brunswick. PEI is home to the Wind Energy Institute of Canada (WEICan), which aims to advance the development of wind energy across Canada through research, testing, demonstration, training and collaboration. Biomass use is primarily firewood; sawmill residue and municipal waste for the generation of heat. To a lesser extent, cereal grains, oil seeds and crop residues are being used for biogas and heating use. Solar and geothermal energy are used for active and passive residential and commercial heat.

With the exception of Canada's northern communities, PEI has the highest electricity rates in Canada and despite being a leader in the use of wind energy for electricity generation, PEI relies primarily on imported electricity from New Brunswick to meet its total annual consumption of about 1.1 million megawatt hours (MWh). Two undersea cables transmit electricity to and from New Brunswick and Prince Edward Island. Two local utilities, Maritime Electric and Summerside Electric, provide 90% and 10%, respectively, of the Island's electrical needs. PEI's average electricity load is about 160 megawatts (MW), peaking at about 220 MW. When the load exceeds about 200 MW, PEI's utilities rely on locally generated electricity from wind and petroleum products. Of the 164 MW of wind generation capacity, 74 MW is dedicated for local distribution with the remainder used for export. A total of nine oil-fired generating units, with a combined capacity of 161 MW, are used only as a last resort.

Over the past 10 years, reliance on imported electricity, with fluctuating and ever increasing prices, has been addressed through provincial energy strategies (2004 and 2008). A new Prince Edward Island Energy Accord, implemented in March of 2011, focuses on lowering and stabilizing electricity rates and increasing the use of locally generated wind energy. Pursuing renewable energy development offers an alternative to conventional sources and provides greater control of energy prices, security, and diversity of supply.

PEI Clean Energy Goals

In 2004, PEI released its *Energy Framework and Renewable Energy Strategy,* which contained 19 objectives that encouraged and promoted energy efficiency and the use of renewable energy for fuels and electricity.

1. Committing to a Renewable Portfolio Standard for electricity of at least 15 per cent by 2010.
2. Maritime Electric Company Ltd. to file an Open Access Transmission Tariff with the Island Regulatory and Appeals Commission.
3. Evaluating the feasibility of biomass-fueled generating systems to determine their suitability for economical power generation.
4. Endorsing the use of solar technology, particularly for meeting domestic hot water requirements.

5. Continuing to evaluate the economic viability of an ethanol and bio-diesel industry in Prince Edward Island.
6. Evaluating the economic feasibility of collecting biogas from meat packing wastes for energy production.
7. Showing its leadership by immediately introducing transportation efficiency standards for new or replacement vehicles in its fleet.
8. Exploring with the Cities of Charlottetown and Summerside options for the development of public transportation systems.
9. Encouraging the adoption of both the National Building Code and the Model National Energy Code for Houses for new construction to reduce the per capita energy consumption within the residential sector.
10. Implementing electricity efficiency programs within its public buildings.
11. Requiring Maritime Electric Company Ltd. to file an approved energy efficiency plan and demand side management strategy with the Island Regulatory and Appeals Commission.
12. Allowing the PEI Energy Corporation to remain actively involved in advancing and developing wind projects in Prince Edward Island.
13. Exploring the possibility of removing the sales tax on all components of wind turbines.
14. Incorporating net metering for small wind power in statute to promote this development.
15. Evaluating manners of public compensation that may accrue from power generated from large wind facilities that are specifically developed to meet electricity export markets.
16. Ensuring the economic viability of community or wind cooperative systems by guaranteeing a selling price to the utility of up to 85 per cent of the retail residential rate.
17. Pursuing a method of enabling Prince Edward Island residents to invest in local wind energy projects.
18. Embarking on a monitoring program that systematically appraises the wind profiles of the island.
19. Formulating a possible role in advancing, demonstrating and deploying wind-hydrogren technology in Prince Edward Island.

In 2008, PEI released *Securing Our Future*, a three volume energy policy series that built on the objectives set out in 2004 and focused on v.1) Wind Energy; v.2) Energy Strategy; and v.3) Climate Change Action. The 2008 strategy doubled the RPS to 30% by 2013 and set as a goal the capacity to generate 500 MW of wind energy by 2013. The Strategy offered a 10-point plan for the development of wind energy on PEI.

1. Maximizing Energy Security, Independence and Price Stability for residents
2. Generating Revenue from Green Energy Exports
3. Demonstrating Community Support
4. Building a Collaborative Partnership Approach to Cable and Transmission Planning
5. Maximizing Economic Benefits
6. Promoting Sound Land-Use Planning
7. Assuring Compliance with Environmental Review Processes
8. Promoting Fair and Equitable Land Leases
9. Advancing a Consistent Taxation and Business Support Environment
10. Partnering with Proven Developers

In 2011, the Province of PEI, in partnership with Maritime Electric, implemented the five-year *PEI Energy Accord* with the objectives of:

1. Lowering electricity prices
2. Stabilizing electricity rates
3. Increasing the use of locally owned wind energy

In addition, the accord called for the establishment of the PEI Energy Commission to examine and provide advice on how to achieve these objectives.

PEI Clean/Renewable Energy Priorities

Wind

Prince Edward Island's wind energy resource is clearly one of the province's strongest and most valuable natural assets. As the percent of wind penetration on the Prince Edward Island electric grid increases, the ability to manage the energy input and operation of the grid becomes more complex. The PEI Energy Corporation built Atlantic Canada's first commercial wind farm at North Cape in 2001. Since then, the PEI Energy Corporation, Summerside Electric, Maritime Electric, and independent developers have increased PEI's wind capacity to 164 MW, of which 74 MW is dedicated for domestic use. With new wind energy developments underway, wind is targeted to supply approximately 30% of PEI's electricity by 2013.

Priorities for wind energy include:

1. Doubling of renewable energy portfolio standard from 15% to 30% by 2013.
2. Build out capacity to 500 MW
3. Maximize the benefits of large-scale wind developments for residents of PEI
4. Provide support to WEICan and encourage R&D opportunities for small-, medium- and large-scale wind developments on PEI
5. Facilitate the development of smaller community-based wind projects
6. Explore opportunities for economic development in the manufacturing, service and maintenance of small wind energy systems
7. Develop additional small wind capacity in PEI specifically for local demand and energy security
8. Planning for a third transmission cable between PEI and NB
9. Development of storage technologies

The PEI Energy Corporation also operates the PEI Wind-Hydrogen Village, a project that, similar to the NL Ramea project endeavours to integrate wind energy, hydrogen gas production and electricity generation into a self-supporting system that can be operated off-grid.

Biomass

PEI produces almost 10% of its total energy supply from fuel wood, sawmill residue and municipal waste. PEI Energy Systems uses municipal waste and wood biomass to supply thermal energy to commercial, residential and institutional buildings in Charlottetown. In 2007, PEI established the Environmental and Renewable Industries Committee (ERIC) to examine the potential for local biofuel development. ERIC determined that feedstock for bio-energy applications on PEI could be derived from waste management, forestry, agriculture, fisheries

and aquaculture industries. Biomass feedstocks (e.g. wood, cereals, straw, grasses, crop residues), in particular, offered significant potential for space and water heating applications and electrical generation. ERIC recommended the establishment of an Inter-Departmental Biofuels Committee (IDBC) to:

- Evaluate proposals for biofuels projects and studies with a view to making recommendations on their potential economic, environmental, and social benefits to Prince Edward Island.
- Work with biofuels proponents to identify applicable federal and provincial government assistance programs, as well as sources of private sector investment.
- Make recommendations to Executive Council by September 2008 on the feasibility of mandated renewable fuel standards for transportation and/or heating fuels (with and without a requirement for locally produced fuels), and the economic implications of road tax exemptions, rebates, and related policies and measures.
- Identify potential biofuels demonstration projects that can be implemented at government facilities and in government vehicle fleets, thus enabling government to lead by example in the advancement of biofuels.
- Require that the committee's activities be linked conceptually and strategically with the economic innovation strategy being developed by the Office of Bioscience and Economic Innovation.

Biomass challenges:

- Better understand the need to modernize labor regulations for the staffing of small heating plants
- Better understand the environmental and health concerns associated with biomass emissions (i.e. wood smoke)
- Determine the proper role that local biomass resources can play to meet the electrical and thermal requirements of PEI residents
- Ensure that increasing the use of local biomass resources is accomplished in a sustainable fashion
- Determining the proper transition for the production of locally grown feedstock to meet market demand
- Finding/creating the land use balance between food and energy crop production
- Understanding the full environmental, social and economic impacts of individual feedstocks and technology platforms for the production of liquid biofuels

Priorities for biomass energy include:

- Review existing codes and regulatory barriers affecting the further development of biomass fuel in PEI.
- Demonstrate biomass technologies in select public buildings across PEI.
- Actively promote the use and encourage the installation of biomass heating systems in PEI homes and businesses.
- Further investigate the use of biomass in urban district heating systems and the potential for cogeneration facilities with PEI utilities.
- Only be supportive and promote biomass installations that meet acceptable emissions levels.
- Identify and explore opportunities and applications for the utilization of pure plant oils.
- Consider the introduction of escalating Renewable Fuel Standards for ethanol and biodiesel.

- Endorse the concept of a Low Carbon Fuel Standard (LCFS), as a guiding policy framework to reduce GHGs, through the increased use of environmentally and economically sustainable alternative biofuels.
- Engage neighboring Provinces and States in formulating a collaborative regional approach to GHG reduction through the adoption of low carbon fuel standards.

PEI Current and Future Projects of Interest and potential areas of Regional Cooperation

Wind Energy Institute of Canada (WEICan) – Wind Energy Storage

The Wind Energy Institute of Canada (WEICan), with $12M of federal funding from the federal Clean Energy Fund and a $12.8M loan from the PEI government, is developing a 10 MW Wind Energy R&D Park with an energy storage system (Further discussed in Section 3). This research project will look at how energy storage can be utilized to maximize renewable energy production and stabilize the grid. The Wind Energy R&D Park and its data will also be accessible to those researching wind turbines and ancillary equipment. The project will also further WEICan's work in the small wind sector.

Participants in the project include Maritime Electric, NBSO, the regional system operator and academic researchers at UNB. The new asset base will allow WEICan to expand its mandate and provide sector-enabling support, and allow the project to offer a unique test bench for wind and storage systems. The availability of the project for research purposes will allow WEICan to expand its research role into wind forecasting methodologies, grid integration issues, storage facilities, and storage performance with respect to reliability and economics.

The priority will be to demonstrate the integration of a storage system with a small wind farm on a weak distribution system. The Project will be designed in close collaboration with Maritime Electric.

PEI Wind-Hydrogen Village Project

The PEI Wind-Hydrogen Village was developed over the past decade as a research, development and demonstration project that integrates conventional wind energy sources and hydrogen production technologies with the aim of creating an off-grid electricity supply for small, isolated communities. The wind turbines have a combined capacity of approximately 250 kW. Electricity from the turbines powers hydrogen production and storage equipment; the hydrogen is then added to the diesel fuel supply for the genset generator.

Two of this project's attributes set it apart from most other wind-hydrogen projects:

An innovative power supply configuration enables the wind turbines to serve as the sole source of power to the hydrogen production system. To operate off-grid, challenges related to the variability in quantity and quality of power has to be overcome.

The genset uses common diesel technology modified to allow hydrogen to be injected into the inlet air to displace diesel fuel, allowing the genset to obtain up to 50% of its energy from hydrogen. Although it is currently not cost-competitive with conventional diesel generation, it

may compete in certain niche markets such as northern and remote communities of Canada and beyond.

Maritime Electric – PowerShift Atlantic

Maritime Electric is involved in PowerShift Atlantic, discussed throughout various sections of this report (see Section 3), through its participation in the Residential Research Program within PowerShift. Potential residential participants have electric appliances in their homes that qualify for the program. 200 PEI residences have been selected to have a device installed on the qualified appliance that will enable Maritime Electric to monitor and control appliance loads. The program is in its early stage.

Town of Summerside – Load Switching Pilot Project

The Town of Summerside receives power from Summerside Electric, a utility owned by the town. The utility imports 51% of its electricity from New Brunswick. 49% of its power needs are generated on PEI either from the West Cape wind farm, the utility's 10 MW diesel turbine, or their new $30M Summerside wind farm. Summerside has embarked on a $2M pilot project using smart controls that could boost the performance of its wind farm by making the most efficient use of the wind when it's available. The controls indicate when wind power is available and can also be hooked up so that some appliances turn on automatically when wind energy is available. The utility can charge ceramic furnaces during off peak hours for load shifting. Households involved in the pilot can lease or buy high efficiency electric furnaces or water heaters that are connected to and controlled by the Summerside Utility via optical fibre internet connections. The cost of the high speed internet connection is included in the modest monthly lease charge. 100 smart control boxes are being used for the pilot that will expand to a 500-user demonstration.

