# Wind Technology Road Map

# Appendices

# Appendix A: Wind Energy Sector Snapshot

# Notes

This document is an abridged version of the "Wind Energy Sector Overview" prepared by the CANMET Energy Technology Centre (now CanmetENERGY) in August, 2008.[1]

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# 1.0 Introduction

Wind energy represents a substantial opportunity for Canada to meet electricity needs and generate significant economic gains in an environmentally sustainable manner. In order to enable Canada to achieve its full potential in this area, the Government of Canada has provided support for an industry-led effort to create a technology roadmap for wind energy.

The objective of the Wind Technology Roadmap (WindTRM) is for technology developers, adopters, and users, to identify wind energy innovation priorities. Ultimately the objective is to identify key investments and actions so as to increase Canadian innovation and social and economic outcomes.

The WindTRM will identify the key technologies that the wind energy industry needs to succeed in the future and document the steps required to develop and implement these technologies.

This appendix, the Wind Energy Sector Snapshot, is intended to provide an analysis of the global and Canadian wind energy sector today. The purpose of this analysis is to provide the WindTRM reader with contextual information to better understand the opportunities and challenges associated with implementing the WindTRM recommendations.

# 2.0 Wind Energy Industry Overview

The wind energy sector has been rapidly growing worldwide over the last decade, emerging as a commercial source of renewable energy. According to the Global Wind Energy Council, wind energy capacity increased from 7,600 MW in 1997 to 120,798 MW in 2008.[2] This translates into roughly 29% annual growth per year.

Wind energy deployment in Canada is a part of that success story, with a 46% increase in capacity per year over the last five years, and a current installed capacity of 2,854 MW – enough to power over 860,000 homes.[3] However, wind in Canada is still only at the margin of what it could be: we are just beginning to tap into Canada's wind resource potential; and, we have seen limited domestic manufacturing and technology development to date. This section provides key data on the global and Canadian wind energy markets.

## 2.1 The Global Wind Energy Market

Wind energy has become a multi-billion dollar global industry, and is continuing to experience rapid growth. The Global Wind Energy Council has predicted that the global wind market will grow to reach 332 GW of total installed capacity by 2013, representing an addition of 181 GW in 5 years (120% growth. This would result in wind energy accounting for around 3% of global electricity production (up from just over 1% in 2007).

The Global Wind Energy Council also provides these predictions for the major regional markets in the period between 2009 and 2013:

- *"**Asia** is expected to be the fastest growing region in the world as of this year. The annual market is expected to triple in the next five years, reaching 25.5 GW by 2013, up from 8.6 GW. This will take the cumulative wind capacity up to 117.4 GW by 2013, almost on a par with Europe by that time."*

- *"**PR China** has been doubling its installed capacity every year for the past four years, and is set to continue the rapid upscaling of its wind capacity to become the world's largest annual market. Annual additions are expected to reach more than 20 GW in China by 2020. This development is underpinned by a very aggressive government policy supporting the diversification of the electricity supply, supporting the growth of the domestic industry, and making significant investments in the transmission needed to get the electricity to market."*

- *"**Europe** will continue to have the largest installed capacity up to 2013. It is expected that by 2013, the total capacity in Europe will stand at 118 GW, 52 GW more than at the end of 2008. By 2013, the annual market will reach 12.5 GW. At the end of the period under consideration, large scale offshore developments will start to have an impact on growth rates in Europe, and this will lend new momentum to developments in the following years."*

- *"In **North America**, wind energy development will see a small drop in 2009, especially in the US, as a result of tightening project finance. It will recover quickly to its 2008 size on the basis of the package of measures just agreed by the US Congress, and the prospect of national emissions reduction legislation. By 2013, the annual market in North America will have grown to 15 GW, up from 8.9 GW in 2008. This means that a total of 55 GW of wind power capacity will be added in the US and Canada over the next five years.."[4] The US Production Tax Credit (PTC) has been renewed with in-service dates for wind extended to 3 years. The program has also expanded to include more renewable energy sources.[5]*

Figure 1 provides an estimate of wind energy as a percentage of electricity demand in countries around the world.

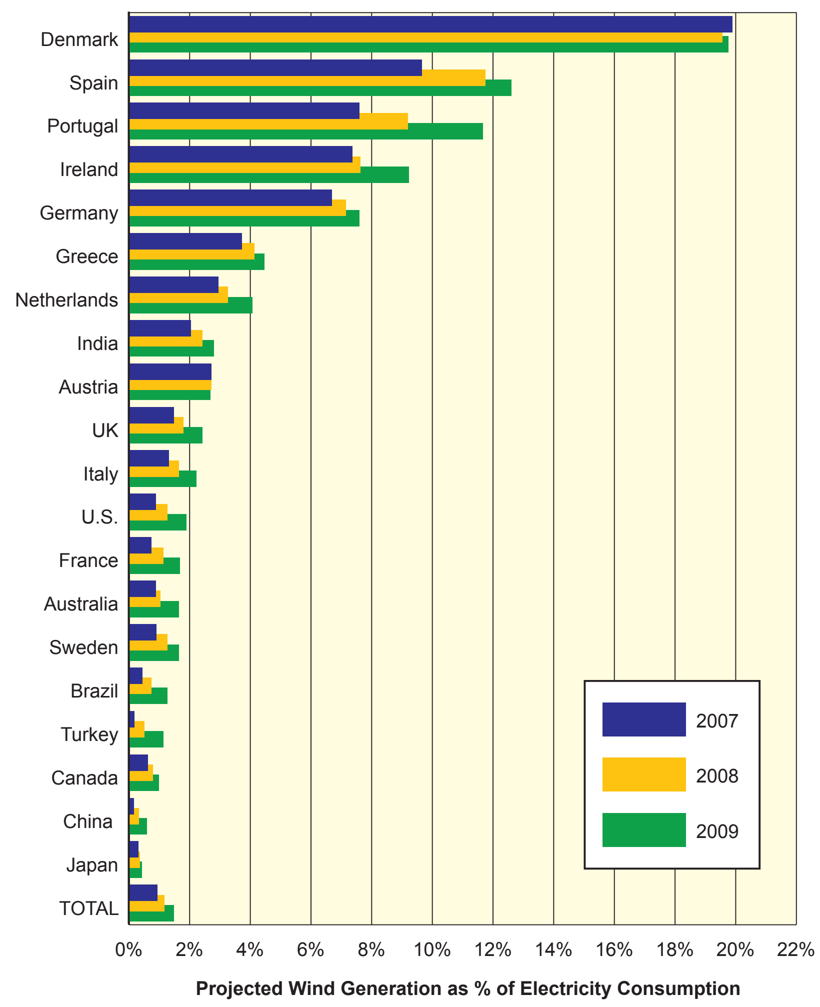
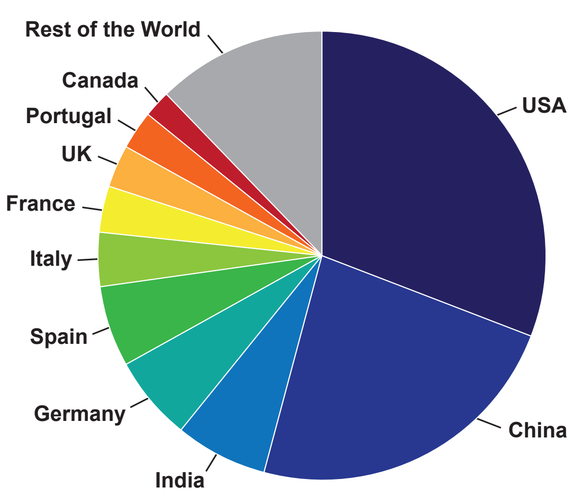



**Figure 1: Projected Wind Generation as % of Electricity Consumption (approximate)[6]**

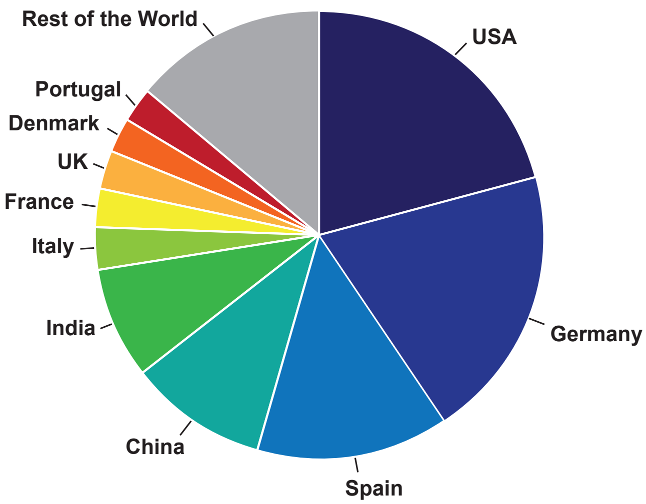
The following key statistics give a sense of the size and scope of the current global wind energy market:

- Over 90 countries now have wind generating capacity[7], indicating the breadth of the global adoption of this renewable energy technology.
- Over 27,000 MW of new capacity was installed in 2008, representing a 36% growth rate in the annual market[8]. Worldwide investment in wind during this period was about € 36.5 billion.[9] Figure 2 provides details on new installed capacity in 2008 and Figure 3: Top 10 Total Installed Wind Capacity Worldwide (2008) provides details on worldwide total installed capacity.
- Wind power could supply 16.5% of world electricity by 2020, according to a moderate projection by the Global Wind Energy Council, which represents 560,000 MW of installed capacity and more than $1 trillion US in investment. This would also represent a savings of 825 million tonnes of $CO_2$.[10]
- Denmark reached a world record of 20% penetration of wind energy in its national electricity supply in 2007.[11]
- Globally, 350,000 to 400,000 people are employed in the wind energy sector, which includes manufacturing, development, installation, operations, and maintenance.[12]




| Country | MW | % |
|---|---|---|
| USA | 8,358 | 30.9 |
| China | 6,300 | 23.3 |
| India | 1,800 | 6.7 |
| Germany | 1,665 | 6.2 |
| Spain | 1,609 | 5.9 |
| Italy | 1,010 | 3.7 |
| France | 950 | 3.5 |
| UK | 836 | 3.1 |
| Portugal | 712 | 2.6 |
| Canada | 526 | 1.9 |
| **Total of Top 10** | **23,766** | **87.8** |
| Rest of World | 3,285 | 12.2 |
| **Total** | **27,051** | **100.0** |

**Figure 2: Top 10 New Installed Wind Capacity Worldwide (2008)**[13]




| Country | MW | % |
|---|---|---|
| USA | 25,170 | 20.8 |
| Germany | 23,903 | 19.8 |
| Spain | 16,754 | 13.9 |
| China | 12,210 | 10.1 |
| India | 9,645 | 8.0 |
| Italy | 3,736 | 3.1 |
| France | 3,404 | 2.8 |
| UK | 3,241 | 2.7 |
| Denmark | 3,180 | 2.6 |
| Portugal | 2,862 | 2.4 |
| **Total of Top 10** | **104,104** | **86.2** |
| Rest of World | 16,693 | 13.8 |
| **Total** | **120,798** | **100.0** |

**Figure 3: Top 10 Total Installed Wind Capacity Worldwide (2008)[14]**

- The top ten wind turbine manufacturers had 94% of the market share in 2008, and come from 6 countries: Denmark, Spain, the United States of America, Germany, India and China.[15] Details of turbine manufacture market share are provided in Table 1.

| | Accumulated MW 2007 | Supplied MW 2008 | Share 2008 % | Accumulated MW 2008 | Share accumulated % |
|---|---|---|---|---|---|
| Vestas | 29,508 | 5,581 | 19.8% | 35,089 | 28.7% |
| GE Wind | 12,979 | 5,239 | 18.6% | 18,218 | 14.9% |
| Gamesa | 13,306 | 3,373 | 12.0% | 16,679 | 13.7% |
| Enercon | 13,770 | 2,806 | 10.0% | 16,577 | 13.6% |
| Suzlon | 4,724 | 2,526 | 9.0% | 7,250 | 5.9% |
| Siemens | 7,002 | 1,947 | 6.9% | 8,949 | 7.3% |
| Sinovel | 746 | 1,403 | 5.0% | 2,148 | 1.8% |
| Acciona | 1,647 | 1,290 | 4.6% | 2,961 | 2.4% |
| Goldwind | 1,457 | 1,132 | 4.0% | 2,589 | 2.1% |
| Nordex | 3,886 | 1,075 | 3.8% | 4,960 | 4.1% |
| Others | 11,269 | 4,955 | 17.6% | 16,225 | 13.3% |
| **Total** | **100,317** | **31,326** | **111%** | **131,644** | **108%** |