PEI Renewable Energy Initiative

The Renewable Energy Initiative (REI) is a $7 M program offered through the Agricultural Flexibility Fund, a cost-sharing agreement between the Government of Canada and the Province of Prince Edward Island. The program is delivered by the P.E.I. Department of Agriculture in cooperation with the provincial Office of Energy Efficiency. Renewable energy sources can provide farmers with a degree of energy independence while improving both the individual farms and the agriculture sectors environmental footprint. Renewable energy is perceived as a major opportunity for farms on Prince Edward Island to reduce their energy input costs. This initiative is part of the overall effort to increase the competitiveness of the agriculture sector.

The REI provides financial assistance towards farm energy audits and the implementation of on-farm renewable energy systems. The purpose of the REI is to demonstrate the potential for on-farm renewable energy to improve farm net income while enhancing environmental sustainability. There are three components to the program:

1. On-Farm Energy Audit (a pre-requisite for Component 2)
2. Implementation of Renewable Energy Systems
3. Post Energy Audit (compulsory for those who receive funding

Potential for regional collaboration therefore resides in all areas (large and small) of the wind sector. Bioenergy is a component of the Renewable Energy Initiative, and biomass and biofuels are of great interest to PEI. Some interest may exist in tidal lagoon potential in the Northumberland Strait. AS well PEI was once a per capita leader in solar thermal residential use. Finally geothermal heat pumps are in use in commercial buildings in Charlottetown.

1.4 Nova Scotia

NS Background

Nova Scotia generates electricity from coal, petroleum coke, fuel oil, natural gas, biomass, wind, hydropower, and tidal energy. The largest component, approximately 65 percent on an installed capacity basis, comes from thermal plants owned and operated by Nova Scotia Power Inc., the province's privately-owned electrical utility.

Nova Scotia has four coal- and petroleum coke-fired generating stations with a combined installed capacity of 1,252 MW (see below). The Tufts Cove Generating Station in Dartmouth is the only natural gas-fired power plant in Nova Scotia, equipped with three generation units and two combustion turbines. With an installed capacity of 450 MW, it is the second largest generating station in the Province. The new heat recovery generator has a capacity of 50 MW and uses waste heat from the two combustion turbines as well as added natural gas (Nova Scotia Power).

In addition, Nova Scotia Power operates nine fuel-oil fired combustion turbines in Burnside Industrial Park, Tusket and Victoria Junction with a combined capacity of 222 MW. These turbines are primarily used to address peak demand loads and as back-up for intermittent generation supplies such as wind energy.

Three biomass-fuelled electrical generating facilities with a combined capacity of 46 MW are located in the province. All are operated by private companies with the largest being the Brooklyn Power Corporation in Queens County with a capacity of 21 MW. Two smaller facilities are associated with sawmills in the province. Nova Scotia Power is currently constructing a fourth biomass plant in Point Tupper, Richmond County that will have a capacity of 60 MW.

In terms of Renewable Electricity, Nova Scotia has 33 hydro generating stations, with a total installed capacity of 360 MW. The two units at Wreck Cove account for 220 MW of that capacity. The Annapolis Tidal Power Plant, the only tidal power plant in North America, has an installed capacity of 20 MW.

Nova Scotia has a total of 34 wind farms (including single turbines) with a combined installed capacity of 317 MW, up from approximately 200 MW at the end of 2010. This includes a total of 181 turbines of 0.5 MW and greater capacity located primarily in Northern Nova Scotia, Cape Breton and Southwestern Nova Scotia (Nova Scotia Power).

NS Clean Energy Goals

Over the last decade interest in reducing the province's Greenhouse Gas emissions has grown significantly, especially as it relates to electricity production. Nova Scotia's efforts to reduce Greenhouse Gas emissions are based on the high percentage of coal-based generation, from which it derives the highest percentage of its total capacity from fossil fuels (approximately 57 percent) when compared to the three other Atlantic provinces.

In 2010, the Province of Nova Scotia released a Renewable Electricity Plan that includes a detailed program to significantly alter the province's mix of electricity generation. At the time, nearly 90 percent of the province's electricity supply came from fossil fuels, a result of Nova Scotia's historical coal mining industry.

To accomplish this, regulations were enacted that commit the province to reach 25 percent in-province renewable electricity sources by 2015. A target of 40% of electricity generation from renewable by 2020 has also been established, which would quadruple the amount of renewable electricity generation capacity in 10 years.

In addition to electricity-based clean energy goals, the province made a commitment to support renewable thermal energy in Nova Scotia. These additional technologies include geothermal heating and cooling and biomass-source heating. Both of these programs are financially supported through Efficiency Nova Scotia programs that incentivise their inclusion in new construction and use as replacements for oil and electricity-based heating sources.

NS Clean/Renewable Energy Priorities

While energy efficiency remains a high priority with its own set of programs, the focus of the shift to renewable energy is new, with an emphasis on energy sources located within the province. The new capacity will be created through four mechanisms:

- Community feed-in tariffs (ComFITs): Community-based projects lead by non-profit group, First Nations, municipalities, institutions or for-profit entities employing a Community Economic Development Investment Fund (CEDIF). These projects must employ wind, hydro, tidal or biomass technologies that meet the ComFIT requirements. A goal of 100 MW of capacity has been established for this mechanism.
- Independent Power Producers: A Request for Proposal process established by a new Renewable Electricity Administrator will be used to establish contracts for large and medium-sized renewable energy projects. An equal amount of electricity generation capacity will be procured through continued RFPs issued by Nova Scotia Power Inc. The Utility and Review Board (UARB) will evaluate and approve NSPI-sponsored projects in the traditional way. While technologies are not prescribed for these RFP processes, it is expected that wind energy, biomass and tidal energy will fill the requirements.
- Extra-provincial sources: through agreement with generators in other provinces, renewable electricity will be procured to provide a large source of electricity that will both reach the 2020 goal of 40 percent renewable electricity generation, and provide a source that can balance intermittent local sources such as wind and tidal. Currently, Nova Scotia is looking to the proposed Muskrat Falls hydroelectric project on the Lower

Churchill as the source that would meet the requirements of this component of the Renewable Electricity Plan (refer to Section 1.1).

- Net metering: individuals and small businesses can, within the program requirements, establish their own distribution grid-connected sources of renewable energy and offset the cost of the electricity that they use. This existing program has been enhanced to allow greater generating limits and to provide retail rate compensation for excess electricity generated over a given one-year period.

NS Current and Future Projects of Interest

Of the energy sources expected to provide the required generation capacity described in the preceding section, tidal energy converters are the only non-commercialized technology. Due to the unique and abundant tidal resources in Nova Scotia, major research, development and demonstration initiatives are underway with the aim of achieving commercial-scale deployment of tidal energy converters that will provide a significant generating capacity. These initiatives are discussed in Section 3.3, but are summarized below:

- Environmental Impacts – primarily conducted through Acadia University's Centre for Estuarine Research, several projects are underway that examine the potential effects of tidal energy converters on marine life and the physical environment of the Bay of Fundy.
- Resource evaluation – numerical modelling to produce high resolution simulations of tidal currents in the Bay of Fundy, focussing on key tidal energy resource areas including the Minas Passage, Grand Passage and Petite Passage. Potential effects of the presence of turbines and arrays of turbines are also being modelled.
- Technology Demonstration – The Fundy Ocean Research Centre for Energy (FORCE) has established a technology demonstration site in the Minas Passage and will install transmission cables to connect the four berths to the provincial grid in 2012. Funded by the Province of Nova Scotia, the Federal government, EnCana and the berth holders, FORCE has established a program to allow technology developers to deploy tidal energy conversion devices with the goal of developing a commercially-viable marine energy industry in Nova Scotia.
- Wind projects have accounted for the majority of new renewable energy in Nova Scotia over the past several years, and will continue to be the main source of new renewables helping to meet the 2015 target of 25 percent of electricity generation from renewable sources. While the technology is well-established, RD&D activities are being conducted in Nova Scotia to address issues related to turbine tower manufacturing, blade de-icing, and two small-scale wind technologies: the expansion of Seaforth Energy's product line and market share; and the optimization of a turbine intended for use in agricultural and rural settings.

A new 60 MW biomass facility is under construction in Point Tupper, Nova Scotia by Nova Scotia Power Inc. This facility will help to close the gap on the 2015 renewable electricity target while providing steam to the adjacent pulp and paper mill. In addition to this industrial development, a number of RD&D projects are underway as discussed in Section 2, including the use of marine biomass to produce fuels, the use of fast-growing agricultural crops to produce pellets, and the use of biomass to produce high-value chemicals.

NS Potential Areas of Regional Cooperation

Nova Scotia's current track for the development of clean energy presents several opportunities for collaboration and cooperation. The largest and most well-known is the development of the Lower Churchill project and the related transmission lines connecting it with Nova Scotia. The project involves the two provincial governments and the provincial utility companies and presents significant future opportunities for cooperation through the establishment of the first grid connections between the island of Newfoundland and mainland North America. These opportunities primarily relate to Newfoundland and Labrador's capability to export renewable electricity, and thereby be a potential supplier of the same to the other three Atlantic Provinces.

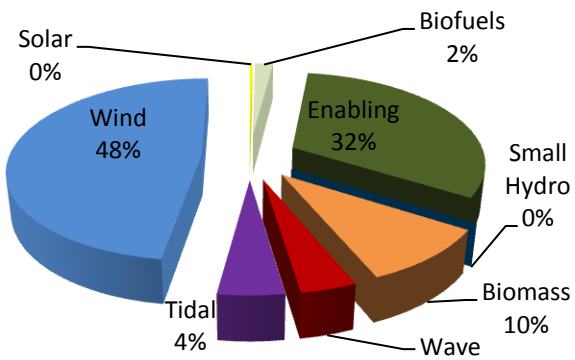
The use of various forms of biomass to generate heat and electricity has been identified as a focus area in Nova Scotia, New Brunswick and Prince Edward Island, where the agriculture and forest industries are interested in opportunities to supplement or replace traditional markets. Potential exists to cooperate in RD&D activities related to crop selection and productivity, processing methods, and technologies for conversion to fuels.

While Nova Scotia has the largest accessible tidal resource in Atlantic Canada, New Brunswick and Newfoundland and Labrador also have significant resources. The RD&D work currently underway in Nova Scotia, both for large and small-scale tidal conversion, presents a tremendous opportunity for the entire Atlantic region. Collaboration among researchers at government, industry and academic institutions in Nova Scotia, PEI, New Brunswick, and Newfoundland and Labrador provides opportunities for innovation that will assist in advancing the sector towards commercialization. Research capacity in science and engineering at the region's academic institutions and government labs, coupled with world class marine research infrastructure at the region's research facilities, along with a vibrant marine industry could all contribute to making Canada's marine renewable energy sector highly competitive in the global marketplace.

SECTION 2 CLEAN ENERGY RESEARCH AND DEVELOPMENT CAPACITY THROUGHOUT ATLANTIC CANADA

Clean energy RD&D is being conducted in academic institutions, by researchers, and involving the private sector, throughout Atlantic Canada, with localized focus on specialty areas of interest. Continued advancement in clean energy solutions and enabling technologies will effectively increase the capacity of each individual Atlantic Provinces to excel and provide stability to a future Pan-Atlantic working partnership.

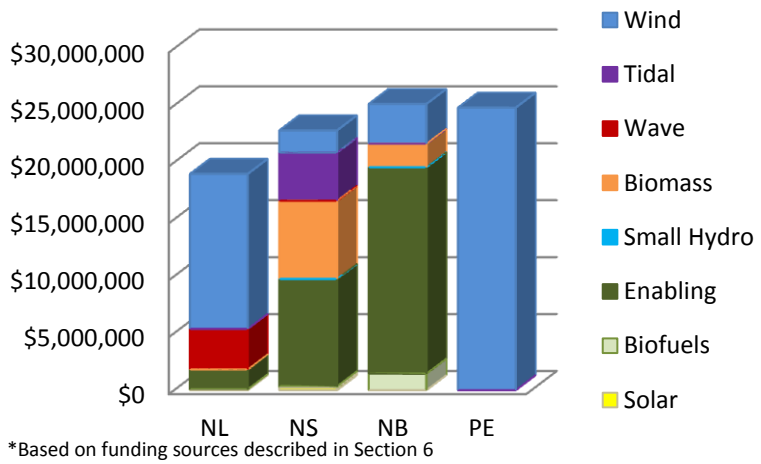
Figure 1 - Total Clean Energy RD&D in Atlantic Canada*



*Based on funding sources described in Section 6

Funding for the various researchers, institutions and programs has been a key component of the current Pan-Atlantic clean energy success. For example, “Since 2006, more than $343 million has been invested through the Atlantic Innovation Fund (AIF) in 145 RD&D projects throughout Atlantic Canada” as was noted on the ACOA website. With increased interest in the expertise and innovation within the Atlantic region it is apparent that all four provinces are poised to provide localized efficient resources for a clean energy economy.