**Table 1: Turbine Supply Market Share, 2008[16]**

## 2.2 The Canadian Wind Energy Market

Canada currently ranks as the world's 10th largest nation in terms of new installed wind energy capacity and is nearing the 3 GW mark with 2,854 MW total installed capacity as of September 2009. Canada's wind energy market experienced its second best year ever in terms of capacity growth in 2008 with a total of 500 MW of new wind energy capacity installed; increasing Canada's total by 34% compared to 2006. Figure 3 shows the rapid growth of the Canadian wind market. Canada's current wind energy installed capacity is enough to meet the needs of 860,000 homes making up about 1% of Canada's total electricity demand.[17]

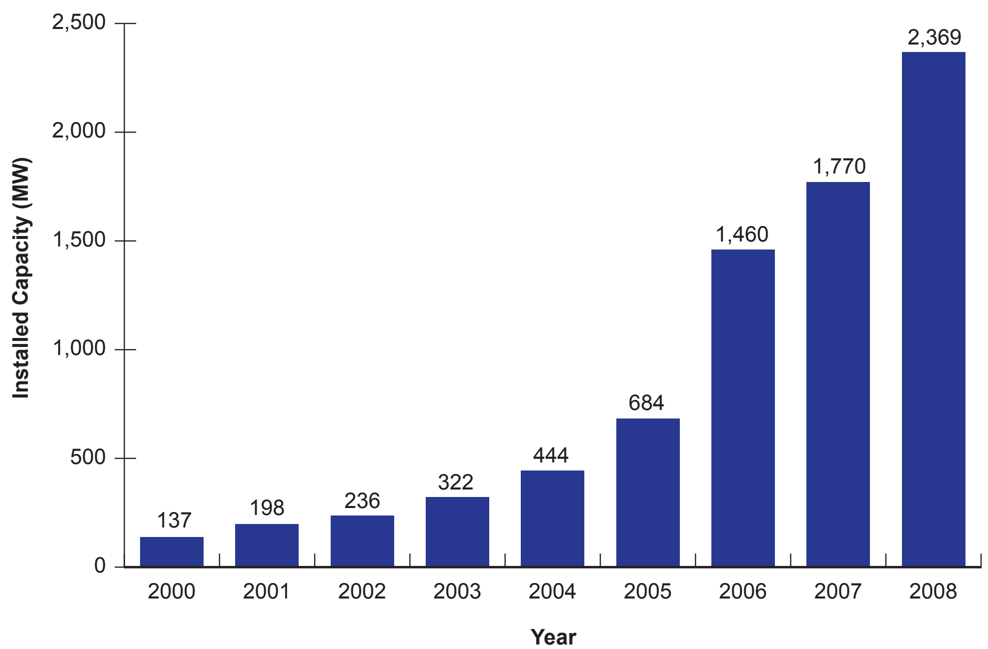



**Figure 4: Cumulative Installed Wind Capacity in Canada by Year[18]**

Canada-wide incentives for wind energy growth include the very successful federal ecoEnergy program that provides a power production incentive of 1¢ /kWh, as well as federal tax incentives. As of May 2009, Canada had 5,700 MW of wind energy projects either under signed contracts or under construction[19], most of which are planned to be installed by 2011. In 2009, installations are expected to exceed 600 MW – Canada's second best year ever.[20]

If all of Canada's provincial governments and/or utilities meet their stated targets for wind and/or renewable energy development, it is anticipated that Canada will have a minimum of 12,000 MW of installed wind energy capacity by 2015.[21] 12,000 MW of installed wind energy capacity would produce around 31,200 GWh, enough to meet about 5% of total Canadian electricity demand in 2016.

Based on Natural Resources Canada's Energy Outlook between 2005 and 2016, the expected additional 29,000 GWh would constitute 39% of the increase in annual electricity demand. The Emerging Energy Research predicts that Canada's installed wind power capacity will grow nearly tenfold to 14,100 MW by 2015[22], even higher than the current provincial targets.

In terms of previous projections, a Navigant Consulting Study in 2007 identified that wind markets in 2007 were roughly 50-75% larger than they had anticipated in a 2003 version of their renewable energy multi-client study.[23] In addition, the Global Wind Energy Council's most aggressive development scenario in 2005 underestimated the actual growth that did occur in 2006 and 2007. The wind energy sector has consistently outperformed the expectations of analysts and governments.

## 2.3 Provincial Markets

The provinces have accelerated the growth of Canada's wind power sector through a range of approaches including mandated Renewable Portfolio Standards (RPS) in New Brunswick and Nova Scotia, Feed-in-Tariffs (FITs) in Ontario and British Columbia (planned), and procurement of large blocks of wind power through Requests For Proposals (RFPs) in virtually all the provinces. Key drivers for provincial governments to encourage wind power development include rising energy demand and pricing volatility, energy export opportunities, reducing national emissions, industrial development and rural economic development.

Canada's provinces and territories have distinct local markets based on their different approaches to electricity generation, transmission and distribution of wind energy. All provinces and territories have wind resource potential to develop, and all have or plan to have wind in their energy mix.

Provinces have integrated federal incentives into their initiatives in different ways, with some retaining a portion of the incentive, and others allowing developers to retain the full amount. Figure 5 shows the cumulative impact of the federal incentive and provincial initiatives on the price of wind power in some selected provinces.

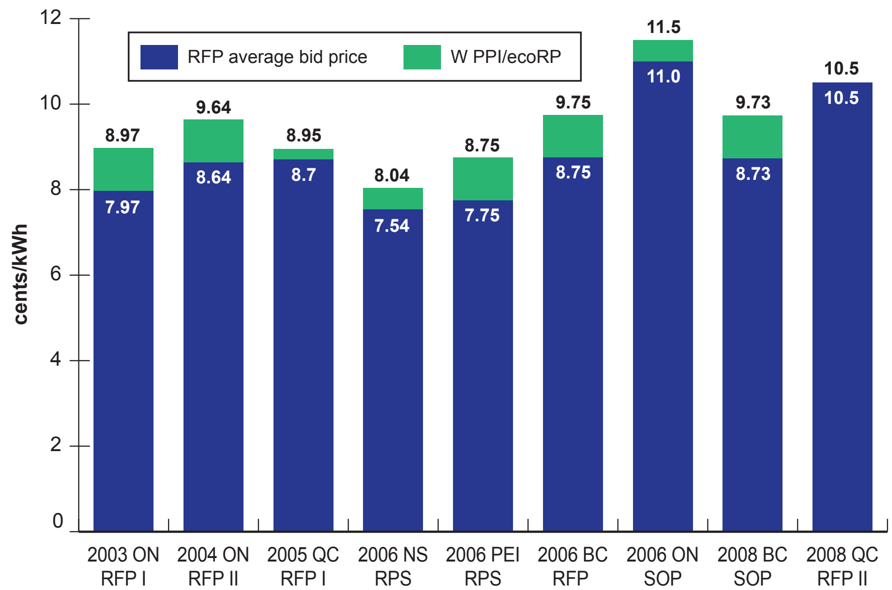



**Figure 5: Provincial Wind Power Prices, 2003-2008**[24]

A brief overview of the status of each provincial market is provided below:

- **Newfoundland and Labrador** has targeted 80 MW of wind energy on the island of Newfoundland. To date, 54 MW has been built.[25] Newfoundland is also exploring wind development potential in Labrador.

- **Prince Edward Island** is a world leader in terms of wind penetration. The province has 151 MW of wind and a peak load of 200 MW. The province anticipates reaching 500 MW total capacity by 2013. The excess energy would be available to off-island markets.[26] When asking for bids, PEI's power authority received about 1,500 MW worth of responses.[27]

  PEI is interconnected with New Brunswick via two 138 kV submarine transmission cables with a combined total capacity of 200 MW. PEI has been considering doubling the current capacity of its interconnection with a new transmission cable from the Island to New Brunswick. These interconnections enable PEI to export wind power in times of high wind and low demand, and import power in times of low wind and high demand.

- **Nova Scotia** has a Renewable Energy Standard (RES) that requires that 5% of the total Nova Scotia electricity requirement be supplied by new renewable energy sources by 2010, rising to 10% by 2013. In addition, by 2015, 25 per cent of Nova Scotia's electricity will be supplied by renewable energy.[28] The province has 59 MW of wind production capacity and plans to add another 230 MW within the next 5 years. When asking for bids, they received 2,000 MW worth of interest.[29]

- **New Brunswick Power** announced power purchase agreements with a total capacity of 213 MW. The province has a wind energy target of 400 MW by 2010.[30] When asking for bids for 300 MW of wind, NB Power received 25 proposals totaling 1,400 MW.

- **Quebec** has held two calls for wind power, one for 1000 MW in 2003 and a second call for 2000 MW in spring 2005[31]. 15 bids for a total of 2,004 MW were accepted in the 2nd RFP that would come on stream from 2011 to 2015.[32] This will result in roughly 4,000 MW by 2016. In May 2009, Quebec also held a Call for Tenders for two 250 MW wind projects involving municipalities and first nations.[33] There are currently 532 MW of installed wind capacity in Quebec.[34]

- **Ontario** has 1,161 MW of wind energy currently installed. The Ontario Power Authority calls for 4600 MW of wind energy by 2020 in its proposed integrated power system plan (IPSP)[35]. Ontario's Standard Offer Program, which offers $0.11/kWh to wind energy projects of less than 10 MW has resulted in approximately 758 MW contracted to date. Following extensive collaboration with industry, Ontario passed the Green Energy Act in September 2009 which includes support mechanisms for renewable energy projects through streamlining the approval process and a feed-in tariff system to guarantee prices, as well as providing opportunities for First Nations to own and operate renewable energy projects.[36]

- **Manitoba** has 104 MW of installed wind energy capacity and is targeting 1,000 MW by 2017. The province is currently negotiating to sign a 300 MW power purchase agreement (PPA).[37]

- **Saskatchewan** has 171 MW of installed wind energy capacity, and a target to reach 300 MW by 2011.

- **Alberta** has 524 MW of wind power capacity, and was the first jurisdiction to reach 500 MW in Canada. The province has no official target, but is designing transmission upgrades to connect 3,000 MW in Southern Alberta. There are over 11,000 MW of wind project proposals that are seeking to connect to the transmission system.[38] Demand for wind power depends on its short and long-term cost-competitiveness, including the provincial retail "green power" market, the most vigorous in Canada.

- **British Columbia** has 100 MW of wind under construction as of July 2009, and contracts awarded for a further 200 MW. The province is also expected to announce the results of a renewable energy Request for Proposals in 2010. However, the province is expected to announce the results of a renewable energy Request for Proposals in 2009[39], and is proceeding on developing a Feed-in-Tariff program.

- Canada's three territories have a challenging climate for many electricity generation technologies, including wind, which must deal with a significantly colder climate than turbines are normally designed for. Populations are also smaller, with a large number of remote communities. Therefore, wind energy development in the north is expected to proceed more slowly, and focus on smaller developments using smaller turbines. The status of wind energy development in the territories is as follows:

  - **The Yukon** has 0.810 MW installed wind capacity to date. This capacity consists of a Bonus 150 kW on Haeckel Hill, which continues to work well in the northern climate 13 years after its original installation; and a 660 kW Vestas, installed on Haeckel Hill in 2000.

  - **North West Territories** does not currently have any installed wind energy capacity. However, the territory has identified the goal of having one wind energy installation by 2009 in their energy planning.

  - **Nunavut** does not currently have significant installed wind energy capacity, although, the territory does have experience with wind energy through a number of small wind projects that have been developed in the past. These include three 80 kW Lagerwey LW18/80 turbines that were put in service in 1994 to 1997, and one Atlantic Orient AOC15/50 66 kW that was put in service in 2000.[40]

- Canada has no **offshore wind** energy capacity but several projects are in development including in the Great Lakes and off the coast of B.C.[41]

The global wind energy market is expected to continue its rapid growth for some time to come. As one of the top 10 countries in new installed wind capacity with significant resource potential, Canada is making solid progress even though each province is taking a slightly different approach to development. There are however, a number of opportunities to maximize the benefits of wind power in Canada. These opportunities are discussed in Section 3.0 – Canada's Wind Energy Opportunities and Capacity.

# 3.0 Canada’s Wind Energy Opportunities

With Canada’s long coastlines, vast landmass, high latitude, and abundant storage capabilities through hydroelectric generation, there are plenty of sites that provide ideal conditions for wind power generation. The most ideal wind profiles are found off the west coast, in the Prairies (ranch land in Alberta and grain-producing areas of Saskatchewan), in the Great Lakes region, along the coastal areas of Northern Ontario, along the coast of the Gaspé area and in the Atlantic provinces.[42] Canada’s Atlantic Provinces have exceptional wind power potential; wind resources on Canada’s east coast far exceed its electricity load.[43]

A recent partnership between the Canadian Wind Energy Association, the Royal Canadian Geographical Society and Canadian Geographic Enterprises, with support from Natural Resources Canada, created an educational map on wind energy in Canada. The map, shown as Figure 6 below, shows the wind resource across Canada as obtained from Environment Canada’s *Wind Energy Atlas of Canada* (www.windatlas.ca), along with current wind projects and Canada’s major electricity transmission corridors.

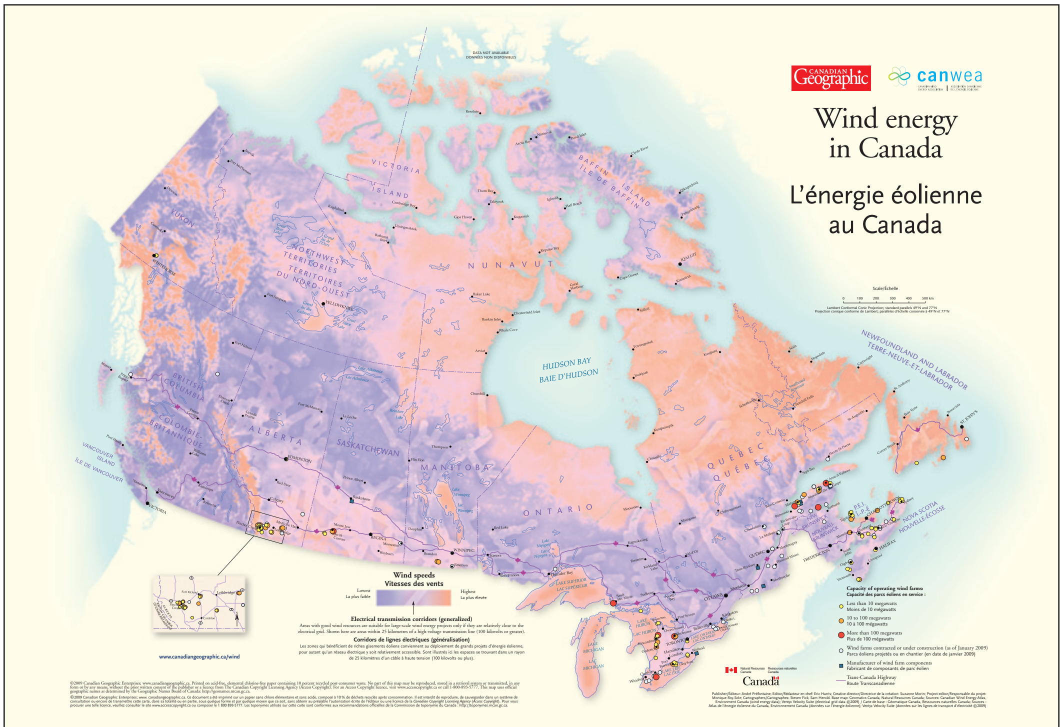



**Figure 6: Wind Energy in Canada, showing wind resource, current projects, and Canada’s major electricity transmission corridors**

This section will look at opportunities created by the combination of this vast wind energy resource with current Canadian industry composition and capacity.

## 3.1 Opportunities Resulting From Wind Energy

With an enormous wind energy potential to develop, Canada could produce a significant portion of its electricity from wind power in the future. This creates an opportunity for Canada to realize economic, environmental and energy benefits from wind power.

The Wind Technology Roadmap proposes the fllowing vision statement:

> *By 2025, Canada has become a world leading supplier of key wind energy technologies and policy solutions. More than 20% of its electricity needs are met by wind in 2025 and sustained annual growth creates additional wealth through export.*

A strategic approach is required to ensure benefits from wind energy are maximized. In addition, Canadian initiatives must recognize the significant growth in the global market, which presents both challenges and opportunities.

A recent American initiative, 20% Wind Energy by 2030, examined the impacts of significant growth of wind energy in the United States. The results of their analysis are presented in Figure 7.[44]

In Canada, there are a number of strategic advantages identified that would result from sustained wind deployment and industry development. The advantages to Canada will depend on whether domestic manufacturing and technology development are established, therefore advantages to wind deployment and industry development are considered separately.

**20% US Wind Scenario: Projected Impacts**

- Environment: Avoids air pollution, reduces GHG emissions, and reduces water use in electricity generation. Reduces electric sector $CO_2$ emissions by 825 million metric tons.
- U.S. energy security: Diversifies our electricity portfolio and represents an indigenous energy source with stable prices not subject to fuel volatility.
- Energy consumers: Potentially reduces demand for fossil fuels, in turn reducing fuel prices and stabilizing electricity rates.
- Local economics: Creates new income source for rural landowners and tax revenues for local communities in wind development areas.
- American workers: Generates well paying jobs in sectors that support wind development, such as manufacturing, engineering, construction, transportation, and financial services. The new manufacturing will cause significant growth in wind industry supply chain. Over 500,000 total jobs would be supported by the wind industry by 2030.
- Water savings: Reduces cumulative water use in the electric sector by 8% (4 trillion gallons)

**Figure 7: Project Impacts of 20% wind in the USA**

### 3.1.1 Strategic Advantages to Canada from Sustained Wind Energy Deployment

Deployment of wind energy provides benefits to all Canadians. The following are key benefits that have been identified:

- Avoiding volatile fuel costs provides price stability that comes from investing in wind;[45]
- Investing in wind power hedges against future greenhouse gas emission regulations that would make traditional fossil generation more expensive[46]; and will significantly contribute to reduced air emissions as recognized by the award of offset credits to wind energy under Canada's Offset System;[47]
- Canada's wealth of hydro power reservoirs allows a lot of flexibility to add large amounts of wind and smooth out the variation in its output;[48]
- Continued wind development provides a strong base for industrial development and innovation.

Clearly, the electricity supply mix in each province will influence the impact of these benefits. However, there are clear benefits for both hydro power and thermal power based provinces.

### 3.1.2 Strategic Advantages to Canada from Sustained Wind Energy Industrial Development

Sustained development of the wind energy industry, including manufacturing and innovation, provides important benefits in addition to those of wind deployment, including:

- Improved economic benefits to Canada with a larger proportion of capital investment from wind energy deployment remaining in Canada, which would provide a significant increase in domestic job creation;
- Increased opportunities to ensure that Canadian needs are met by manufacturers in the supply of wind turbines through earlier and stronger partnering in the innovation cycle;
- Increased international competitiveness for Canada, including the potential for Canadians to market their expertise internationally.

*3.1.3 Benefits to Rural Communities from Wind Energy Development*

Wind energy development can help to diversify the local and regional economies of rural and remote communities through:

- Job creation for construction of wind sites and long-term employment for the operation and maintenance of wind farms;
- Additional tax revenue for local governments, through property taxes;
- Income for landowners from annual land lease payments;
- Reduction in reliance on costly and polluting diesel fuel for electricity production in remote communities[49].

## 3.2 Canadian Wind Industry Composition

The Canadian wind energy industry is rapidly growing with the increase in wind energy development. The Canadian Wind Energy Association has 425 members involved in project development, operation and ownership, as well as manufacturing, engineering, construction, maintenance, and non-construction services.

The Canadian Wind Energy Association's member directory, **http://www.canwea.ca/about/membersdirectory_e.php**, provides a detailed listing of the Canadian wind industry's main stakeholders.

Most of CanWEA's growth in new membership stems from companies in the supply chain or seeking to join the supply chain. Traditionally, CanWEA's membership was composed mainly of developers and service providers[50]. There has been limited technology development and manufacturing of large wind turbines, however, Canada does have a number of small wind turbine manufacturers, manufacturing turbines of less than 100 kW.

## 3.3 Human Resources for Wind Energy in Canada

The potential exists for large employment opportunities in Canada in the research, planning, manufacture, installation and maintenance of wind power facilities. While there is some existing human capacity, Canada lacks a large, well-trained workforce in this sector. Since Canada currently imports almost all of its large-scale turbines and components, many of the employment benefits from Canada's wind growth are accruing to foreign countries. Given the recent slowdown in Canada's automotive sector, there is clearly an untapped human resource potential in Canada to meet the growing needs of the wind energy industry.

Labour demand in the wind power sector is expected to grow rapidly as installed capacity in Canada increases. The International Energy Agency (IEA) estimated in 2004 that there are 4.8 jobs created for every MW of installed wind capacity.[51] One study conducted by the European Wind Energy Association (EWEA) found that the wind industry has created 33 jobs every day in Europe over the last 5 years.[52] In another study, it was determined that for every MW of large-scale wind energy capacity installed:

- 10 job/years in manufacturing activities are created or preserved;
- 2 job/years are created in planning, installation and construction activities;
- 2 permanent jobs in service and maintenance are created.[53]

It should be noted that these job creation estimates include the full manufacture of wind turbines. Outside of Quebec, Canada does not currently have any manufacturing of large-scale wind turbines or components, except for wind turbine tower manufacturing in Ontario and Saskatchewan. As such, these estimates would overshoot the actual employment benefits that would accrue to Canadians. Recognizing this, one key to maximizing the economic benefits of wind energy deployment to Canadians would be to increase domestic manufacturing of components. To address this, Ontario's new Green Energy Act has plans to increase local content requirements for renewable energy projects in Ontario.[54]

Previous analysis has been done in regards to human resources within the wind energy sector specific to Canada, which takes into account the likely Canadian share of employment related to Canadian wind energy development. The research done by Delphi for CanWEA makes a conservative estimate for the present and future Canadian share in the major activity areas. The results of their analysis suggested that a total installed capacity of 10,000 MW by 2015 would result in 10,600 person years of work.[55] The report, CanWEA – Detailed Labour Forecast – 2015, provides information on the human resource requirements by category of employment and required training.

In large, networked wind farms (>30 MW), wind turbines represent up to 70% of the total capital investment, making them the most important cost element for the wind energy developers. The remaining 30 percent is dedicated mainly to construction, balance of plant and also includes project preparation and wind farm operations.[56]

Supervision and management of a wind farm can be performed remotely, and a mobile crew of two people can attend to about 20 to 30 turbines. A wind turbine requires about 40 hours of maintenance per year.[57]

Given the growth profile of wind energy in Canada, and the related human resource requirements, enhanced training programs to develop the required skill sets in Canada will be a critical component for success.

## 3.4 Canadian Capabilities and Strengths

While Canada is not a global leader in the design or manufacture of wind turbines, there are areas in which Canadian firms currently excel. Canada boasts some of the lowest business costs in the industrialized world, which acts as a clear incentive for founding or expanding wind power facilities in Canada.[58] Canada's close proximity to the United States, one of the largest global wind markets, makes Canada an ideal place for locating manufacturing facilities, particularly because of the challenges associated with transporting very large pieces of equipment. The following sections detail areas of current Canadian capability.

### *3.4.1 Manufacturing, Deployment & Operation Expertise*

Early wind energy developments in Canada were sourced almost entirely from international suppliers with little or no domestic manufacturing. As the pace of development in Canada has increased, domestic manufacturing capability has increased. Currently Canada has only one large turbine manufacturer, AAER, who is positioning itself to take advantage of the growing market. Canada has capacities in other areas also. Specifically, Canadian firms offer[59]:

- Expertise in large-scale wind turbine tower, base frame and rotor blade manufacturing;
- Nacelle assembly expertise;
- Leading edge technology in electric inverter, power conditioning equipment and large-scale battery storage;
- Expertise in cold and harsh climate wind turbine research and applications;
- Wind resource assessment and mapping expertise;
- Wind farm planning, financing and development expertise;
- Utility-scale wind farm operation and management expertise;
- Small (10-60 kW range) wind turbine manufacturing;
- Design, installation and integration of wind generation systems for isolated and off-grid hybrid system applications.

Two new manufacturers, RePower and Enercon, have announced plans for manufacturing components and assembly in Canada over the next few years.[60] A third, Multibrid, is considering manufacturing in Ontario.[61]

### 3.4.2 Codes, Standards, and Best Practices

Codes, standards, frameworks and best practices are important industry tools to build expertise, reduce risks, minimize obstacles to trade and establish consistent, safe and sustainable practices.

CanWEA helps develop frameworks and best practices, including:[62]

- a model Canadian grid code that established best practices for interconnecting wind turbines to utility grids across Canada (2006);
- best practices on sound, outlining acceptable thresholds for sound and how to assess sound, and best practice guidelines for assessing potential interference with radio, radar and seismo-acoustic installations, and Ontario guidelines involving safety with respect to icing and blade failure (2007).

The Canadian Standards Association (CSA) is the standards development organization responsible for developing Canadian wind energy standards. With the financial support of Natural Resources Canada, the CSA has published five new Canadian standards, as well as the CSA Guide to Canadian wind turbine codes and standards. Current work through CSA includes:

- updates to the Canadian Electrical Code (CEC) Part I – Section 64 – "Renewable Energy Systems";
- updates of existing standards to improve references and adopt improvements based on International Electrotechnical Standards;
- preliminary examination of the international draft offshore wind standard for adoption in Canada.

### 3.4.3 Science and Technology Capacity

Canada has a wide range of industry, academic, non-profit and governmental organizations that provide science and technology expertise to the wind energy industry.