Figure 2 - Clean Energy RD&D by Province*



*Based on funding sources described in Section 6

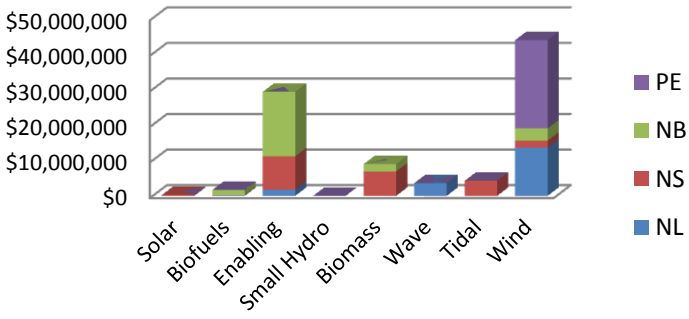
Each province has goals for their sustainable initiatives as detailed in the previous sections. The following capacity charts are constructed based on the main funding agencies project support over the last number of years. The reader is cautioned that the dollar values represent those reported through publicly available sources of the funding bodies noted. It does not reflect added funding through the leveraging sources. It nevertheless provides an order of magnitude picture of clean energy capacity for each province.

Figures 1 through 3 provide a summary of clean energy area project dollar values across the region. In terms of regional spread, most funding for clean energy is focussed on wind, enabling technologies often related to wind, and biomass/biofuels. Localized capacity exists in tidal (NS), wave (NL) and some solar (NS).

2.1 Newfoundland and Labrador

Areas of Clean energy R&D in NL appears focussed on aspects of: wind energy (wind/hybrid systems, advanced weather forecasting for wind, a craft to access offshore wind farms); two wave energy projects, biofuels from fish oil and forest residue; and; a number of enabling technology applications, namely fuel cell work led by Dr. Peter Pickup. Academic work is focussed at Memorial University and to a lesser extent at the College of the North Atlantic, often in conjunction with Nalcor or NL Hydro. While not incorporated in Figure 3, Nalcor and NL Hydro have and continue to complete studies in hybrid systems, wind and wind

Figure 3 - Clean Energy RD&D in Atlantic Canada*



*Based on funding sources described in Section 6

environments, small hydro and hydro related climate / environmental studies, but much of this work cannot be considered R&D or RD&D.

Overall much Energy R&D focus in NL has been aimed at providing solutions to challenges in oil and gas exploration and development. This, coupled with NL's clean energy from hydro and grid limitations, again has negated a need to prioritize R&D in wind and other alternative energy sources.

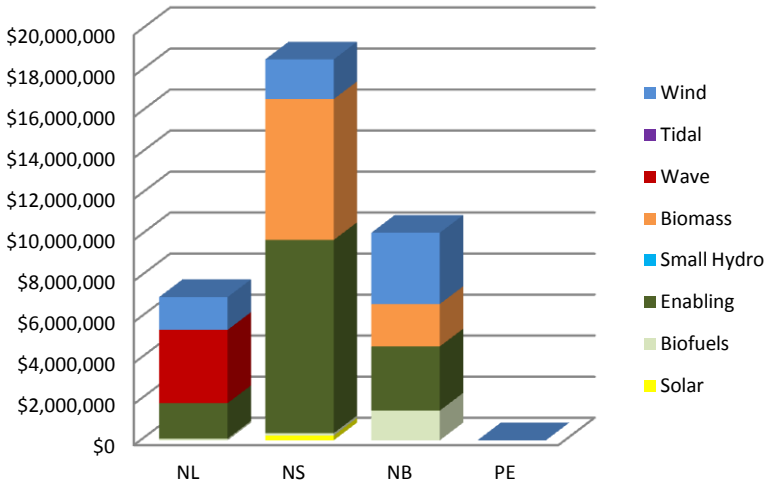
2.2 New Brunswick

In New Brunswick, much RD&D work in concentrated in areas of enabling technologies of demand side management (DSM), hydrogen storage and fuel cells. Through PowerShift, NB is leading DSM efforts. There is additional capacity in biomass/biofuels and ongoing work related to wind. UNB has developed a unique capacity under Dr. Luichen Chang's Sustainable Power Research Group. Dr. Chang is the lead and/or participant researcher in several projects concentrated on distributed generators, hydrogen and fuel cell technologies, as noted under the Wind-to-Hydrogen Atlantic Workshop, and is a member of the NSERC Wind Energy Strategic Network (WESNet), which partners with numerous enterprises, federal and provincial agencies and utilities across Canada, and the Wind Energy Institute of Canada.

2.3 Nova Scotia

Given Nova Scotia's immense tidal resources, particularly in the Bay of Fundy, untapped clean energy resources are present that could allow Nova Scotia to become a leader in marine energy conversion. Additionally, with the advancements of leading university institutions, such as Acadia University, tidal power innovation could be shared with other Atlantic Canada provinces. Tidal power expertise within Nova Scotia is also provided by RD&D completed by FORCE. NS R&D capacity in biomass energy is significant, and other provinces should look to partnerships with the NS academic community. As well, Mr. Jeffrey Dahn at Dalhousie leads efforts in advanced related enabling technologies (fuel cells). It is noted that Dahn and Memorial's Mr. Peter Pickup have partnered on strategic projects.

Figure 4 - Funding Excluding Major Projects*



*Based on funding sources described in Section 6

2.4 Prince Edward Island

Prince Edward Island leads the region in wind energy technologies and RD&D. Funding for a wind/storage project PE was provided by CEF and the PEI Government. This project consisted

of the development of the Wind Energy R&D Park and Storage System for Innovation in Grid Integration (Park).

Energy storage systems and development of enabling technologies will be key R&D components at the Park. It is recognized that the above noted charts are heavily skewed toward wind and enabling technologies due to large dollar amounts of funding provided under the Clean Energy Fund to three of the four primary RD&D projects presented in the following Section 3 (these are NB's PowerShift, NS's Tidal efforts and PEI's wind/storage project.

For interest, removing these projects from the analysis reveals that recent capacity trends are consistent, revealing strengths in the areas of enabling technologies (NS, NB, and NL), biomass (NS, NB), wind (NB, NS, NL) and biofuels (NB) (refer to Figure 4).

SECTION 3 EXAMPLES OF EFFECTIVE RD&D PROJECTS THROUGHOUT ATLANTIC CANADA

Section 1 of this report outlines provincial clean energy priorities as well as the current and future projects that will enable the provinces to achieve these goals. In Section 2, the report focuses on the research capacity and the research infrastructure that exists in Atlantic Canada. Section 4 to follow discusses the components of effective RD&D projects and Section 5 speaks to research areas within Atlantic Canada that may benefit from knowledge sharing and regional cooperation. This component of the report, Section 3, focuses on an example of effective RD&D projects that are underway throughout the region to provide a basis on which to build future effective and collaborative clean energy RD&D projects.

Throughout the duration of the work, select RD&D projects were cited by government and utility representatives as being excellent examples of regional cooperation, as well as government/private sector and academic partnering. An example from each province is discussed.

3.1 Newfoundland and Labrador – Ramea WHD Energy Project

See http://www.nalcorenergy.com/assets/nalcorenergyrameareport_january2010.pdf. A video is available at: www.nr.gov.nl.ca/nr/. The Wind-Hydrogen-Diesel Energy Project (WHD Project), led by Nalcor, makes the community of Ramea, on Northwest Island off the southwest coast of the island of NL, home to one of the world's few wind-hydrogen-diesel energy projects. The $12-million RD&D project, mainly funded by Nalcor/Government of NL, ACOA and Natural Resources Canada (NRCan), has been under development since 2007. Under Nalcor's lead, along with NL, ACOA and NRCan/CANMET, other project partners include NL Hydro, Memorial University and the University of New Brunswick, as well (originally) as Frontier Power. Specifically, academic support has been provided by Engineering and Applied Science, Memorial University; and the Sustainable Power Research Group, University of New Brunswick.

The WHD Project research focuses on integrating traditional diesel generation with wind generation and hydrogen production, storage and generation with the goal to reduce, and ultimately replace, the reliance on diesel generation technology to supply electrical service to remote and isolated grids. The Project involves the design of the overall system and energy

management system, procurement of equipment, construction, commissioning and the monitoring/studying system. The WHD project will use wind and hydrogen technology to supplement the diesel requirements of this isolated community. If successful, the technology could wean Ramea off diesel-generated electricity almost entirely and bring cleaner energy to the island and other isolated communities.

Ramea was the site of Canada's first wind-diesel demonstration project, which was constructed on the island in 2004. Wind now makes up about 10 per cent of Ramea's electricity supply, offsetting some of the originally entire dependence on diesel generation. The small wind farm included six refurbished 65 kilowatt turbines that produced at times too much energy for the local grid to handle. Nearly 60 per cent was wasted. The new hydrogen aspect is being tested in an effort to solve this problem, and the new wind-hydrogen energy system is expected to reduce the village's reliance on diesel significantly or perhaps entirely.

Three larger wind turbines (Northwind 100B, 100 kW) have been added to the island. Now when there's too much wind power, it will be used to produce hydrogen though water electrolysis. The hydrogen gas will then be stored in tanks and tapped when wind energy is not creating enough power for the community. A hydrogen converter generator will convert the stored hydrogen to electricity, producing much fewer greenhouse gas emissions than diesel.

Technical components of the project include a **hydrogen electrolyser**. Hydrogen is created by the electrolyser through the process of electrolysis using water and electricity to create oxygen and hydrogen gases. Oxygen is released into the atmosphere while hydrogen is stored in high-pressure cylinders to be used as an energy supply. The WHD project's first hydrogen production was achieved on December 12. Other components include the **hydrogen genset**, and an **energy management system (EMS)**, which will provide all automatic control and monitoring of the wind turbines, the electrolyser, genset, hydrogen storage, and the diesel plant to ensure safe and reliable delivery of energy to homes and businesses in Ramea. The EMS is the computer system which dispatches each piece of equipment associated with the WHD Project. The EMS was designed and is being built by Hydro and Nalcor Energy will retain all intellectual property rights to this critical piece of software.

A 40-metre meteorological tower was installed near the new wind turbines. The tower provides highly accurate meteorological data for wind speed, direction, temperature and humidity into Nalcor's Energy Management System to optimally dispatch different energy sources. This data will be stored on a central server and will be very useful during the research phase.

System integration entails the connection of the cables and piping that link the wind, hydrogen and diesel equipment together, and includes a safety instrumented system (SIS). The SIS consists of five safety stations that monitor the entire hydrogen system and will alert the operators of any problems with the equipment. In addition to the SIS there is numerous safety controls designed into the hydrogen mechanical system such as pressure regulating and relief valves and a specifically-designed vent stack.

Electrical switchgear interconnects all new equipment to the existing diesel plant 4160V bus. The switchgear provides Hydro with the ability to isolate the new equipment from the existing equipment if any problems occur on the system.

A network communications system will relay protection and control data to ensure the reliable operation of the WHD system. The communications system consists of network equipment; optical fiber and copper linking the diesel plant, new wind turbines, electrolyser, hydrogen genset, SIS and the meteorological tower. The new equipment allows Hydro to gain access to, and control, this remote site from its Energy Control Centre and Network Management Centre in St. John's; similar to other generation assets on the provincial electricity grid. A wireless radio link is also present providing communications between the Ramea diesel plants to Frontier Power's wind farm.

While the localized role is small, the provincial, regional, national and international potential for export is promising in the medium term. Nalcor hopes its wind-hydro-diesel energy technology can be commercialized and exported worldwide. Newfoundland alone has nearly two dozen isolated diesel-dependent electricity systems. If successful, similar systems could have application in any other of Canada's 100+ isolated communities. Globally there are many hundreds more isolated off-grid communities, many of which rely heavily on petroleum based energy or have no major energy system. The future goal would be commercialization of the energy management system needed for integration.