Some key organizations are:

- The Canadian Wind Energy Association (CanWEA) is a non-profit trade association that promotes the appropriate development and application of all aspects of wind energy in Canada, including the creation of a suitable policy environment. CanWEA has worked with a variety of experts to support research on impacts related to wind energy deployment including noise, wildlife impacts, and public acceptance issues. CanWEA also collaborated with the Alberta Electricity System Operator to analyze the effectiveness of various wind forecasting models in Alberta.

- The Wind Energy Institute of Canada (WEICan) is a not-for-profit experimental facility for the Canadian wind industry. The facility supports the development of wind power generation and wind energy-related products and services for Canadian and international markets. WEICan is equipped with laboratories and workshop areas and is designed to meet the needs of both large and small-scale projects. Work at the institute focuses on testing and certification, research and innovation, and public education.[63]

- The recently established Wind Energy Strategic Network (WESNet) brings together wind energy researchers at 16 Canadian universities, federal (including Natural Resources Canada and Environment Canada) and provincial (including Hydro-Québec and Manitoba Hydro) agencies, institutional partners of the wind sector (including CanWEA and the CORUS Centre). Through the National Science and Engineering Research Council's Strategic Network program, WESNet will enable Canada's academic researchers to develop integrated projects to address Canadian wind energy needs. The Network will help train 153 students and ensure the transfer of know-how and technological advances to the wind industry.[64] With financing of $5M over 5 years, the research network's objectives are to:

  - Develop innovative solutions to key technical issues facing the wind industry, particularly cold climate issues;

  - Empower the Canadian wind manufacturing sector to become an international player;

  - Address the growing needs for highly qualified personnel in the wind energy sector;

  - Promote wind energy as an economically competitive and environmentally beneficial supplement to energy portfolios.[65]

- The CORUS Centre was set up by the Wind Energy TechnoCentre as part of a collaborative effort involving several Québec universities closely connected to the wind energy industry. Located in Murdochville, on the Gaspé Peninsula, the CORUS Centre is dedicated to research, development and the transfer of technology. Two wind farms with a total capacity of 108 MW surround it. This location makes the research centre a unique natural laboratory in which to study the impact of the cold environment on the extraction of wind energy.[66]

A number of Canadian private sector firms are involved in research and development projects from developing new power converters and generators, to novel tower and blade concepts. Financial resources for science and technology (S&T) activities are extremely limited in Canada, which limits the amount of S&T activity that can be performed.

### *3.4.4 Federal Government Science and Technology Capacity*

Canadian federal government researchers perform research and development work in support of the Canadian wind energy industry. These groups include:

- CanmetENERGY, Natural Resources Canada performs research and development on wind energy technologies, electricity storage technologies and grid integration;
- Canadian Wildlife Service, Environment Canada performs important research related to the environmental impacts of wind turbines on birds, strengthening the guidance on siting of wind turbines;
- Science and Technology Branch, Environment Canada, performs research and develops tools to enable wind energy resource assessment and wind energy forecasting, including the *Wind Energy Atlas of Canada* (**www.windatlas.ca**) and the Anemoscope software;
- Meteorological Service Canada, Environment Canada, provides operational weather forecasting services, including for wind atmospheric icing; and manages and analyses the national climatological archive, which is used for wind energy prospecting and for the development of design wind pressure loadings, atmospheric icing, and lightning climatology to enable wind energy developers to follow the Canadian Standards Association's standards for wind turbines;
- The National Research Council's Canadian Hydraulic Centre is involved in research, development and tank testing of foundations for offshore wind turbines, and has been sought out for their expertise in the development of Denmark's Nysted Offshore Wind Farm.

The following programs provide the main federal investments in Energy Research and Development:

**Federal Science and Technology Funding:**

- The Program for Energy Research and Development provides approximately $500 thousand/year for wind energy research and development including work on codes and standards, offshore wind, wind in the North, and small wind turbines;
- The ecoEnergy Technology Initiative provides $1 million/year for wind energy research and development including support for Canada's participation in the International Energy Agency, and Environment Canada's work on wind forecasting tools.

**Federal Funding for Academic Research and Development:**

- The National Science and Engineering Research Council program provides funding for university research in wind energy, including most notably the Wind Energy Strategic Network (WESNet) for which it provided $5 million over 5 years. A number of academic Chairs have been established, including the Canada Research Chair in the Aerodynamics of Wind Turbines in Nordic Environment at Université du Québec, École de technologie supérieure.

**Federal Funding for Industrial Research and Development:**

- The National Research Council's Industrial Research Assistance Program provides technical and business oriented advisory services and financial support to small to medium enterprises to perform industrial research, including support for wind energy research and development;

- Sustainable Development Technology Canada (SDTC) is a not-for-profit foundation that provides funding for sustainable technology development and demonstration, including support for wind energy technologies, with the aim of "de-risking" these projects. SDTC has approved roughly $20 million for various wind technology projects since its inception. A listing of projects to date is available at: **www.sdtc.ca**;

- Most recently, a new federal program, the Clean Energy Fund, was launched. The $1 billion Clean Energy Fund supports the Government's commitment to make greater use of technologies that reduce greenhouse gas emissions from energy production. The program includes $150 million over five years for research, and $850 million over five years for the development and demonstration of promising technologies. The Renewable Energy and Clean Energy Systems Demonstration Projects component of the Fund received 178 proposals by the closing deadline of September 14, 2009, with a total request for $1.7 billion of CEF funding. The component has an allocation of $191.4 million. The proposals are currently being reviewed, a process that should be completed by late 2009. Projects can include innovative wind energy technologies that address Canadian challenges, including but not limited to cold climates, remote communities, offshore applications and grid integration. Innovative and efficient storage systems for variable renewable power and heat are also included in the program scope. More information on the Clean Energy Fund is available at: **www.cef-fep.nrcan.gc.ca**.

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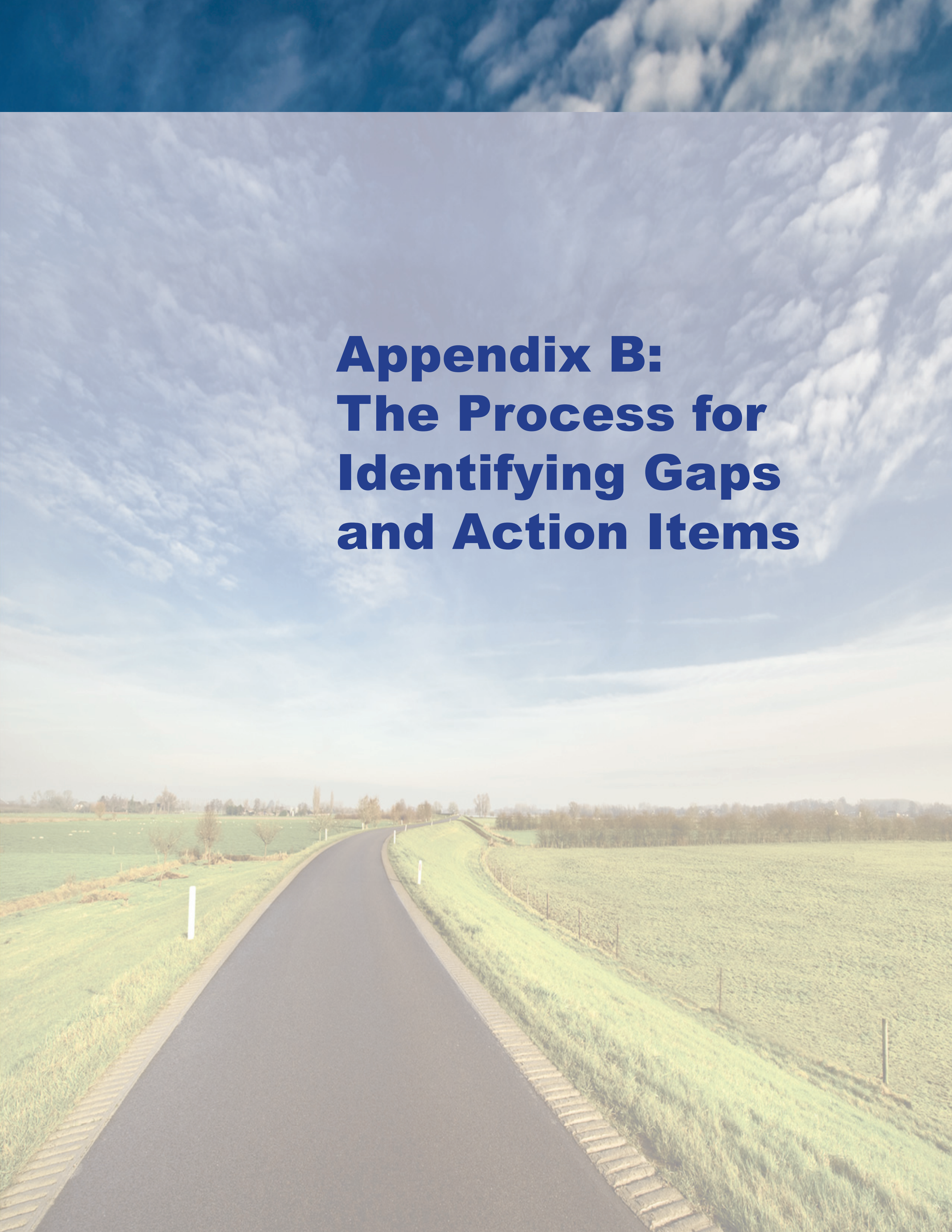
# Appendix B: The Process for Identifying Gaps and Action Items



# Table of Contents

# 1.0 Introduction

Wind energy represents a substantial opportunity for Canada to meet electricity needs and generate significant economic gains in an environmentally sustainable manner. In order to enable Canada to achieve its full potential in this area, the Government of Canada has provided support for an industry-led effort to create a technology roadmap for wind energy.

The objective of the creation of the Wind Technology Roadmap (WindTRM) was for technology developers, adopters, and users, to identify wind energy innovation priorities. The WindTRM identified the key technology and policy needs of the wind energy industry to succeed in the future and documented the actions required. Ultimately, the objective is to identify key investments and actions so as to increase Canadian innovation and social and economic outcomes.

This WindTRM process was led by a team of industry leaders who form the Industry Steering Committee (ISC). In recognition of the diverse challenges and needs for the wind energy industry, the ISC determined that four working groups (two of which were further divided into two subgroups each) should be created. The structure of the working groups is summarized as follows:

- **Working Group 1 (WG1): Market and Economics:** Focus on market, economic and human resources concerns for wind developers in Canada as well as issues faced by Canadian wind energy companies in the global market context.
- **Working Group 2 (WG2): Wind Energy Resource:** Focus on where Canadian technologies, expertise and market leadership can be developed in the area of wind resource assessment and wind engineering for both onshore and offshore projects.
- **Working Group 3 (WG3a and WG3b): Wind Energy Systems:** Focus on where opportunities can be found or created with respect to Canadian technologies, expertise and market leadership in the area of wind turbine manufacturing, procurement, installation, and use. This working group will have a large wind sub-group (3a) and a small wind sub-group (3b).
- **Working Group 4 (WG4a and WG4b): Wind Energy Integration:** Focus on the regional challenges in integrating wind energy into the Canadian energy supply as well as some possible technical solutions to them. This working group will have a planning sub-group (4a) and an operations sub-group (4b).

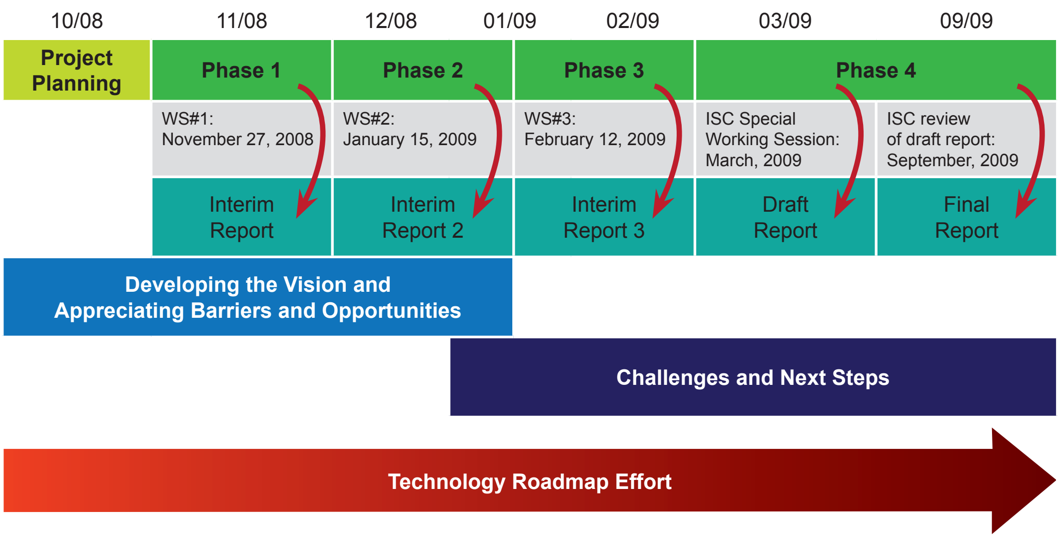
PricewaterhouseCoopers LLP (PwC) was engaged to:

- Administer the WindTRM process. This involved working with Industry Canada (IC), Natural Resources Canada (NRCan) and the ISC to develop the format and agenda of ISC meetings, workshops and working group breakout meetings;
- Facilitate the ISC meetings and workshops;
- Synthesize information and feedback after each phase and develop, draft, and write the WindTRM Report, and deliver a PowerPoint presentation to federal representatives and the ISC.

PwC's role was limited to facilitating the process: all content, including barriers, recommendations, cost estimates and other information was based on input from participants throughout the process.

The following chart illustrates the phases and timeline for the development of the WindTRM.

**The WindTRM Time Frame**



# 2.0 Creating the Vision

The first workshop was attended by over 100 representatives from industry, government and academia (see Annex 1 for a listing of all attendees). The objective of this workshop was to bring together interested stakeholders to identify key opportunities and develop a vision for the WindTRM.

To set the context for the WindTRM vision discussion, representatives from the Canadian Wind Energy Association (CanWEA) and Toronto Hydro presented a summary of the current status of the wind energy industry in Canada and worldwide.

## 2.1 Identifying Opportunities

The development of the vision was guided by an initial discussion on opportunities. A number of key opportunities and considerations were identified by the workshop participants that served as the basis for the discussion of the vision. The opportunities were grouped into five major themes: Taking Advantage of Canada's Wind Resource, Exploiting Wind's Economic Opportunities, Developing Innovative Technology, Creating Employment, and Connecting with Complementary Initiatives. Specific opportunities are listed below.

**1. Taking Advantage of Canada's Excellent Wind Resource**

- Each of the regions in Canada has excellent wind energy resources.
- Increasing electricity from wind enables a reduction in the carbon footprint of the energy sector.
- Wind is scalable, less expensive and better understood than other low emission energy sources.

**2. Exploiting Wind's Economic Opportunities**

- Canada's substantial wind resource and North America's interconnected electricity grid provide the basis for strong export potential to the US by many regions across the country.
- The credit crisis (being experienced at the time of the first workshop in November 2008) creates opportunities for further consolidation and optimization of the wind energy industry. Given that Canada may be in a stronger economic position than most other industrialized countries, this is the time to ensure that restructuring in Canada leads to strength on a comparative basis globally.
- Canada's cold climate and remote communities create opportunities for municipalities to develop micro grids and for Canada to develop global niche market solutions for rural and remote communities.

- An appropriate mix of energy source options needs to be developed taking into account capital and operating costs, pricing considerations and the need for a stable and secure energy supply.

- Many industries with complementary assets (e.g. agriculture, transportation equipment manufacturing) are currently experiencing a downturn and seeking opportunities to have their assets (land, skilled resources, technology, manufacturing machinery and equipment) devoted to a more productive use.

- Efficiencies are possible through a variety of means, for example, developing an integrated approach to site assessment, streamlining approval and permitting processes, and taking advantage of offshore opportunities.

- Government can leverage its role as power purchaser to increase the strength of Canadian industry; for example, the Quebec government requires a proportion of each project's equipment be manufactured in the province, and Ontario's Green Energy Act proposes local content requirements.

- Public investments in wind may help address the economic crisis through both the creation of employment as well as the stimulation of additional spending.

**3. Developing Innovative Technology**

- Invest in improving R&D and all aspects of delivery (e.g. manufacturing, generation, transmission, etc.) along the whole value chain.

- Make better use of existing technologies and R&D in Canada and around the world.

- Collaborate in R&D to bring a variety of actors together possessing different assets such as modeling expertise, engineering expertise, data analysis expertise, etc.

- Leverage strengths and skilled resources in Canadian R&D to access world-leading R&D.

- Identify distinct opportunities for three systems such as is done in Denmark and Germany: large wind, community-based wind, and small wind.

- Development is required in a host of areas, notably:

    - Develop and implement better solutions for increasing the penetration of wind into the electricity grid.

    - Develop targeted energy solutions such as wind-diesel in the Canadian North and in developing countries, and hydro based systems for storage of wind energy.

  - Develop technologies in key parts of the system such as components, storage, and transmission infrastructure.
  - Develop and harmonize codes and standards for grid interconnection.
  - Design equipment with transportation/logistics in mind (e.g. near shore and onshore).
- Support leading technology we currently have, specifically for small wind turbine manufacturing.
- Bring Canadian expertise in engineering consulting to the global market:
  - In micro-scale modeling that can be coupled with meso-scale modeling.
  - For remote/cold climate knowledge and experience.
  - By providing research opportunities for academia.
  - Through transfer knowledge of aerodynamics between wind and other industries.
- Use wind integration as an opportunity to update high voltage transmission systems.

**4. Creating Employment**

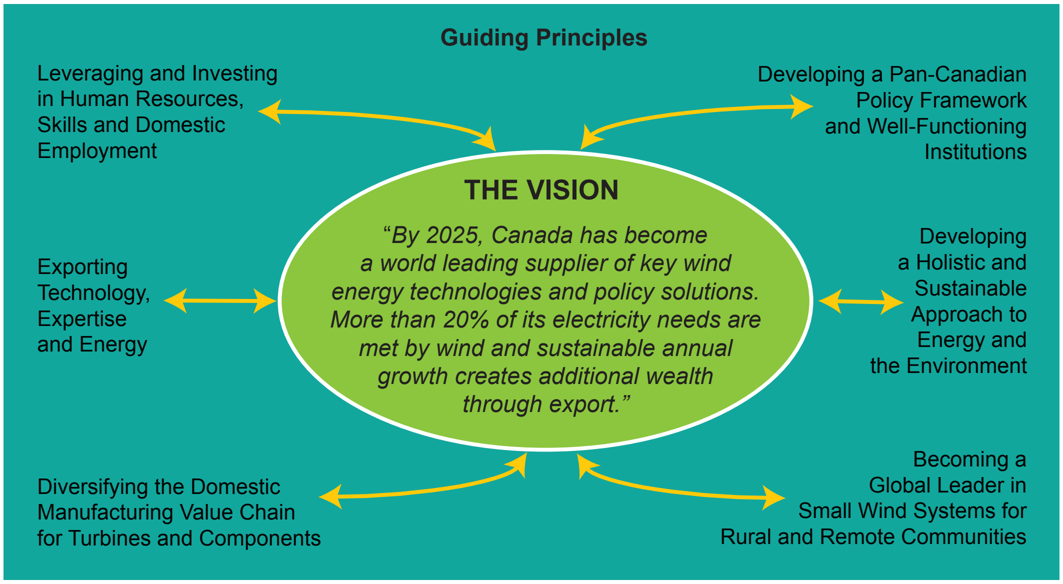
- Leverage the fact that Canada has excellent wind resources, a highly trained workforce, and competitive labour rates.
- Take advantage of labour opportunities, specifically: the automotive industry downturn (being experienced at the time of the first workshop in November 2008), the opportunity to capitalize on youth interest in renewable energy, immigration, and the aging workforce/turnover opportunities.
- Develop programs to retrain and transfer expertise from other sectors and create sustainable jobs in all regions.
- Forge partnerships between industry and colleges, universities and academia to better target knowledge development and skills development

**5. Connecting with Complementary Initiatives**

- Harmonize CanWEA vision with economic and technical barriers.
- Feed into NRCan's Policy Framework discussion that is currently underway.

## 2.2 Articulating a Vision to Guide the Wind Energy Technology Roadmap

Following the identification of opportunities as described above, participants suggested and discussed key vision statements. A fundamental starting point was that there was broad support for CanWEA's vision of having wind satisfy 20 percent of Canada's electricity demand by 2025. A review of the vision statements illustrated that there were multiple themes agreed upon by the participants. In order to assess the strategic importance of each of the themes, a survey was sent to all participants, asking them to rate the importance of each theme. The ISC met to review the report from the first workshop, along with the survey findings, and collaborated and agreed on a consolidated vision that incorporated the key themes. The themes and the vision are included in the following chart.



# 3.0 Identifying specific barriers and action items to address the vision

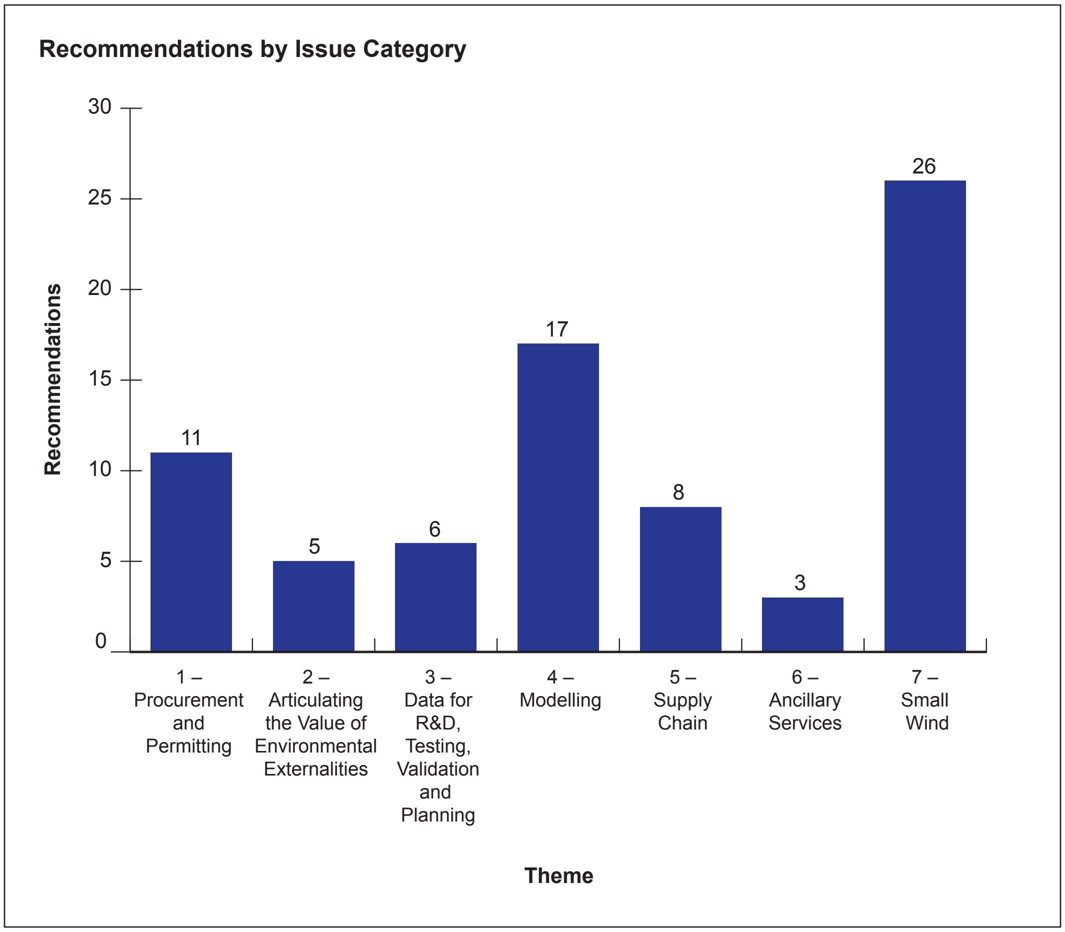
The second workshop involved identifying the barriers to achieving the vision. The schedule for the day involved the following:

- The workshop opened with a plenary session wherein the work on the vision leading up to the second workshop was discussed.
- There were two presentations during plenary sessions on issues that affect the North American Wind Industry. Mark Lauby from the North American Electric Reliability Corporation first spoke on the key challenges and opportunities of planning and integration for the new wind projects. Steve Lindenburg from the United States Department of Energy then spoke on a recent initiative undertaken by the Department looking at overcoming obstacles to meeting 20% of the United States' electricity demand with wind energy by 2030. Copies of both speakers' presentations are available on the WindTRM forum.
- The bulk of the day was devoted to break-out group discussions on barriers and action items.
- The groups reconvened in a plenary session at the end of the day, wherein the chair persons from each of the working groups reported back on the key barriers and action items for next steps.

The third workshop consisted of a series of plenary and break-out group sessions.

- The workshop opened with presentations from Geoff Nimmo of Industry Canada, on "Implementing Wind Technology Roadmap Priorities" and from Liuchen Chang of the University of New Brunswick on the "NSERC Wind Energy Strategic Network".
- The participants provided recommendations on priority action items in the morning and afternoon breakout sessions.
- ISC chairs reported back to the group following the afternoon breakout session.