3.2 New Brunswick - PowerShift Atlantic

PowerShift Atlantic (much of this discussion is taken directly from www.powershiftatlantic.com) is a collaborative research project led in partnership by Natural Resources Canada through the Clean Energy Fund, New Brunswick Power, Saint John Energy, Maritime Electric, Nova Scotia Power, New Brunswick System Operator, the University of New Brunswick, the Government of New Brunswick and the Government of Prince Edward Island.

The four-year $32 million project, which started in 2010, focuses on finding more effective ways of integrating wind energy to our electricity system in the Maritimes. While a clean renewable energy source, wind is more unpredictable and irregular than traditional generation. One solution to working with the variability of wind generation is to find ways to shift the times that energy is delivered to homes and commercial buildings when it isn't needed. The goal of the project is to experiment and find acceptable ways to shift the time that electricity flows to homes and businesses, with minimal or no disruption or inconvenience to the customer.

The partnership has formed an innovative technology cluster to provide ancillary services for wind integration. This ancillary service will be carried out by shifting commercial and residential loads. The primary demonstration objective is to determine if load shifting can provide for more economical integration of wind rather than expensive supply side options to be built in the future. The scope of the project is significant with load shifting in up to 2000 sites. The primary objectives of the project are:

- Evaluate if load control is a cost effective and reliable ancillary service to dispatch net requirements.
- Evaluate load control performance in response to measured and forecasted wind power.
- Evaluate the customers' role and their acceptance of utility control for the purposes of renewable energy integration.

The PowerShift Atlantic Research Project concentrates on finding acceptable ways to remotely adjust the amount of electricity that flows to homes and businesses, with minimal or no disruption or inconvenience to project participants, at times when it is not required by the customer. The Residential Research aspect is conducted by Saint John Energy, Maritime Electric and Nova Scotia Power. Specific criteria are set by the various utilities and an initial group of participants is selected. The utilities determine if potential participants have electric appliances in their home that qualify for the program. Participants who qualify and agree to join the program have a device installed on a qualified appliance.

The Commercial Research Program will be conducted at Nova Scotia Power and New Brunswick Power. Commercial customers will be approached by their local utility to determine whether they are interested in participating in the research program and whether they qualify for the project. Commercial customers will be required to have a qualifying end use (for example, refrigeration/freezer storage), as well as a suitable energy load that can be shifted, based on the availability determined by the customer. Through a mixture of required hardware and software, the utility will be able to remotely control certain end uses at the customer's location to help integrate wind energy more efficiently into our electricity system in the Maritimes.

The primary academic partner is the University of New Brunswick's Sustainable Power Research Group, led by Dr. Liuchen Chang in the Department of Electrical and Computer Engineering. The group conducts research and training in the areas of distributed power generation, renewable energy conversion, power electronics, electrical machines, communications, and advanced control systems. The current research activities include development and demonstration projects of distributed power generation based on wind, photovoltaic, small hydro, micro-gas turbine and fuel cell systems.

Shifting power demand has regional and global application, and could bring major change to the Maritimes and to North America as a whole, and offers the potential to bring more wind energy to North America.

3.3 Nova Scotia – Tidal In-Stream Energy Conversion

Nova Scotia has a world class tidal energy resource in the Bay of Fundy, with significant resources located in other areas of the province. Research from the California-based Electric Power Research Institute published in 2007 identifies the Bay of Fundy as the best site in North America for tidal power generation. An estimated 14 billion tonnes of sea water passes through the Minas Passage on each tide cycle creating currents in excess of 5 metres per second. Recently, local scientists have estimated that potentially 2,000 MW of tidal energy could be safely extracted from the Minas Passage alone.

Tidal in-stream energy converters are the preferred technology for the generation of electricity from tidal energy resources because heavy civil works such as dams, and the significant environmental effects that accompany them, are not required. In-stream devices convert the kinetic energy of moving water to electricity, but with a higher capacity factor than wind turbines. Another advantage of tidal energy conversion is the predictability of the electricity that is generated; tides are predictable therefore the energy that can be extracted from them is also

somewhat predictable, making it easier for transmission utilities to integrate tidal power with electrical grids.

Aside from being a potentially useful source of electrical generation, the development of tidal in-stream energy converters holds significant promise for future economic benefit to the parties involved in its successful commercialization. As with efforts underway in the United Kingdom, the proponents of Nova Scotia's nascent tidal industry hope to see socio-economic benefits to Nova Scotia beyond the electricity sales generated through the installation of commercial arrays in the Bay of Fundy.

Two Offshore Energy Research Associations were established by the Province of Nova Scotia in 2006 – the Offshore Energy Environmental Research Association (OEER) and the Offshore Energy Technical Research Association (OETR). In 2008, the independent, non-profit Fundy Energy Research Network (FERN) was established at the Acadia Centre for Estuarine Research at Acadia University to "c*oordinate and foster research collaborations, capacity and information exchange to understand the environmental, engineering & socio-economic factors associated with tidal energy development in the Bay of Fundy".* In 2009, the Province enabled the formation of the Fundy Ocean Research Centre for Energy (FORCE). FORCE is a non-profit organization that is funded by the Government of Canada, the Province of Nova Scotia, Encana Corporation, and member developers. FORCE has established a demonstration site in the Minas Passage, an observation facility near Parrsboro, and will complete the installation of subsea transmission cables with grid connection in 2012.

In 2008, OEER commissioned a Strategic Environmental Assessment (SEA) that examined potential effects of tidal energy extraction in the Bay of Fundy. The SEA made recommendations intended to ensure that tidal energy developments would maintain the ecological integrity of the Bay of Fundy and environs, and make a "*positive contribution to the social, economic and cultural well-being of Nova Scotia as a whole and of rural communities in particular*". The report also recommended that demonstration trials be conducted for both large and small-scale technologies that could be deployed in a variety of locations.

The report reinforced the need to ensure that other marine resources and users are not adversely affected, and further emphasized the need for research to examine long-term, cumulative and far-field effects of commercial operations. With respect to the devices, the report recommended environmental monitoring programs and the establishment of threshold criteria to define the circumstances under which devices must be retrieved.

Subsequent to the SEA report, the Government of Nova Scotia made the development of tidal energy a component of its Renewable Electricity Plan and established FORCE as a demonstration site for large-scale in-stream tidal energy technology. There is also a strong commitment by Nova Scotia to support community-based small scale tidal energy conversion. These two elements are discussed separately, below.

<u>Large Scale Generation: The Minas Passage</u>

OEER has been the primary funder of tidal energy research in the Bay of Fundy. OEER has facilitated investigations into the impacts of tidal energy devices on the environment of the Bay

of Fundy, as well as the impacts of the Bay of Fundy on tidal devices deployed in its rather harsh environment.

Determining the potential effects associated with the extraction of tidal energy from the Bay of Fundy requires information from a variety of scientific and technical disciplines. Since their inception, OEER, FORCE and FERN have initiated research projects to begin filling gaps in the understanding of the Bay of Fundy as a natural system and how tidal energy converters may impact that system. Research programs funded by these organisations focus on hydrodynamics, geophysics, biology, ecology, and cable installation and monitoring.

Research investigations have been collaboratively conducted by institutions such as Acadia, Dalhousie, St. Mary's, the Nova Scotia Community College and the Bedford Institute of Oceanography, with funding from Federal and Provincial governments through FORCE and OEER and with the close interaction of device and site developers.

Environmental effects monitoring programs are in place to examine changes to the acoustic environment, benthic habitat, fish movement, lobster presence, marine mammal and seabird behaviour and presence in the Minas Passage.

Concurrent with this research is the device-oriented RD&D that is undertaken and funded by the technology developers. To date only the Open Hydro device has been deployed at the test site by Open Hydro and its utility partner Nova Scotia Power, although three other technology developers hold berths and are planning demonstration projects.

Small Scale Generation

Several locations within the Bay of Fundy have been identified as having strong potential for electricity generation on a smaller scale, including Digby Gut and passages between Digby Neck, Long Island and Briar Island, all in Digby County. A community-based company, Fundy Tidal Inc., has been pursuing tidal energy development in these and other areas since 2007. With the introduction of the Nova Scotia Community Feed-in Tariff (ComFIT) program in 2011, Fundy Tidal Inc. now has a financial mechanism that will allow development to proceed.

Research specific to Fundy Tidal's proposed devices and deployment sites ongoing with funding provided by NSERC and OEER/OETR. Work completed to date includes assessment of tidal resource, modelling of tidal arrays in Grand Passage and deployment of a device in Grand Passage. OEER/OETR also funded a gap analysis for small scale in-stream tidal technology earlier this year to identify sites suitable for device demonstrations, device efficiency, and an assessment of environmental impacts associated with the devices.

Currently, an assessment of the in-stream tidal energy resources in Southwest Nova Scotia (Shelburne, Yarmouth and Digby Counties) is being conducted by Acadia University in collaboration with Dalhousie University, the Nova Scotia Community College and Fundy Tidal Inc. Field work will include deployment of Acoustic Doppler Current Profilers (ADCP) and input from local fishermen and communities. All research and technological developments included in the work scope will include the training of students in Marine Renewable Energy.

According to OEER, "the Resource Assessment will incorporate all phases of small scale ocean renewable energy development for Southwest Nova Scotia for both pilot and commercial scale developments. Deliverables from the project will include charts with information on current water use and areas of high velocity currents, recommendations for ADCP deployment locations and tide corrected high resolution bathymetry in GIS and latitude, longitude and depth formats. The project will take place from November 2011 – April 2012".

3.4 Prince Edward Island – Wind/storage

PEI has no conventional energy resources of its own and as a result has developed its capabilities in wind energy, clearly one of its most valuable natural resources. In its last two provincial Energy Strategies (2004 and 2008) and in its most recent Energy Accord (2011), wind has played a major role in PEI's goals of reducing and stabilizing energy rates and in increasing energy security. The PEI Energy Corporation is responsible for developing wind energy projects on PEI. Beginning in the 1980s it began to develop a wind energy test site, which grew into what is now known as the Wind Energy Institute of Canada (WEICan). WEICan strives to advance the development of wind energy in PEI and across Canada through research, testing, demonstration, training and collaboration.

Recently, WEICan received funding to develop a Wind Energy R&D Park with a utility-scale energy storage system. The priority will be to demonstrate the integration of a storage system with a small wind farm on a weak distribution system. The project will feature 5 DeWind Co, D9.2 wind turbines - generating capacity of 10 MW, a utility-sized electricity storage system and the examination of grid integration technologies to increase the economic viability of intermittent electricity generation. DeWind, a wholly-owned subsidiary of Daewoo Shipbuilding and Marine Engineering Co. Ltd. will be supplying the wind towers through another subsidiary, DSTN Trenton, a Nova Scotia company. The project represents a milestone for DeWind: the first DeWind turbines installed in Canada and the first DSTN towers supplied for DeWind turbines.

The Federal Clean Energy Fund contributed $12M and the Province of PEI contributed $12.6M as a repayable loan. The award will allow for the sustainable operation of WEICan through electricity sales to partner Maritime Electric. The project will investigate how energy storage can be utilized to maximize renewable energy production while reducing instability of the provincial electrical grid. The Park will be made available for wind energy research and development, making its data available for research projects and as a test bed for auxiliary technology concepts for wind turbines and wind farms. Support, through this project will also further WEICan's research, development, and demonstration in the small wind sector.

The new Wind Park will allow WEICan to expand its research mandate and provide sector-enabling support helping manufacturers, governments, and academia evaluate and improve their technologies. The project will offer system operators and utilities a test bench environment for wind and storage systems that currently do not exist. The availability of the project for research purposes will allow WEICan to expand its research role into:

- Optimization of wind forecasting and forecasting methodologies using real-time data
- Grid integration issues
- Continued testing, research, development, and demonstration of small wind technologies

- Storage facilities to mitigate energy intermittency
- Storage performance with respect to reliability and economics.

WEICan presently collaborates internationally and with companies in Canada and the Atlantic region. The demonstration involves a number of collaborators from Maritime Electric and the New Brunswick System Operator. Seaforth Energy's AOC 15/50 Wind Turbine is being commissioned at WEICan for "Testing Leading to Certification". Academic research collaborators include the Sustainable Power Research Group (SPRG), Directed by Dr. Liuchen Chang, UNB. Focusing on renewable energy systems, particularly wind energy conversion systems, SPRG has grown into one of the largest academic research groups for renewable energy Canada. The Canadian Wind Energy Strategic Network (WESNet), also led by Dr. Liuchen Chang, includes leading researchers from 16 Canadian universities in six provinces, NRCan and Environment Canada, the Canadian Wind Energy Association, utility companies, wind sector businesses and WEICan. Holland College, located on Prince Edward Island, offers a 9 month Wind Turbine Technician program. The program is certified by the internationally recognized BZEE Education Centre for Renewable Energies in Germany. Holland College and WEICan operate a training tower located at WEICan's North Cape site and provide wind tower climbing and rescue training to their students. Dr. Yves Gagnon, KC Irving Chair in Sustainable Development at the Universite de Moncton is Vice Chair of the WEICan Board.

Potential exists for new collaborative relationships with the Dalhousie Research in Energy, Advanced Materials and Sustainability (DREAMS) program, Directed by Dr. Mary Anne White and the newly created Renewable Energy System's Lab, in the Faculty of Engineering at Dalhousie, directed by Dr. Lukas Swan.

The WEICan project exemplifies positive benefits to government, academic, and industry stakeholders in Atlantic Canada; WEICan has become fiscally sustainable, regional academics can benefit from and contribute to the success of the project, regional industry earns revenue and benefits from services, and governments achieve goals; a win – win – win situation.

SECTION 4 COMPONENTS OF AN EFFECTIVE RD&D PROJECT

The initial discussion in this Section steps away from the direct topic at hand to review more generic characteristics that have come to be recognized as components that constitute effective high quality R&D projects. Following this, the components are applied to the four key clean energy projects to test the parameter's fit. Prior to a discussion of the parameters that "make up" good RD&D projects, it is important to recognize the stages of the innovation chain, and what project stage appears to broadly meet the needs of AEG stakeholders.

Using the Canada Revenue Agency's Scientific Research and Experimental Development (SR&ED) program qualification parameters, the early stages of innovation can be defined as:

- Basic research – research to advance scientific knowledge without a specific practical application in view
- Applied research - research to advance scientific knowledge with a specific practical application in view

- Experimental development - to achieve technological advancement to create new materials, devices, products, or processes, or improve existing ones

The Atlantic Energy Gateway (AEG) initiative aims to facilitate development of the Atlantic renewable energy sector by fostering collaboration, common understanding, and communication among governments, and between governments and the private sector, to maximize and expedite the development of renewable energy sources in the region. The AEG will foster regional cooperation and collaboration in the planning and operations of the Atlantic electricity sector, which will facilitate the development of clean and renewable energy in the region, thereby displacing GHG-emitting sources of electricity.

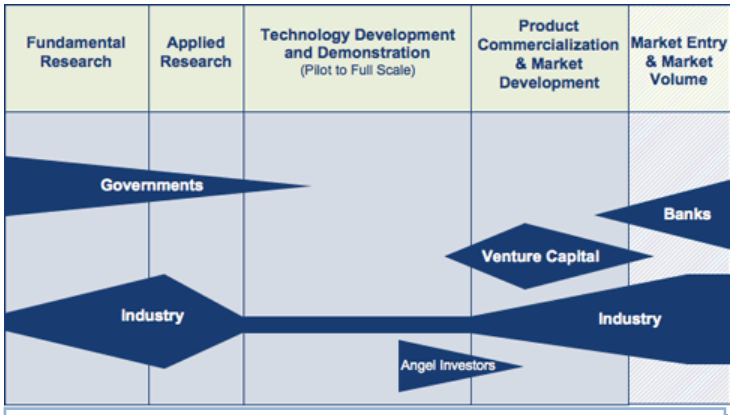


Figure 5: Innovation chain and funding (Sustainable Development Technology Canada)

In keeping with the objectives of the AEG, the development of the region's clean energy resources entails a focus toward the "middle" of the innovation chain. Indeed, the four projects previously presented in Section 3 range from applied research to pre-commercial demonstration, essentially in the middle of the innovation chain noted above. This is not to say that pure fundamental research should not be supported. A number of financial programs such as NSERC are in place to do so, and these will be discussed later in Section 7.

Members of the SLR/Maxis team have been involved in the study of the topic of R&D in a number of sectors throughout Atlantic Canada. The clean energy projects noted above share similar characteristics to other RD&D approaches deemed successful in other sectors. With reference to Atlantic Canada's offshore petroleum industry, extensive study has focussed on assessing methodologies to identify effective applied R&D strategies, in part to assist industry in meeting stringent Atlantic and Nova Scotia Accords requirements of offshore operators respecting R&D commitments and expenditures. Effective RD&D projects work when:

- The region has a significant resource base (has **local relevance**)
- There is a realistic chance of **use-ability and innovation**
- **Priorities** are established and recognized
- They meet a **market need** (international relevance, export potential)
- Industry needs are front and center; **industry is engaged** as an active participant
- **Government needs / objectives** and policies are **aligned**
- Local/regional industrial and academic **capacity** exists to provide solutions (facilities, Highly Qualified People (HQP))
- Industry and government needs are **matched** with local RD&D capabilities to create regional value

- **Adequate funding** is maximized by leveraging (industry, government and academia; programs without matching or repayable conditions are often ineffective)
- **Global** links and international **alliances** are struck when relevant (recognize that other area of the world might be more advanced in certain subsectors)
- Plans and structures allow open **communication** and information sharing (effective means of internal and external communication, as well as keeping data current)

The components above allude to partnering and cooperation between government entities, the private sector, and the academic community. Depending on the size and global reach of the application of technologies and projects in question, cooperative partnerships are valuable on a local, regional, national, and international scale. Effective RD&D projects are often supported by an organizational structure that includes a central body to play a "fourth pillar" facilitation role, supported by a "with or without walls" working and assessment group.

The four projects highlighted in Section 3 align well with these parameters on the framework of effective partnering (Table 2). In conclusion this basis of project assessment can be applied to future potential clean energy projects approved under the AEG.

Table 2 – Attributes of the Four Major Projects

	Ramea Wind Energy	Power Shift Atlantic	Tidal Energy	Wind Storage
Local Relevance	✓	✓	✓	✓
Use-ability and Innovation	✓	✓	✓	✓
Established Priorities	✓	✓	✓	✓
Market Need	✓	✓	✓	✓
Industry is Engaged	✓	✓	✓	✓
Consistent with Government Objectives	✓	✓	✓	✓
Local/Regional Academic Capacity	✓	✓	✓	✓
Matching (Industry, Government and Academic Partnerships)	✓	✓	✓	✓
Adequate Funding	✓	✓	✓	✓
Global Alliances (if required)			✓	
Communication and Information Sharing	✓	✓	✓	✓

SECTION 5 AREAS THAT MAY BENEFIT FROM INFORMATION SHARING AND REGIONAL COOPERATION

All four Atlantic Provinces have varying levels of interest in, or in advancing, energy/electricity generation from aspects of wind energy, biomass, biofuels, marine renewable energy (primarily

tidal, with wave/current technologies noted), small hydro, and to a lesser extent solar and geothermal sources. The challenges and immediate priorities differ somewhat locally within the region.

Determining detailed clean energy priorities and specific related projects are beyond the scope of the SLR/Maxis team. Areas of shared interest are, nevertheless, evident within the findings of this report. These broad areas can potentially form the basis of more detailed technical review to determine the merits of pursuing related regional partnering projects.

5.1 Offshore and Onshore Wind (larger turbines)

The entire region has an interest in advancing offshore wind but recognize that the prospect of large scale development is not an immediate priority and would depend on an ability to compete in export markets. Utilities and governments can remain abreast of international developments and communicate with each other through the AEG structure proposed in the next section.

A regional interest exists in ongoing wind energy development, but concerns voiced primarily in NB and NS are related to the challenges in wind integration and balancing. Current demand side management work under PowerShift Atlantic is designed to be a means of addressing this, and further studies may well be required. PowerShift complements storage options, which are a second means of dealing with the same issue: integrating the highly variable wind generated power.

The WEICan Wind Energy R&D Park offers wind energy infrastructure for testing and demonstration. The institute collaborates internationally and with companies and researchers in Canada and the Atlantic region. PEI offers a wind energy technician program at Holland College. UNB and University of Moncton collaborate presently and Dalhousie can collaborate through researchers in Science, Engineering and Management. Dalhousie's DREAMS program offers top materials researchers and a funded supply of the undergraduate students to post-Doctoral Fellows that they supervise. The Institute for Research in Materials and a proposed Clean Tech Research Chair offer further potential. NS, NB and PEI have considerable experience in introducing wind energy into the grid, and two Nova Scotia companies produce wind towers and/or turbines and blades (DSME and Seaforth Energy).

Limitations on NL's grid for additional renewable energy given the abundance of hydro power have detracted from a need to develop large wind farms. Yet the province has identified wind as an important clean energy source, and has commenced studies focussed on road-mapping the impacts of harsh (cold) environments on turbine performance and transmission.

The entire region is affected by harsh environments, and in some cases poor weather has caused the shut-down of turbines in Atlantic Canada (e.g. Suez Energy's NB Caribou Mountain ice and cold issues in 2011 and 2012), and internationally. The region would benefit from shared insight and regional partnering to address the international challenges associated with the negative impacts of high winds, cold and ice of large (and small) turbines. Further, improved accuracy of weather/wind forecasting on an hourly basis would benefit the industry as a whole, and clearly an interest exists. In July 2010 NL hosted a "Wind Energy Development in Harsh Environments Workshop." Over 120 people participated, 10 of whom were representing

organizations from the other three Atlantic provinces: NB (UNB, NSERC Atlantic, NRC-IRAP); NS (Stantec Consulting, Emera, Offshore Energy Research Canada, Nova Scotia Power), and; PEI (Island Technologies Inc, Frontier Power Systems).

The Atlantic Region can and does benefit from expertise at the University of New Brunswick's Sustainable Power Research Group, Directed by Dr. Liuchen Chang; Dalhousie University's Renewable Energy System's Lab, Directed by Dr. Lukas Swan; and the University of Moncton's expertise under Dr. Yves Gagnon, KC Irving Chair in Sustainable Development. Combine the expertise of participants, researchers and stakeholders for the Ramea Wind Energy Project RD&D with the current active enabling technology such as the Available Wind Power Forecasting, which was developed by AMEC Americas Limited, and efficient enabling technologies will increase the effectiveness of wind power locally, and ultimately, regionally. The net power forecasting, of which a portion is currently used as a tool by NTV local weather forecasts, could provide the capacity for a Pan-Atlantic wind forecasting service. Provision of regionally-based wind forecasting service could benefit the overall capacity for the generation and distribution of wind energy. This in turn, could also be redesigned or modified to provide the capacity of wind fluctuations and power forecasts regionally for tidal and/or wave projects. PEI's WEICan site, with an added recent focus on wind energy storage and grid integration is as well consistent with the priorities of NB and NS. Indirect added work in coatings and turbine repair can also benefit the region as a whole.

In terms of smaller wind applications, NL is regionally unique in that a number of communities are off-grid, and hence interested in solving the challenges and expense of diesel generation in these communities. NL is not unique in its interest in small wind turbines for a number of small technology applications. Interest exists in Nova Scotia in the area of vertical axis turbines suitable for agricultural and rural environments. Again, one NS based company manufactures a 3.7 kW and a 50 kW turbine, and is now developing a 50 kW turbine that will operate at lower wind speeds.

5.2 Additional Demand Side Management Studies

New Brunswick and other provinces could benefit as a whole implementing a provincial and regional Powershift using respective predominant clean energy sources. Each province would be able to provide a certain capacity to the Powershift system by accommodating the intermittent nature of wind power for instance. Currently communities in NB, PEI and NS have been contributing to the Powershift program, which focuses on the capacity of a collaboration between smart grid technologies, customer loads, and intermittent renewable energy sources from the respective provinces.

The region may learn from the experience of others when it comes to smart grid technologies. For example, in response to opposition to nuclear power in the wake of the Fukushima disaster, South Korea's plans to install smart meters in half the country's households by 2016, which could cut electricity consumption equivalent to the cost of one nuclear power plant.