The report from the Third WindTRM workshop represented the culmination of several rounds of input from industry practitioners, government experts and academic specialists from both the third workshop and follow-up conference calls after the third workshop. The report presented 76 recommendations provided by stakeholders and synthesized shared messages across the broader wind energy community. These have been broken down into issue categories in the following chart.




The ISC met to prioritize the recommendations and agreed on six top action items. The body of the report was drafted with the collective input of the ISC and support by PwC. While the body of the document presents the priorities and action items at a high level, the following text presents a more fulsome discussion of the barriers that the priorities sought to address, and the specific action items.

It is important to note that these action areas overlap in many cases. For example, much of the emphasis in many actions areas will be focused on large wind. However, small wind represents both an important opportunity and a need for Canada. Hence, the issues pertaining to small wind have been discussed in one action area focused on small wind, but steps specific to small wind will need to be addressed in other action areas. Consequently, the “Small Wind” section demonstrates the need to inform Canadians about the small wind opportunities and benefits, but specific steps in this regard should be undertaken under the action area to “Inform and Engage Canadians”.

## 3.1 Strengthen the Policy Framework

*What is Required*

The need for a strong policy framework to support the continuing growth of wind energy in Canada has never been more important. Without comprehensive, consistent nation-wide policies regarding wind energy, and renewable energy more generally, wind energy will not achieve its full potential in Canada.

*Why Action is Needed*

Currently in Canada, and indeed around the world, the true value of non-emitting energy sources has not been fully taken into account. The lack of a national carbon tax, cap and trade system or alternative mechanism for the valuation of environmental impacts, forces wind energy to compete on an “uneven playing field” with other traditional energy sources that create more negative environmental impacts.

Canada has the opportunity to establish a framework and send a clear message to power purchasers and manufacturers that wind energy is a truly economical and environmentally-sound choice for power generation. In addition, with the recent push towards renewing transmission grid infrastructure across North America, there is an opportunity for provinces and territories to adopt and establish a long-term planning strategy for transmission corridors that could better facilitate the integration of wind energy into the current power mix.

*Current Challenges and Barriers*

Challenges associated with the current policy framework were noted in several of the working groups.

WG4a noted a host of barriers associated with the existing policy framework.

- A key barrier, also noted by numerous groups, was the fact that substantial new transmission investment will be required to incorporate any significant amount of wind energy. However, it takes much longer to develop new transmission capacity than it takes to develop a new wind farm. The long permitting process for transmission development aggravates this problem. It was also noted that sequential “bit-by-bit” treatment of additional generation capacity is a problem for bulk system planning.
- They noted that there was a lack of clarity on how wind fits in with other renewable energy sources.

WG1 reported that Canada lacked:

- A long-term view and provisions to ensure wind capacity objectives are met with respect to current procurement processes;
- East-west and north-south transmission connectivity;
- National and regional cooperation and planning;
- Incentive mechanisms to enable wind to meet its long-term potential and be competitive with traditional energy sources; and
- Certainty around permitting and approval processes for new wind projects.

Other challenges were highlighted by WG3a and WG3b, including:

- Lack of sustained demand for wind power technologies and new wind farm projects;
- Lack of incentives to support production of small wind turbine systems for demonstration and deployment into-grid connected and remote community markets; and
- Lack of evolution in regulatory and utility frameworks to accommodate small wind.

### *Key Action Items*

Overall, the wind energy policy framework in Canada is still in its developmental stage. In order to ensure that wind energy can continue to advance and provide economic growth and ecological benefits, there must be a strong policy framework established. This requires attention in a host of areas to ensure the procurement process meets Canada's long-term wind energy goals. There must be regional cooperation in the planning of wind energy installations, in addition to certainty about the permitting and approval process for developers. There is also a need to properly value environmental externalities to demonstrate the true environmental costs of energy. In order to maintain stable demand for wind energy in the near- to medium-term there must be adequate mechanisms put in place to ensure that wind energy is recognized and valued appropriately for its positive attributes. These points are outlined in the table below.

| Action item | When | Who |
|---|---|---|
| **Put in place temporary incentive mechanisms** | | |
| a) Put in place renewable energy incentive mechanisms. | 6 Months-Long-term | Government |
| b) Establish a broad coalition of stakeholders seeking to ensure that wind energy is able to obtain value for its environmental attributes within the context of leveling the playing field (e.g., municipalities, environmental groups, health organizations, aboriginal communities etc.). | 1 year | Government, industry and NGOs |
| **Create effective procurement practices** | | |
| c) A study should be prepared and distributed to all provincial governments, crown utilities and procurement authorities, that would review different procurement methods for wind energy that have been utilized around the world for wind energy and assess them against the following criteria:<br>1. Ability to create a transparent long-term (10+ years), steady and stable procurement plan for wind energy;<br>2. Ability to reflect and adapt to changing economic circumstances within the wind energy industry;<br>3. Ability to generate investment in local content (e.g., manufacturing supply chain);<br>4. Ability to align with long-term local planning/transmission/demand issues;<br>5. Ability to allow wind energy projects to obtain and retain value for their environmental attributes;<br>6. Ability to produce cost-effective electricity production;<br>7. Ability to accommodate a broad range of potential wind energy project developers; and<br>8. Ability to consider elements of “project quality” other than price. | 6 months | Government and Industry |
| d) Seek to establish simplified permitting and approval processes for wind energy in all regions in Canada (e.g. a one-window approach would likely be optimal for developers). | 1 Year | Government, utilities |

| Action item | When | Who |
|---|---|---|
| **Promote long-term planning of transmission corridors** | | |
| e) Provide clear information (transparency) on available transmission capacity today, and modest near term upgrades which would inform developers and wider marketplace. From a transmission provider's perspective, identify the best place for developers to build. | Initial identification – 1 year and ongoing thereafter | Utilities |
| f) Address long transmission permitting cycles by allowing advance permitting for a transmission line that could/would be constructed in the future, and by establishing transmission right of ways and corridors. This recommendation addresses both land use as well as current regulatory hurdles which requires "proof of need". This would involve the following steps:<br>• Utilities need to establish what they might need to provide for future generation capacity for wind;<br>• Utilities communicate with regulators and discuss a list of options for long-term planning. Potentially allow monies to be spent on developing transmission plans; and<br>• Utilities communicate with governments (all levels) about land use planning to set aside right of ways with various levels of certainty. With a large amount of crown owned land, the government can set aside broad corridors which can be set aside/reserved for future use. | Varies by jurisdiction | Utilities |
| **Produce regulatory roadmaps** | | |
| g) Every jurisdiction should prepare a wind energy regulatory roadmap that clearly identifies all permits and approvals required for a wind energy project and the timelines associated with these permitting and approval processes. | 1 year | Government |
| h) Development of a Class Environmental Assessment for wind energy and improve harmonization and/or delegation of Federal and/or provincial environmental requirements as practical. | 1-2 years | Government and NGOs |

The cost for incentives is estimated to be between two and three billion dollars over a 15 year period. Other actions, such as the establishment of a regulatory roadmap, streamlined permitting process or a class environmental assessment, are expected to have no incremental, or a modest, cost.

### *How These Actions Will Contribute to Achieving the Vision*

Commitment of public funding and improvements in approval processes and long-term planning will create a competitive environment for wind in Canada that will attract global investments, generating environmental and economic benefits for all Canadians.

## 3.2 Inform and Engage Canadians

*What is Required*

The wind energy industry has the opportunity to leverage broad public support within Canada to facilitate integration of wind energy into Canada's electricity supply. The key to cementing public support lies in its ability to provide credible and empirically-supported data to dispel misperceptions regarding wind energy and installations.

*Why Action is Needed*

More fulsome information on the real costs and benefits associated with wind energy, as well as better information on Canada's competitive strengths, is necessary to encourage the investment of time, money and effort of government, industry, academia, investors and workers into wind energy. For example, with a significant proportion of small wind manufacturers being based in Canada, it is important to inform Canadians that in some respects Canada is already at the forefront of wind energy technology, but that greater support is needed, in particular from municipalities where by-laws and regulations can often impede greater penetration of wind energy. Equally important is the need to provide the correct signals to the current generation of students, namely that the wind energy industry is supported in Canada and that pursuit of wind energy-related education is a prudent choice. This will further the goal of developing a strong and highly-trained human capital base to serve wind energy operation, wind firming, manufacturing and other ancillary services required by the industry.

*Current Challenges and Barriers*

Key challenges in securing broad action-oriented public support for wind energy were noted across most of the working groups.

- It is believed that the general public lacks a full understanding of the costs of traditional energy technologies and sources. By understanding the complete lifecycle and environmental costs of energy sources and their potential negative impacts, Canadians would be able to make more informed decisions on their choice of energy (WG1);

- While there is public support at a national level for wind energy, social acceptance of wind projects at the local level remains a concern; some Canadians want wind power, but "Not in my backyard" (the NIMBY phenomena) (WG3a);

- Relatively recent developments in wind energy have highlighted the current lack of skilled personnel in commissioning, operations and maintenance services, contracting, and engineering for wind energy projects (WG3a);

- Developers and manufacturers have difficulty raising debt and/or equity due to the lack of broad acceptance and understanding of costs and benefits of wind energy (WG3a);
- There is a lack of public awareness of the potential of small wind installations (WG3b); and
- Education programs provided by university programs in engineering and other related areas do not adequately address the needs of the wind industry. (WG4a)

### *Key Action Items*

In order to promote wind energy as both an ecologically and economically beneficial industry in Canada, the public must be engaged by credible representatives of government, NGOs and industry that can provide the facts on wind energy. From a public and municipal government standpoint, resistance to wind energy must be countered with empirical evidence to build greater support for wind installations. The cost to initially provide documents to support the aforementioned goals, per target group, would likely be modest; however, longer term maintenance and expansion of such documentation could cost from one to five million dollars per target group. From an economic standpoint, universities and other educational institutions must partner with industry to develop programs that will provide students with the skill sets necessary to meet the needs of the wind industry in Canada. The following table lists some of the action items needed to meet these goals.

| Action item | When | Who |
|---|---|---|
| **Create a centralized repository of peer reviewed studies** | | |
| a) Develop and maintain an authoritative set of government documents, based on global literature reviews that address key concerns raised about wind energy projects (e.g., noise, infrasound, ice throw, structural failure, effects on wildlife). | 6 months and continuing to the Long-term | Government, industry, NGOs and academia |
| **Provide analysis to decision makers of costs and benefits of wind in electricity systems** | | |
| b) Provide decision-makers with information on the environmental impacts of electricity production and the costs associated with such impacts to support arguments for valuation of wind energy's environmental attributes. A first step in this process would be to produce a solid communications / outreach document based on a literature review of work done on the environmental impacts of electricity production and their costs – this should primarily draw on work from North America and Europe. | 1 year | Government, industry, NGOs and academia |

| Action item | When | Who |
|---|---|---|
| c) Complete analysis to develop a national perspective (e.g. adaptation of US DOE 20% Integration Study). | 9 Months | NGOs, Government, Academia and/or Industry |
| **Share evidence-based information with decision-makers, media, opinion leaders and the general public** | | |
| d) Address public acceptance issues by developing public relations and communications material through industry associations and government programs (eg. campaigns against littering or smoking), with increased emphasis on jobs and economic benefit. | Immediate and ongoing | Industry, NGOs and Utilities |
| e) Establish a broad coalition of stakeholders seeking to ensure that wind energy is able to obtain value for its environmental attributes within the context of leveling the playing field (e.g., municipalities, environmental groups, health organizations, aboriginal communities etc.). | 1 year | NGOs |
| **Improve and update education and training to build a sustainable and skilled workforce. This recommendation has two major target groups – appropriately educating new graduates coming out of university, as well as retraining the current workforce and providing continuing education resources to both groups.** | | |
| a) Make promotional materials available to public schools to promote wind as a career option. | Ongoing | Industry, NGOs, academia and government |
| b) Define what basic skills utilities need/want students to have. | 1 year | Utilities |
| c) Create, promote and support educational opportunities for target audiences to provide training in the appropriate areas (e.g.: probabilistic planning tools). For example, this could involve: a conference/training workshop for continuing education (focusing on technical and practical skills), a series of lectures by experts, and/or recorded lectures by experts at utilities for use by professors in their lectures/courses. As some of the target group would be students, funding and/or sponsorships would be needed. | 2 years | To be determined |
| d) Rebuild educational programs to refocus engineering curriculums with a view to the future (where industry is going) rather than where the industry was. | Several years | Academia |
| e) Continuing education could be taken over by the center of excellence, or this could become a profit center for a university institution with expertise in power systems. | 2-5 years | To be determined |

*How These Actions Will Contribute to Achieving the Vision*

Improved communication to the public, the workforce, financiers and government officials of the real benefits and opportunities for wind energy will create an environment wherein the broader population in Canada will commit funds, time and energy to the advancement of the wind energy industry.