5.3 Energy Storage Technologies

Electricity storage is an increasingly important component of renewable energy use. Within the Atlantic region, academic capacity expertise exists in electricity storage, fuel cells and battery technologies. The Wind Energy Institute of Canada (WEICan) is advancing the development of wind energy across Canada through research, testing, demonstration, training and collaboration. The new 10 MW Wind Energy R&D Park will investigate and demonstrate how energy storage can be utilized to maximize renewable energy production and help to stabilize the electrical grid. Again, potential exists to build on the current collaborative relationship with Sustainable Power Research Group at UNB. Similar to the discussion on wind, collaboration potential exists with the Dalhousie Research in Energy, Advanced Materials and Sustainability (DREAMS) program. The purpose of DREAMS is to train a cohort of research scholars (Masters and PhD students, undergraduate summer research students and postdoctoral fellows in Chemistry, Physics and Mechanical Engineering) at Dalhousie University who will address important aspects of energy production, storage and sustainability. Furthermore, the newly created Renewable Energy System's Lab, within the Faculty of Engineering at Dalhousie, offers electricity storage expertise for wind energy and transportation needs. Dr. Jeffrey Dhan at Dalhousie and Dr. Peter Pickup at Memorial are both recognized as world experts of Energy Storage and Fuel Cells.

5.4 Small Hydro

While a moratorium on hydro development remains in effect on the island portion of NL, Nalcor is looking at small-scale hydro development in Labrador, and studies have been completed over the years looking at a number of small hydro sites on the island. NB's Blueprint points to river hydro as having potential for its Large Industrial Renewable Energy Purchase Program. The NBDOE has recently released hydro resource maps showing the technical power potential for small hydro in the province (http://www.gnb.ca/0085/Hydro_Conventional-e.asp).

While penstock-type small hydro might not be considered RD&D, the provinces of NL and NB might benefit from shared effort in small hydro development. Further, emerging smaller tidal technologies (such as run-of-river/kinetic devices) can have application in river settings (see Tidal discussion) and might be considered, as an AEG area of interest, in conjunction with ongoing work in NS. It is of added interest that Seaforth Energy, discussed previously under wind regarding their manufacturing of the AOC 15/50 turbine in Dartmouth, also owns and operates an 850-kW run-of-river hydroelectric facility in New Germany, Nova Scotia under subsidiary Morgan Falls Power Corporation.

5.5 Tidal

While Nova Scotia has the largest accessible tidal resource in Atlantic Canada, New Brunswick and Newfoundland and Labrador also have significant resources. The RD&D work currently underway in Nova Scotia, both for large and small-scale tidal conversion, presents a tremendous opportunity for the entire Atlantic region. Collaboration among researchers at government, industry and academic institutions in Nova Scotia, PEI, New Brunswick and Newfoundland provides opportunities for innovation that will assist in advancing the sector towards commercialization. Research capacity in science and engineering at the region's

academic institutions and government labs, coupled with world class marine research infrastructure at the region's research facilities, along with a vibrant marine industry could all contribute to making Canada's marine renewable energy sector highly competitive in the global marketplace.

Halifax and St. John's are both centres of oceans excellence. The Halifax Marine Research Institute brings together five Federal government research labs (Defense Research and Development Canada (DRDC); DFO; Geological Survey of Canada-Atlantic; NRC Institute for Marine Biology; Environment Canada - Atmospheric Science and Technology), Maritime Universities along with Nova Scotia companies involved in the oceans tech sector. St. John's offers the Marine Institute, the Institute for Ocean Technology at the NRC, the Centre for Cold Ocean Resources Engineering (C-CORE), Memorial University and a variety of ocean technology companies. Outside of these centres, expertise exists in New Brunswick's Huntsman Marine Science Centre in St. Andrews and at UNB and UPEI.

Small tidal device technologies, such as those in development by Fundy Tidal Inc. in southwest Nova Scotia, may be employed in Atlantic rivers, and may therefore have broader application throughout the region. The effects of ice, corrosion, and debris on such applications may need considerable study. Smaller more flexible technologies appear to have application in settings where small wind and small hydro are under consideration, thus serving remote, off-grid communities that presently rely on unsustainable diesel-electric generator sets.

5.6 Biomass with Focus on Pellets

While province by province challenges exist, interest in the use of biomass for heat/combined heat/power and electricity generation is of interest across the region. The forest industry is a significant regional employer. Environmentally sustainable development of biomass and related products holds the potential to offset challenges in the global pulp and paper industry that are affecting Atlantic Canada.

Bioenergy is a component of the PEI's Renewable Energy Initiative, and a similar program exists in NS. Researchers at UPEI and the PEI Departments of Agriculture and Forestry along with private research companies (e.g. Atlantec BioEnergy) could collaborate with NB and NS researchers on the concept of bio-refineries.

The area of wood pellets is not considered RD&D, and a number of companies throughout Atlantic Canada produce wood pellets, and the Government of NB has expressed an interest in developing and implementing supporting policies to optimize the energy output from wood based biomass resources with a specific focus on pellets. The development of pellet standards, in conjunction with similar and current efforts in the U.S., is cited as an area of potential regional cooperation. Academic expertise in biomass and biofuels exists throughout the region to support partnering initiatives.

The primary use of pellets in Atlantic Canada is for heat generation. In terms of electricity generation (through discussions with government and industry representatives), pellet use is common in areas of Europe. Standard wood pellets cannot be exposed to the elements (wet

weather) so large supplies must be stored in sheltered locations. Wood pellets must also be pulverized for use with coal in electricity power plants (source: personal discussion). Other challenges exist with the high ash content of pellets that are produced from agricultural biomass.

With respect to RD&D, new advancements are being made with black pellet technology. Efforts of a number of small Nova Scotia based companies (Bio Vision Technology Inc. and B. W. BioEnergy Inc) along with large global energy companies, in particular Sweden's Vatenfall AB. These companies are working on perfecting the "torrefaction" process that thermally treats (chars) the wood to a charcoal-like substance. These pellets hold the potential to replace coal, or be more easily combined with coal, providing a more environmentally friendly energy source, made up almost entirely of biomass and waste wood, which can be derived from local resources. The technical pros and cons of new pellet technologies appears to be an area of shared area of RD&D interest. It has been suggested that a demonstration project to test the effectiveness of new biomass technologies to produce electricity might be a regionally beneficial project.

5.7 Power Purchase Agreements (PPAs), Independent Power Producers (IPPs), Community Involvement and Large Industry Initiatives

A detailed review of all programs introduced by each province to encourage participation in electricity generation through PPAs, IPPs, Comfits, etc., is beyond the scope of this report. Suffice to say that all four Atlantic Provinces have varying degrees of experience, both positive and negative, in engaging communities, organizations and industry outside of utilities in the supply of electricity. According to officials within the Government of NL, the Government still operates under the policy that Nalcor is responsible for coordinating all hydro developments and all wind developments on Crown land. In its procurement of grid wind projects in the past, Nalcor has released RFPs to solicit projects from IPPs, and did the same for small hydro in the 1990s. Nalcor is open to working with proponents of community wind projects in the isolated diesel communities using diesel-fuelled electricity generation. However, the projects would have to be developed in partnership with Nalcor. There are no plans for any standard offer or feed-in tariff program.

An AEG based roundtable in which the core discussion focuses on strategies that have worked, and those that have not, might be beneficial for the region as a whole.

Matching of regional of strengths and priorities with the region's R&D capacity (Figure 6), reveals areas of potential cooperation to advance clean energy throughout the region and beyond. There exists, for example, broad yet regionally varying interest on the part of all four provinces in the areas of: harsh environment impacts and forecasting; small wind applications; biomass; and energy storage. This matches, again to a varying degree, academic capacity, private sector involvement and ongoing related studies.

These observations are important considerations when developing ideas for potential projects of interest, and regional cooperative partnerships. Each province can bring to bear shared as well as unique interests and capacities for the benefit of the region as a whole.

A tabular format is provided (Table 3) to summarize what in essence the overall point of this report, and that is: (1) What are some shared areas of interest and (2) what potential partnerships can be struck to foster regional cooperation and collaboration in the planning and operations of the Atlantic electricity sector, and facilitate the development of clean and renewable energy in the region.