## 3.3 Expand the Role of Canadian Industry

*What is Required*

The success of wind energy in Canada ultimately rests on the shoulders of Canadian industry. As such, it is critical to conduct research and map all the potential roles and areas of competitive advantage for Canadian industry, so as to encourage investment in the areas where Canada can be most successful. It is important to note that this mapping should consider all inputs, including services, technologies, materials, infrastructure, and so forth, in the wind energy industry.

*Why Action is Needed*

The mapping of the full life-cycle value chain of the wind energy industry will enable identification of key strengths and opportunities for improvement and illustrate where there is room for Canada to grow and become a competitor in the world market. It can also help to highlight bottlenecks and cost pressures that currently limit development of wind energy in Canada. This mapping is necessary to identify what should be imported, what areas Canada should focus on for development within its borders, and what areas Canada can serve as a competitive global leader. The mapping can also identify critical areas for future research and development efforts and enable Canada to be at the technological leading edge.

*Current Challenges and Barriers*

Some of the main challenges currently facing Canadian industry in its efforts to establish a strong domestic wind energy manufacturing and services base were highlighted by WG2:

- Insufficient knowledge of supply chain opportunities in Canadian industry;
- Limited number of manufacturers for key components; and
- Lack of R&D collaboration between industry and academia.

Other challenges were also highlighted by WG3a included:

- Import and export duties across Canada/US border create higher costs; and
- Lack of clarity of investment opportunities and associated returns creates difficulty in raising debt and/or equity for developers and manufacturers.

### *Key Action Items*

In order to fully realize the economic benefits of the wind energy industry, the entire value chain must be mapped out. This mapping will then enable identification of viable supply chain opportunities and potential areas for competitive advantage. It is also necessary to identify key partners and collaborators and leverage existing infrastructure that could be repurposed for the wind industry so that the whole supply chain in Canada can be as efficient as possible. Some of these initiatives, such as mapping the value chain and facilitating partnerships, are expected to cost in the range of a quarter of a million dollars each. Other activities, such as identifying opportunities for Canadian industry, are anticipated to require larger investments (in the order of approximately one million dollars each). An understanding of requisite investment levels for creating an attractive climate for investment in wind energy overall will require continued analysis and consideration as the market matures.

| Action item | When | Who |
|---|---|---|
| **Map the value chain** | | |
| Map out full life-cycle supply chain for onshore and offshore projects, building on existing work. This includes estimating value and volume of the Canadian large wind industry and potential export opportunities. | 6 months | NGOs, Government and Industry |
| **Identify opportunities for Canadian industry** | | |
| Identify supply chain opportunities based on the results of value chain mapping. | 1 Year | NGOs, Government and Industry |
| Assess current Canadian context and identify opportunities based on the mapping activity. This could include an adaptation or similar work to recent wind turbine supply studies done in the US. | 9 Months | NGOs, Government and Industry |
| **Facilitate partnerships and encourage Canadian sourcing of materials, components and services** | | |
| Identify Canadian capability for innovation and export and scale of potential export market and how to build on the opportunities. | 1 Year | NGOs, Academia |
| **Create an attractive climate for investment in wind energy** | | |
| See other action areas (e.g. Strengthen the Policy Framework, Inform and engage Canadians, etc.) | | |

*How These Actions Will Contribute to Achieving the Vision*

Identification of key areas of need and opportunity for Canada, through mapping of the value chain, will create the information necessary to spur investment by industry and educational institutions in developing infrastructure, operations and skill sets to support the advancement of the wind energy industry in Canada.

## 3.4 Create Centres of Excellence

*What is Required*

To efficiently implement higher levels of wind penetration in the Canadian electric energy supply mix, better data, technologies, systems, services and tools are required. Centres of excellence have been used widely throughout Canada to foster this type of extensive industrial development in a variety of sectors. These typically function as hubs of innovation where researchers, practitioners and policy makers can collaborate on a wide variety of issues. Cross-fertilization in thinking may be further enhanced by direct support for specific initiatives, such as a small wind research program or a shared repository of peer reviewed research on the impacts of wind development.

*Why Action is Needed*

The achievement of the WindTRM vision requires improved modeling and wind integration technologies and tools which reduce uncertainty when designing and planning the system. This will in turn reduce development and integration costs while diminishing financial risk. The currently available technology is based on data and models which were not specifically developed for wind energy and therefore lack the necessary relevance. Wind flow models lack the required level of precision and accuracy for large wind penetration levels. Current transmission planning models and operation room tools are not well suited to the stochastic and variable nature of the wind energy. Wind firming technologies have not been sufficiently developed to ensure adequate behavior of the overall electrical system. Lack of action will exacerbate the shortcomings of the current tools and paradigms. This will inevitably lead to higher cost, reduced efficiency and more risk. On the other hand, concerted action by relevant stakeholders will not only allow higher levels of wind penetration into the system but also will it contribute to a modern and more reliable electricity system.

*Current Challenges and Barriers*

A lack of advanced and reliable tools to facilitate large wind farm development, transmission planning and short-term forecasting (real-time and day-ahead modeling) was cited as a key barrier to the advancement of wind energy by most participants throughout the process.

- WG2 indicated that there was a significant lack of accurate and robust modeling technologies for: micro-scale models, meso-scale models, array loss models, technical loss models, climate change models and short-term forecasting models.
- WG4a similarly concluded that a lack of validated planning models, updated planning material and methods of determining the reliability of wind plants was substantially limiting the progress of the industry.
- WG4b also reported that a lack of precise and reliable short-term forecasting modeling tools was severely hindering the advancement of the industry. Specifically, they noted challenges in regards to inadequacy or lack of forecasting tools and technologies for: providing reliability assessments of the system, providing probability predictors for generator dispatch, predicting the behaviour of wind turbines, monitoring embedded generation, providing information on wind specific alarm events and guidance on how to react to them, and in general understanding and quantifying risks. They also noted the difficulty in finding personnel to carry out short-term forecasting, which usually requires the ongoing monitoring of relevant meteorological stations.

Challenges in improving current models and tools are due in part to the barriers related to accessing sufficient and adequate data for validation purposes. In particular, WG2 identified the following factors as high priority barriers which need to be addressed in order to enable the emergence of next generation simulation and resource assessment tools to achieve the WindTRM vision:

- Lack of standards for collecting data. This includes a lack of a standard for wind resource assessment, operational reporting and a lack of instrument certification. Moreover, the Canadian cold climate needs to be specifically addressed to reduce uncertainty.
- Lack of validation data. This includes a lack of high-quality and long-term data on wind, a lack of detailed data for operational wind power plants, (which is not accessible because it is privately owned) and a lack of high-resolution topographic and land use data (which is critical for improved precision).

Similarly, WG4b identified challenges with accuracy, metrics and standards as high priority barriers. More specifically, they highlighted problems due to a lack of data and information exchange:

- between system operators;
- between system operators and utilities;
- between system operators and owner/operators;
- between developers/owner/operators;
- between Environment Canada and system operators; and
- between manufacturers and system operators regarding turbine behaviour.

Lack of training for system operators and skilled operating room personnel was also noted as a key barrier to growth for WG4a and WG4b.

The gap in wind integration and energy storage solutions was repeatedly identified as a high-priority barrier to achieving the vision by many of the working groups

- WG1 emphasized the limitations due to the lack of cost effective energy storage technologies and/or balancing systems given the variability of wind power
- WG4a noted a number of integration challenges mostly related to a lack of understanding in various areas, such as: the level of reinforcement required to integrate wind, the amount of wind energy that can be integrated into each specific Canadian region (flexibility/stiffness of the grid), the generation interconnection process and the queue system. It is also not clear how the grid can be optimized so as to maximize the integration of renewables. Given that capacity factors drive the demand for ancillary services it is also difficult to fully understand the ancillary services that will be available in 2025 and how best to use them.
- WG4b identified similar challenges, including understanding how generation responds to load when there is a significant amount of wind supply on the system as well as the long-term operational impacts of wind with respect to the overall penetration and the concomitant requirements on ancillary services and associated costs.

### *Key Action Items*

In summary, high-quality field and laboratory data, long-term reference data for wind and detailed data from operational wind power plants are necessary for the initialization, testing and validation of various engineering models. Access to such data will enable the validation and implementation of more advanced and more precise planning and operational models and tools. Both wind farm developers and utilities will benefit from such improvements as more precision and less uncertainty will translate into less risk and therefore less cost. Developers will have a better access to capital and utilities will be able to integrate more wind energy with confidence without requiring unnecessary and costly reserves.

Furthermore, in order to improve system operation while meeting reliability requirements, new technologies and operating requirements will need to be developed so as to reach 20% of Canada's electricity demand. The "optimal" technology will depend on the regional characteristics and energy mix. It is likely that wind energy can be integrated at very little cost in some parts of the North American system (although these areas have yet to be fully identified).

Clearly, there is much work to be done to advance the development of the wind energy industry in Canada and optimize the use of wind in Canada. The involvement of a wide range of players from academia, industry and government will be required. In order to prioritize efforts, and facilitate development in multiple areas, it has been recommended that three separate, but interrelated Centres of Excellence be formed.

i. *Wind Resource and Energy Yield Assessment.* This Centre of Excellence would focus on developing databases and associated data standards, as well as a wide range of modeling tools. The work would largely be performed by data analysis and modeling experts, with utility companies and developers providing input on critical needs.

ii. *Advanced Operation and Transmission Planning Methodologies.* This Centre of Excellence would focus on further developing new probabilistic transmission planning tools and improving operating room tools to integrate short-term wind forecasting, using the data and tools developed in the Wind Resource and Energy Yield Assessment Centre of Excellence. In this Centre of Excellence, utility companies and developers would be the drivers, while data experts and modelers would play a supporting role.

iii. *Ancillary Services: Wind Integration and Wind Firming Technologies.* This Centre of Excellence would focus on developing the ancillary services that would be required to fully optimize the use of wind energy.

It is believed that investments of $15 to $25 million, over a period of a few years' time (see tables below), is required for each Centre of Excellence to facilitate the advances that are necessary to move the industry forward towards achieving the vision. The following chart presents the key action items and timing for each Centre of Excellence.

*Centre of Excellence I: Wind Resource and Energy Yield Assessment*

| Theme 1: Wind Resource Modeling Technology | | |
|---|---|---|
| **A) Improve Quality of Experimental Data**<br>Lack of validation data is a major barrier for improving and validating models. The required data includes: high-quality field and laboratory data, long-term reference data for wind and detailed data for operational wind power plants. It is imperative that data be available and accessible at the appropriate comprehensiveness, region and level of detail. It is important to note that a lack of high-resolution topographic and land use data also increases simulation errors and uncertainties. However, no specific actions were recommended to address this issue. | | |
| **Action item** | **When** | **Who** |
| a) Establish a committee to develop better standards and procedures for data collection, resource assessment, planning and operational reporting. | 2-5 years | Government, NGOs, industry |
| b) Establish a federal authority to create and maintain a public database for wind energy-related data (long-term reference, wind & operational data). | 1-2 years to set up, then continuous | Government, Industry |
| c) Develop public domain test sites and test facilities with high-quality instruments for validating flow models. | 1-10 years | Government, Academia, Industry |
| d) Develop measurement technologies specific to Canadian conditions. | 1-5 years | Industry, NGOs, Academia |
| e) Develop a publicly accessible R&D wind farm. | 1-2 years | Government, NGOs, Academia, Industry |
| **B) Enhance model accuracy, precision and robustness**<br>Lack of accurate and robust modeling technologies is a major barrier to increasing reliability in simulations and hence reducing cost. Model improvement needs comprise a range of scales and purposes including micro-scale models; meso-scale models; array loss models; technical loss models (aerodynamic and unavailability); and climate change models. | | |
| **Action item** | **When** | **Who** |
| a) Strengthen international collaboration and contribute with models addressing Canadian specificities. | Ongoing | Government, NGOs, Industry, Academia |
| b) Plan a follow-up for the NSERC Wind Energy Strategic Network (WESNET), as funding will end in 2013. | 5 years | Government , NGOs, Academia, Industry |
| c) Enhance and promote Canadian technology. | 1-2 years | Government, Academia, Industry |
| d) Establish benchmarks for model validation. | 1 year to set up, then continuous | Government, NGOs, Industry |

### Theme 2: Short-Term Forecasting Technologies

Improved short-term forecasting is a necessary condition to achieve high levels of wind penetration in the Canadian energy mix. The current forecasting technologies are based on various deterministic, statistical and stochastic approaches which lack the required degree of precision and reliability. Therefore a significant R&D effort in developing and validating the models is required. It is important to note that many of action items from Theme 1 equally apply to forecasting.