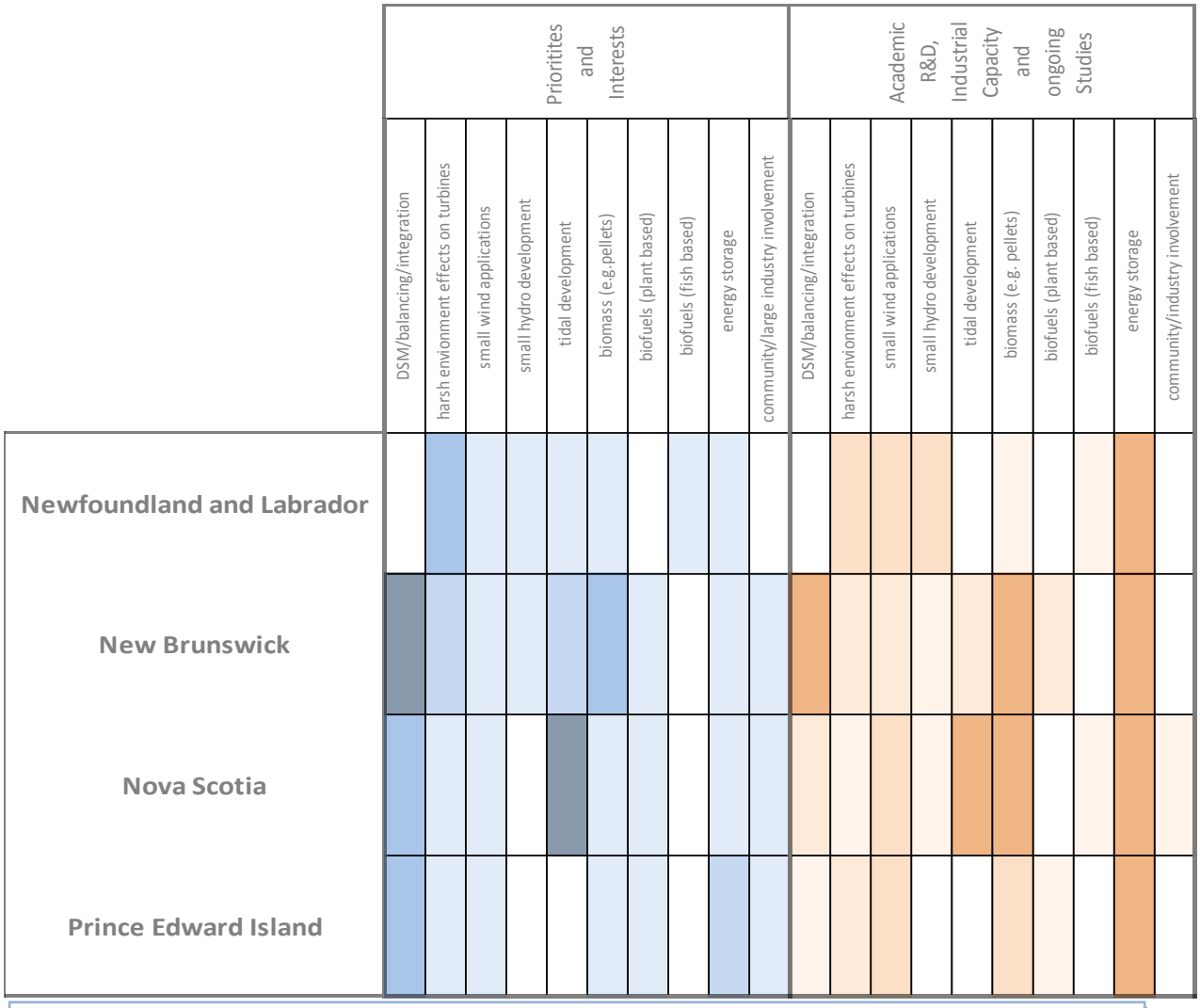


Figure 6 – Priorities and Capacity by Province

Table 3 – Shared Interests and Potential Partnerships

Area	Topic of Interest	Lead Government organizations (in addition to NRC/Canmet, ACOA)	Utility Lead	Private Sector Engagement	Key Academic Participants/Partners
Wind (onshore and offshore)	Harsh environment impacts, advanced weather forecasting, resource mapping, offshore wind interest, application of technologies from other sectors (e.g. aerospace)	NL-DNR, NB-DOE, PEI-WEICan. Other international bodies	Nalcor, Maritime Electric	AMEC. NL road-mapping consultants, MDS-PRAD Tech, Vector Aerospace, WesTower, Extreme Ocean, select wind farm owner/operators (e.g. Suez)	Y. Gagnon/UM, Wind Energy Strategic Network, DREAMS, IRM/Dal, L. Swan/Dal
Small Wind	Turbine technologies, storage application off-grid, application for agriculture, rural areas, households and small businesses	PEI-FEMA, WEICan	NSP re impacts on distribution systems	Seaforth Energy, Frontier Power	L. Chang/UNB, NS Agricultural College, T. Iqbal/MUN,
Demand Side Management	Continued studies and approaches in DSM, balancing of renewable energy, investigating other international regimes experience	NB-DOE	NB Power with all provincial utilities	Large industrial. International bodies	L. Chang et al/ UNB, M. ElHawary/Dal
Energy Storage and converters	Challenges with storage, hydrogen, wind to hydrogen, fuel cells, compressed air, application off grid, grid stabilization	NB-DOE, WEICan, Canadian Hydrogen and Fuel Cell Association (CHFCA)	NB Power with all provincial utilities	Atlantic Hydrogen Inc, custom Research, Elotech, Knowcharge Inc., Yava Technologies, 3M Canada	L.Chang/UNB, S. Eisler/UNB, P.Pickup/MUN, J. Dahn/Dal, J. Ghouili/UM, DREAM/Dal
Small Hydro	Small scale off-grid hydro, large industry small hydro development, small tidal device application, environmental/fisheries impacts	NL-DNR	Nalcor, NSP	Seaforth/Morgan Falls, Fundy Tidal	A.Hay/Dal, authors of studies completed for utilities
Marine Energy (tidal/wave/current)	Regional application following NS lead, small tidal technology applications regionally and in run-of-river settings, wave technologies, off-grid applications, technical challenges, environmental & system modelling and testing	NS-DOE, DFO	NSP/Emera	Fundy Tidal, Oceanic Consulting, Grey Island Energy/Genesis Center (MUN), Stantec/JWEL,	NB Huntsman Center, BIO, M. Graham/CONA, HMRI, MUN/Marine Institute, IOC, C-CORE, R. Karsten, A. Redden., R. Daborn et al/Acadia
Biomass/pellets	Biomass from forestry and agriculture, biomass conversion, short rotational plants/crops (willows), new pellet technology such as torrefaction for RD&D focus, application for heat, combined heat and power, and electricity generation and cogeneration. Investigate demonstration projects	NS-DOE/NB-DOE	NSP – investigate demonstration project for pellets / black pellets. Perhaps build on CEF funded biomass and coal co-firing demonstration project	major forestry companies, woodlot harvesters, sawmills, current pellet manufacturers throughout the region, BW BioEnergy, Vatenfall, Envirem Technologies, BioEnergy Inc, LST Energy, West Nova Agro	UNB, NBCC, Basu, Ghaly, Pegg/Dal, Dr. A. Ghaly/Dal, T. Bouman/CBU, NSCC, H. Manuel/CONA, A. Dutta/NS Agricultural College
Biofuels	Biofuels from fish oils, microalgae, agricultural waste & products, bioprocessing and biorefining, ultraclean diesel, dehydration of ethanol, small scale biogas systems, conversion using supercritical water	NB-DOE or NS-DOE	NSP/NBP	Ocean Nutrition, Pratt/Whitney, Honeywell, Atlantec BioEnergy, BioVision Technology	K. Shiell/NBCC, Y Zheng/UNB, C. Watts/Dal, Galley/NSCC, K. Hawboldt/MUN, R. Helleur, Dr. M Pegg/Dal, H Manuel/Marine Institute
PPAs, IPPS, Community, CEDIFS, FITs, Large Industry involvement	Analyse the pros and cons of stakeholder involvement outside of provincial utilities, successes/failures, lessons learned	NS-DOE	NSP, Maritime Electric	Fundy Tidal, Seaforth, Wind Prospect Inc., other CEDIFS, wind owner/operators	Dalhousie, UPEI, Y. Gagnon/UM

SECTION 6 FUNDING PROGRAMS AND ADDED GOVERNMENT SUPPORT

In recent years most clean energy initiatives in Atlantic Canada, ranging from pure and applied research to demonstration, have been assisted through funding and support provided by the following programs and organizations.

6.1 Financial Programs that Support Clean Energy

Natural Sciences and Engineering Research Council (NSERC)

NSERC provides assistance through investments in innovative research to "increase Canada's scientific and technological capacities for the benefit of all Canadians." NSERC provides supporting funding for postsecondary students and professors, postdoctoral researchers, and Canadian companies for RD&D in their specific area of advanced study and/or industry. In the past decade, NSERC has provided greater than $7 billion in RD&D funding for projects at postsecondary institutions and industry, and/or their partnerships. Additionally, with NSERC funding, training programs have been developed and implemented to assist postsecondary students with careers advancements in science and engineering. "NSERC reports to Parliament through the Minister of Industry…" and is presided over by Dr. Suzanne Fortier, President, and a Council, consisting of 18 appointed members. (Source: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/vision-vision_eng.asp).

NRC Industrial Research Assistance Program (NRC-IRAP)

NRC-IRAP is a national "…innovation assistance program for small and medium-sized enterprises (SMEs)…" and is one of the important aspects of NRC innovation systems. (Source: http://www.nrc-cnrc.gc.ca/eng/ibp/irap/about/index.html). NRC-IRAP has been in service for 60 years with regional offices across Canada. The NRC-IRAP mandate is to "…stimulate wealth creation for Canada through technological innovation…" through SMEs. Their strategic objectives are geared to "…provide support to (SMEs) in Canada in the development and commercialization of technologies; (and to) collaborate in initiatives within regional and national organizations that support… (SMEs).
(Source: http://www.nrc-cnrc.gc.ca/eng/ibp/irap/about/mandate.html).

Natural Resources Canada Program of Energy Research and Development (NRCan PERD)

PERD operates on a federal level within NRCan and is an interdepartmental program; participating agencies and/or departments include: Agriculture and Agri-Food Canada; AECL; CMHC; EC; DFO; HC; INAC; Industry Canada; DND; NRC; NRCan; PWGSC; and TC. NRCan

PERD provides funding support in R&D "…designed to ensure a sustainable energy future for Canada in the best interests of both our economy and our environment." Departments and/or agencies may collaborate with a variety of sources including "…private sector…; other funding agencies; universities; provincial and municipal governments and research organizations; and

international organizations." (Source: http://www.nrcan.gc.ca/energy/science/programs-funding/1603)

Atlantic Innovation Fund (AIF)

The AIF is an initiative provided by the Government of Canada, which has been specifically geared towards "…helping Atlantic Canadian research facilities complete in a global knowledge-based economy…" through access to funding for RD&D projects involving innovative "…ideas, technologies, products and markets." The AIF provides access to funding under the Atlantic Canada Opportunities Agency (ACOA) for "selected eligible projects through a series of competitive funding rounds." In the past decade, AIF has provided approximately $709 million in funding to a total of 279 selected projects with additional funding support ($61 million) secured in March 2011 for another 26 Atlantic Canadian projects. (Sources: http://www.acoa-apeca.gc.ca/eng/ImLookingFor/ProgramInformation/AtlanticInnovationFund/Pages/AtlanticInnovationFund.aspx).

Clean Energy Fund (CEF)

The CEF was initiated under the Government of Canada's *Economic Action Plan* to assist with Canada's commitment to a 17% reduction of 2005 of greenhouse gas (GHG) emission levels before 2020. The CEF objective is to take "…action to ensure a healthy environment." Funding provided by the CEF invests in "…large-scale carbon capture and storage demonstration projects and smaller-scale demonstration projects of renewable and alternative energy technologies." Approximately $146 million has been allocated for investing in support of "renewable, clean energy and smart grid demonstrations…" throughout Canada.
(Source: http://www.nrcan.gc.ca/energy/science/programs-funding/1482)

Sustainable Development Technology Canada (SDTC)

SDTC "is a not-for-profit foundation…" established by the Government of Canada in 2001 administered by the Minister of Natural Resources Canada. SDTC provides supporting funding towards "…development and demonstration of clean technologies…" Two funds are operated under SDTC for funding innovative ideas and solutions "…which deliver economic, environmental and health benefits to Canadians"; these funds are the SD Tech Fund™ and the NextGen Biofuels Fund™. The two funds provide access to $590 million and $500 million in supporting funding, respectively, for climate change, air quality, clean water and soil, and "…establishment of first-of-kind large demonstration-scale facilities for the production of next-generation renewable fuels."
(Source: http://www.sdtc.ca/index.php?page=sdtc-profile&hl=en_CA)

MITACS

Mitacs is a national, not-for-profit research organization that provides funding for training and research for innovative next-generation researchers and facilities. Mitacs partners with various federal and/or provincial government departments and agencies (i.e., Government of Canada

under the *Economic Action Plan* and Networks of Centres of Excellence, the provincial Governments of BC, AB, SK, MB, ON, QC, NB, NL, and NS), research facilities, and academic institutions to provide support towards fostering a new innovative economy in Canada. Mitacs provides funding under 6 individual projects: Mitacs – Accelerate (research internship program); Elevate ("…a foundation (for) research, business, entrepreneurship and scientific management skills to newly-minted PhDs); Globalink ("…introduces Canada as a world-leading research and innovation destination to top undergraduate students from around the world"); Entreprise ("a competitive 6-month internship and business mentoring program…"); Step (provides "…business-ready skills to up and coming researchers."); and Outreach (provides assistance to reach out to "future researchers – our children – through innovative initiatives…"). (Source: http://www.mitacs.ca/about).

Canada Foundation for Innovation (CFI)

CFI is an independent, NGO represented by an active Board of Directors that was established in 1997 by the Government of Canada "…to build Canada's capacity to undertake world-class research and technology development to benefit Canadians" (Source: http://www.innovation.ca/en/AboutUs/History). CFI funds various forms of infrastructure (i.e., "state-of-the-art equipment, laboratories, databases…scientific collections, computer hardware and software, communication…and buildings) "…necessary to conduct leading-edge research" at Canadian institutions not individuals (http://www.innovation.ca/en/AboutUs/WhatCFI). CFI support if categorized into specialized funds: Leading Edge and New Initiatives; Leaders Opportunity Fund; College-Industry Innovation Fund and other industry-specific funds.

Newfoundland and Labrador Green Fund

The NL Green Fund was established by the Government of Canada *EcoAction Trust Fund for Clean Air and Climate Change* and was provided with funding for a "…three-year period to support projects that provide real reductions in (GHG) emissions." The NL Provincial Government included additional funding for the NL Green Fund and "…expanded the criteria to include aspects of environmental sustainability." The NL Green Fund was "no longer accepting application for this fund as of June 29th, 2009."
(Source: http://www.env.gov.nl.ca/env/climate_change/govt_action/greenfund.html).

Research & Development Corporation of Newfoundland and Labrador (RDC)

The RDC is a provincially-based entity that provides funding to RD&D projects in Newfoundland and Labrador (NL) that "…will play a major role in driving innovation, creating wealth and increasing economic growth…for future generations." The RDC was "incorporated under the *Research and Development Council Act* in 2009…" and operates indirectly with the NL

Government. RDC plans to focus their efforts in the next decade on the following objectives: "…Increasing overall R&D investment in Newfoundland and Labrador; pursuing R&D opportunities that are relevant to the local economy; targeting sectors that are of strategic

importance to (NL's) economy; understanding current and future market and research needs; responding quickly and flexibly to opportunities; and encouraging key stakeholders to collaborate and cooperate in the R&D process."
(Source: http://www.researchnl.com/about/index.htm)

Innovation Prince Edward Island (Innovation PEI)

Is a provincially-based entity that provides focus "…on advancing economic development…by investing in people, innovation, and infrastructure." Innovation PEI is based on the *Island Prosperity Strategy* whereby "…targeting key sectors (i.e., bioscience, IT, renewable energy and aerospace) that have displayed a high potential for economic growth within the Province" (Source: http://www.innovationpei.com/index.php3?number=1029613). Innovation PEI provides support by offering a wide variety of programs and services including research chairs, development funds, publications, business improvement programs, etc.

Nova Scotia Research and Innovation Trust (NSRIT)

NSRIT is a provincially-based trust that "…supports research infrastructure in (NS) by matching national funding from (CFI)." To date 340 projects at research facilities in Nova Scotia have been provided a portion of a total $66 million in funding. This funding supports researchers in "...Health and Life Sciences, Ocean Technology, Clean Technology, and Information and Communications Technology." (Source" http://nsrit.ca/)

Nova Scotia CleanTech Open

Is a private clean technology start up competition presented by Innovacorp (a venture capitalist company in Nova Scotia), that is "…designed to find and fund high potential clean technology start ups." The competition started in Dec 2011 with pitch presentations conducted between Feb 13 and 17, 2012, with competition winner announced in April 2012. (Source: http://www.novascotiacleantech.com/about)

NB Climate Change Action Fund

Through the Climate Change Action Fund (CCAF), New Brunswick recently supported six innovative projects in energy. The projects ranged in scope from designing more energy efficient homes, to small hydro re-development, biomass combined heat and power, smart-grid applications and the largest anaerobic digester in Atlantic Canada. All CCAF projects will result in significant reductions of greenhouse-gas emissions and air pollution throughout the province. (*Source: NBDOE*)

New Brunswick Innovation Foundation (NBIF)

NBIF is a provincially-based venture and research capital company that provides funding to start-up projects and R&D. Investments into company's equity are made rather than providing a loan or lender agreement. NBIF designates 5 key strategic industries: "Energy & Environmental Technologies; Knowledge & ICT; Life Sciences; Value-added Natural Resources; and Advanced Manufacturing." Additionally, NBIF offers investment support to education and training efforts (Research Assistantship Initiative only). (Source: http://www.nbif.ca/eng/about/)

New Brunswick Environmental Trust Fund

NB's Environmental Trust Fund uses revenues from the provincial container recycling program to support innovative projects, including energy projects that result in tangible, measurable results, and are aimed at protecting, preserving and enhancing the Province's natural environment. (*Source: NBDOE*)

Canadian Innovation Commercialization Program (CICP)

CICP was announced in Budget 2010 to help companies bridge the pre-commercialization gap for their innovative goods and services by awarding contracts to entrepreneurs with pre-commercial innovations through an open, transparent, competitive and fair procurement process; providing feedback to the entrepreneurs on their products; providing opportunities to enter the marketplace with a successful demonstration of their product ; and, providing information on how to do business with the Government of Canada. The CICP is aimed at several business sectors, including alternative energy (wind, solar, water (low-head, tidal, wave, etc.), geothermal, biofuels, biomass, hydrogen, component technologies (e.g. inverters, generators, control systems)) and energy efficiency (including grid integration technologies, innovative energy storage, heat exchangers/pumps).

The program includes a series of RFPs that include a description of the priority business sectors and criteria for selection. Regional events and trade shows are held so Canadian businesses can showcase their innovative concepts to federal representatives. CICP is managed by Public Works and Government Services Canada and implemented by the Office of Small and Medium Enterprises, which advocates on behalf of small and medium enterprises in federal procurement.

ecoEnergy Innovation Initiative (ecoEII)

EcoEII received funding in Budget 2011 for a large array of research, development and demonstration projects, including clean electricity and renewable and bioenergy. The main purpose of the program is to support innovation to produce and use energy in a cleaner and more efficient way. Two separate funding streams are available; one focused on R&D projects and the other on demonstration projects. Both were launched with requests for Letters of Expression of Interest and closed in fall 2011. NRCan states on their website that "there is no current call for proposals and at present we do not expect that there will be any further calls".

Community Economic Development Investment Funds (CEDIFS) and Community Feed-in Tariffs (ComFITs)

In Atlantic Canada, only Nova Scotia has a renewable energy Feed-In Tariff program, and only Nova Scotia and Prince Edward Island have CEDIF programs (called the Community Economic Development Business program in PEI). While neither of these programs are meant to incent clean or renewable energy RD&D, both can be used to support such initiatives. A CEDIF's activities can include RD&D activities (depending o the desires of the shareholders and directors).

Nova Scotia's ComFIT program (and FITs typically) are intended to allow a broad deployment of commercial technologies by individuals and organizations in a way that is economically viable. The FIT guaranteed rates and contract terms allow proponents to obtain financing and ensure a reasonable rate of return on their investment. It is possible that the leveraging potential of a FIT rate could allow a renewable energy proponent to conduct RD&D activities that are complimentary to their business.

6.2 GOVERNMENT SUPPORT - FACILITATING THE ADVANCEMENT OF CLEAN ENERGY INITIATIVES IN ATLANTIC CANADA?

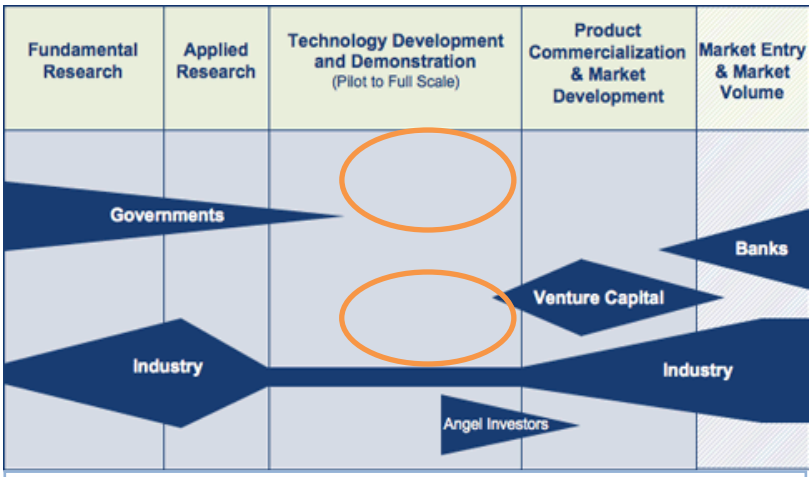


Figure 7 – Development Funding "Pinch"

The discussion above within this section of the report illustrates the broad range of funding programs available from the federal government and provincial governments. Outside of the Clean Energy Fund and its support for three of the four key clean energy projects discussed, many funding programs target the early stages of fundamental and applied R&D and innovation. With reference to Figure 7, it is evident that funding support is "pinched" mid-stream in the development and demonstration phase until product commercialization and market entry, when industry, banks and venture capitalists become involved.

The AEG is focussed specifically on the "Atlantic electricity sector" with the goal of facilitating the development of clean and renewable energy to displace GHG-emitting sources of electricity. Earlier sections of this report allude to the fact that technology development and demonstration projects appear to be of most interest to industry and utilities in Atlantic Canada's electricity

sector. The point has been made that the four primary RD&D project examples are within the development and demonstration stage, in the middle of the innovation chain noted. To restate, this is not to say that pure fundamental research should not be supported, and examples of such programs have been provided herein. An overall policy consideration for the AEG is, therefore, to work with industry to continue to assist in funding projects in the middle innovation chain RD&D stage.

An underlying key message in this report is the value in partnering and participation within industry, in collaboration with researchers. These values are consistent with four key pillars of the AEG mandate: **COLLABORATION, COOPERATION**, and **COMMON UNDERSTANDING** toward **DEVELOPMENT** of the renewable energy sector in the region. The components of highly rated and effective R&D projects are noted in Section 4, and, good projects are those that embrace these underlying principles.

The analysis so far in this report is meant to provide intuitive areas of consideration for the AEG and members of the AEG Steering Committee. Ultimately technical analysis preferably by experts within the electrical sector, is required to determine projects of interest with respect to the advancement of clean energy as it pertains to electricity generation.

SECTION 7 CONCLUSION AND POLICY CONSIDERATIONS

All four Atlantic Provinces have different energy resources and electrical energy generation mixes. All are making efforts to move toward a more diverse energy portfolio by harnessing sources that produce less greenhouse gases. Over the next two decades, provinces have an opportunity to capitalize on the strengths and diversities of each other to advance clean energy locally and across the entire region.

Atlantic Canada has natural resources that can yield significant, new and expanded clean energy sources, including tidal energy, hydroelectric power, wave energy, biomass sources and related biofuels, and wind power. The contributions that our scientific and technical communities are making to the development of clean energy are helping to advance clean energy initiatives around the world.

It is clear that clean energy capacity clusters exist where one particular institution has built a significant capability in a specific area of interest. Examples would include Acadia's strength in environmental studies related to tidal, and UNB's unique Sustainable Power Research Group. Memorial has highly qualified people engaged in individual clean energy projects. In other clean energy areas, such as battery/fuel cell R&D, capabilities exist throughout the region.

Academics working with industry is a given. There is but an added need for researchers to work more cooperatively with each other within and across institutions on a local and regional basis, so a second key consideration is the importance of academic cooperation.

NL priority areas, also of regional interest and potential cooperation, lies in: onshore wind; large

and small hydro; the effects of cold/snow/ice on wind turbine performance; small wind technologies; storage and integration technologies, and (while not in all cases RD&D); forest based biomass and wood pellets. Areas of clean energy R&D in NL is focussed on aspects of: wind energy (wind/hybrid systems, advanced weather forecasting for wind, even a craft to access offshore wind farms); some wave energy, biofuels from fish oil and forest residue; and fuel cells. Work by Nalcor/NL Hydro continues in hybrid systems, wind and wind environments, small hydro and hydro related climate / environmental studies.

NB is focussed on smart grid technologies and other issues related to demand side management; wind balancing and integration; smaller scale renewable energy developments – biofuels, small hydro, wind; community, First Nations, and large industry involvement, and; biomass and wood pellets. In terms of academic capacity in NB, much work is concentrated in the areas of enabling technologies and demand side management (DSM), hydrogen storage and fuel cells. Through PowerShift, NB is leading the region in DSM efforts. There is additional capacity in biomass/biofuels and ongoing work related to wind, particularly at the University of Moncton. UNB's unique capacity under the Sustainable Power Research Group is of benefit to the region as a whole.

Nova Scotia has the largest accessible tidal resource in Atlantic Canada, and is clearly focused on this source as having great future potential. The use of various forms of biomass to generate heat (and electricity) is also of great interest in NS. Extensive RD&D work is currently underway in Nova Scotia, both for large and small-scale tidal conversion. NS R&D capacity in biomass energy and biofuels is significant, and other provinces should look to partnerships with the NS academic community. As well, Dalhousie leads efforts in advanced related enabling technologies (fuel cells).

In PEI, government priorities lie in all areas (large and small) of the wind sector, as well as in bioenergy (biomass and biofuels). Some interest may exist in tidal lagoon potential in the Northumberland Strait, and it was noted that PEI was once a per capita leader in solar thermal residential use. PEI's development of the Wind Energy R&D Park and Storage System for Innovation in Grid Integration (Park) will benefit the region as it strives to address the various challenges of wind energy.

While each province has unique energy mixes, and levels of academic capacity that are as well provincially unique, the analysis reveals that broad regional interest on the part of all four provinces exists in: harsh environment impacts and forecasting; small wind applications; biomass; and energy storage. These interests and regional priorities generally match academic capacity, private sector involvement and ongoing related studies in the region as a whole. In terms of regional spread, most funding for clean energy is focussed on wind, enabling technologies often related to wind, and biomass/biofuels. The review of R&D capacity reveals that regional strengths exist in the areas of enabling technologies (NS, NB, and NL), biomass

(NS, NB), wind (PEI, NB, NS, NL) and biofuels (NB, NS). Localized capacity exists in tidal (NS), wave (NL) and some solar (NS).

Matching these broad regional priorities with regional academic capacity leads to conclusions and policy considerations that are consistent with these findings:

- Projects as noted in Table 3 exhibit considerable potential for regional partnering between governments, the private sector, and academia in the areas identified.

- The parameters that define an effective R&D project should be considered: local relevance; chance of use-ability and innovation; established priorities shared by government and industry; industry engagement and willingness to leverage financing; market need; global linkages when beneficial.

- Work with industry to continue to assist in funding projects in the middle innovation chain RD&D stage.

    - Decision makers might consider a rating scheme for projects in which a progressively increasing percentage of government contribution is triggered when key criteria/requirements are met in keeping with the overall mandate of maximizing regional cooperation and common understanding. Rated criteria / parameters as noted include: local relevance; chance of use-ability and innovation; established priorities shared by government and industry; industry engagement and willingness to leverage financing; market need; and global linkages when beneficial.

    - Additional favourable project attributes include the level or regional cooperation between provinces and academia, as well as the level of cooperation between individual researchers / High Quality People (HQP) working together within and across regional institutions.

- If international expertise is deemed to be necessary or advantageous in enhancing a project, then fund day-rates/allowances, travel, accommodations to bring them to the table.

- In terms of international potential or export, recognize that the export of electricity is one aspect, but equally important is the export of technology or solutions with international reach, such as off grid applications.

CLOSING

This report has been prepared by SLR Consulting (Canada) Ltd. with all reasonable skill, care and diligence, and taking account of the resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

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www.nsrenewables.ca for ComFIT and CEDIF information links