| Action item | When | Who |
|---|---|---|
| a) Develop and test higher resolution (time and space) Numerical Weather Prediction (NWP) tools using local and regional data sets. Research new methodologies such as ensemble average NWPs. Develop methodologies including operational data from existing wind farms to improve performance. | 2-5 yrs | Government, Academia, Industry |
| b) Develop and validate high-level tools for wind farm and grid operators. Utilities and developers will need to define their needs early in the process. | 1-2 yrs | Utilities, Operators, Industry |

*Centre of Excellence II:*
*Advanced Operation and Transmission Planning Methodologies*

**Develop modeling methodologies and analytic tools that will account for both generation and transmission probabilistically.** Stability and reliability are fundamental cornerstones of a well-functioning electricity grid. As the energy regime evolves to include new forms of electricity and demand-side management initiatives, system planners will require more advanced tools to predict power generation and balance transmission loads. Currently, uncertainties in production capacities lead to overbuilding in generation, transmission and distribution to meet a predicted level of demand. Even marginal levels of wind integration complicate system planning as supply characteristics are difficult to accurately predict with deterministic models. New models that apply probabilistic estimation processes to regional wind characteristics are required to reduce the uncertainties in forecasts. This action involves numerous steps outlined as follows:

| Action item | When | Who |
|---|---|---|
| a) Utilities first define the needs | 18 months | Utilities |
| b) Vendors to produce customized tools | 2 years | Industry, Academia, Utilities |
| c) Develop standards concerning probabilistic planning models. | 2-4 years | Industry, Academia, Utilities, Goverrnment |
| d) Change planning standards | 10 years | Utilities |
| **Improve operating room tools to integrate short-term wind forecasting.** The real time operations of a regional electricity grid involve matching supply with varying demand within the confines of a strict regulatory framework. Thus, the more uncertainty in the system, the harder it is to meet stability requirements. Traditional energy sources have historically been the "lever" through which operators balance demand loads. The variable nature of wind power production complicates the task of providing system reliability. As Canada moves towards a 20% penetration level of wind power, control room operators will need advanced real time and day-ahead tools to meet ramping and load balancing requirements. Research on the analyses and forecasting models that Environment Canada maintains for each of the regions will also be required. Utilities and vendors will need to work together to integrate short-term wind forecasting tools into the operating room. | 2-4 years | Industry, Academia, Utilities |

## *Centre of Excellence III:*
## *Ancillary Services: Wind Integration and Wind Firming Technology*

**There is a need for improved ancillary services to help balance supply and demand with large amounts of wind penetration. Potential solutions include: enhancements of energy storage devices; the development of interregional wind systems to take advantage of the diversity of wind production in different geographic areas; and the creation of solutions to meet generation increase/decrease requirements including demand management and more flexible energy interchanges between regions.**

| Action item | When | Who |
|---|---|---|
| a) Develop a consistent methodology to determine requirements for ancillary services. For example: what factors/inputs must be considered to produce consistent assessments across the country? | 12-18 months to scope out research | Utilities, NGOs, Industry |
| b) Assess the extent to which demand loads can be met by using wind from one area to offset variances in wind from another area (i.e. wind firming wind) instead of relying on ancillary services. | 12-18 months to write whitepaper on methodology | Government, Utilities, NGOs, Industry |
| c) Quantify the amount and type of ancillary service required in a balancing area as wind penetration increases. | A few years to quantify geographical diversity benefits | |
| d) Identify storage technology options that can optimize wind energy on the grid and identify benefits, co-benefits and cost of various storage technologies. | 1 year | |
| e) Explore options (conventional and non conventional), for providing these ancillary services and conduct a cost-benefit analysis of each. Non conventional options include demand-side management (DSM), smart grids, pumped storage and other storage systems. There is a need to:<br>• Inventory what kind of work is already ongoing in other jurisdictions; and<br>• Assess what is appropriate for Canada. | 3+ years to quantify ancillary services (AS) requirements as wind penetration increases | |
| f) Explore options for designing and constructing Flexible AC Transmission Systems (FACTS) to address the future need. | 1-3 years for university research on AC options, 3-5 yrs to run a pilot project | |
| g) Develop educational program(s) on the interpretation of various forecasts in the context of system operation. | Ongoing | NGOs, Academia |

*How These Actions Will Contribute to Achieving the Vision*

The Creation of Centres of Excellence will enable the necessary developments in tools, systems, technologies and services, so as to develop competitive niche areas for Canadian industry and drive down the cost of, and therefore increase the incentive to invest in, wind energy in Canada.

## 3.5 Accelerate Development of Small Wind Technology

*What is Required*

With almost one seventh of all small wind manufacturers operating in Canada there are numerous opportunities to advance small scale wind technology. In order to facilitate the success of this developing industry there needs to be increased support in Canada – publically, financially and technically.

*Why Action is Needed*

While small wind is perceived as having a relatively small market, there actually may be greater potential than that for large wind in terms of applications for remote and off-grid communities. Within the Canadian context, there remains strong potential for integrating systems with diesel generators to provide reliable co-generation for remote and northern communities. If provided with sufficient financial incentives to reduce GHG emissions in the North (or other incentive mechanisms), wind-diesel may experience an exponential increase in interest. In addition to direct financial incentives, small wind could realize benefits from its potential to generate carbon offsets; however the emission reduction potential would likely need to be aggregated across a community to qualify under currently proposed cap and trade schemes.

*Current Challenges and Barriers*

There are numerous difficulties facing the small wind industry, both within and outside of Canada. Key technical barriers faced by small wind were highlighted by WG3b:

- Low investment levels in the small wind sector have left unresolved deficiencies in many aspects of small wind technology;
- Small wind developers need access to wind tunnel testing, in addition to better promotion of such facilities in Canada; and
- The installed cost for small wind projects is still too high and reliability is too low.

There were also broader policy and regulatory difficulties identified by WG3b:

- Regulatory and utility frameworks have not yet evolved to accommodate small wind;
- Certifications, codes and standards have to be developed for small wind;
- Interconnection codes and standards discourage small wind usage;
- There is a lack of policies and incentives to support production of small wind systems for demonstration or deployment into grid-connected and remote community markets; and
- Permits, by-laws and ordinances currently discourage the technology.

### *Key Action Items*

One of Canada's key wind energy strengths is the strong presence of domestic small wind manufacturers. However, these manufacturers need assistance on a number of different fronts, starting with policy support for the technology in communities, particularly where wind-diesel co-generation is possible. There is also a need for streamlined interconnection standards that are consistent and transparent to promote more small wind adoption. The cost for this is estimated to be less than one million dollars. Additionally, there is a significant need for funding to promote technological enhancements that will enhance the efficiency, durability, reliability and cost-effectiveness of small wind turbines. In aggregate, these actions are anticipated to cost on the order of five to ten million dollars within the next decade. Some of key action items to achieve these goals are listed below:

| Specific Key Action Items of Small Wind in Need of Technical Remediation and Innovation | | |
|---|---|---|
| **Action item** | **When** | **Who** |
| **Research technology enhancement opportunities** | | |
| a) Develop and test advanced blade design; different rotor size options for modest wind and high wind regimes; and tall towers for modest wind regime. | 1-3 years | Government, Industry and NGOs |
| b) Adopt synthetic lubricants; and gearbox insulation and heating. | 1-3 years | Government, Industry and NGOs |
| c) Adopt and develop passive blade de-icing technologies (special coating). | 1-3 years | Government, Industry and NGOs |
| d) Develop and deploy universal inverters for three-phase and single-phase applications, and for standalone systems. | 1-3 years | Government, Industry and NGOs |
| e) Improve manufacturing technologies for turbine components (including blade process technologies such as vacuum assisted resin transfer molding (VARTM)). | 1-3 years | Government, Industry and NGOs |
| f) Develop and improve self-erecting technology such as tilt-up towers; towers for various ground conditions ranging from rock to sand to permafrost and foundations that can avoid importations of cement and expensive drilling equipment. | 1-3 years | Government, Industry and NGOs |
| **Improve system performance and reliability** | | |
| g) Develop remote monitoring, diagnosis and firmware/software upgrade as well as short-term and fast acting energy storage. | 1-3 years | Government, Industry and NGOs |
| h) Develop a coordinated program to support small wind testing and certification. | 1-3 years | Government, Industry and NGOs |
| i) Examine alternatives for increased reliability. | 1-3 years | Government, Industry and NGOs |
| j) Develop improved siting tools for small systems (wind resource estimation, noise estimation, etc.). | 1-3 years | Government, Industry and NGOs |
| k) Develop templates for wind turbine documentation (installation, interconnection, commission, operation and maintenance and troubleshooting). | 1-3 years | Government, Industry and NGOs |

| Specific Key Action Items of Small Wind in Need of Technical Remediation and Innovation | | |
|---|---|---|
| **Action item** | **When** | **Who** |
| l) Improve turbine output power quality (power factor, harmonics, flicker etc.). | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry, Utilities and NGOs |
| m) Develop cost effective, integrated and certified protection and interconnection equipment and solutions. | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry and NGOs, Utilities |
| n) Develop long-term energy storage and load management & control technologies. | 1-3 years to initiate continuing to Five to Ten years | Government, Industry and NGOs |
| o) Develop advanced drive-trains such as direct-drive generators for variable speed operation and variable pitch mechanism; advanced power electronics for maximizing performance and for integrating storage technologies. | 1-3 years to initiate continuing to Five to Ten years | Government, Industry and NGOs |
| **Reduce life cycle energy costs** | | |
| p) Investigate lower life-cycle cost turbine components. | 1-3 years | Government, Industry and NGOs |
| q) Advance wind-diesel integration technology. | 1-3 years | Government, Industry and NGOs |
| r) Develop templates for wind turbine documentation (installation, interconnection, commission, operation and maintenance, troubleshooting). | 1-3 years | Government, Industry and NGOs |

There were also a host of action items that, while championed under “other” action areas, highlight needs specific for small wind advancement.

| Other Key Action Items Pertaining to Small Wind | | |
|---|---|---|
| **Action item** | **When** | **Who** |
| **Adopt streamlined and consistent interconnection standards** | | |
| a) Acknowledge the benefits that small wind can bring to Canadians (including a market study of international small wind potential and potential benefits to Canada) | Urgently needed, in Short-term | Government |
| b) Establish policy support for wind-diesel systems in remote communities | Commence in Short-term, Continue for Medium Term | Government |
| c) Establish policy support for grid-connected systems | Commence in Short-term, Continue for Medium Term | Government |
| d) Public outreach for ensuring that Small Wind Certification Corporation (SWCC) guidelines are understood and applied | 1-3 years | Small wind advocate groups |
| e) Develop cost effective, integrated and certified protection and interconnection equipment and solutions | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry, Utilities and NGOs |
| f) Increase the engagement of utilities across Canada to better understand and document technical concerns and collectively find solutions | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry, Utilities and NGOs |
| g) Engage utilities to streamline the process for connecting small wind. | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry and NGOs, Utilities |
| h) Adopt uniform standards in Canada for utility-interconnection | 1-3 years to initiate;<br><br>1-3 years to engage utilities and resolve issues | Government, Industry and NGOs |
| i) Engage municipalities to ensure SWCC certifications are reflected in zoning regulations | 1-3 years | Small wind advocate groups and Government |

*How These Actions Will Contribute to Achieving the Vision*

Collaboration, funding and support for advancements in small wind systems will both allow Canada's individuals, small businesses and communities to have stable, secure, economical, wealth generating energy solutions, and provide leading-edge solutions for rural and remote communities around the world.

## 3.6 Fund Innovative Demonstration Projects

*What is Required*

In order to gain broader acceptance of wind energy and to enable further implementation it will be important to demonstrate several of the technologies identified in the WindTRM. This could entail research and development in wind firming technologies such as: battery, capacitor, compressed air, and pumped hydro storage technologies, as well operational approaches such as hybrid operation (e.g. wind-hydro or wind-diesel combinations), smart grids and grid operation techniques that are demand-response driven and that shift energy sourcing depending on wind power availability. Collaboration with the Centres of Excellence described in section 3.4 is key to successful innovative demonstration projects.

*Why Action is Needed*

Marquee and demonstration projects are critical to reducing uncertainty in wind energy both from a public and engineering point of view.

*Current Challenges and Barriers*

The working groups highlighted three broad barriers in this area:

- A lack of easy access to an operating wind farm for R&D experimentation (WG1);
- A lack of demonstration and deployment programs for small wind projects (WG3b); and
- Other technological barriers (e.g. modeling tools) as discussed throughout this document.

*Key Action Items*

To promote innovation and public and private support for wind energy there is a strong need for operational testing and demonstration of wind technology. The establishment of an R&D wind farm would provide a perfect testing ground for technologies that can adapt to Canadian climate conditions. Such a wind farm could also provide an area where academia and industry could collaborate on joint R&D ventures. Additionally, innovative demonstration projects could enable pilot technologies to be exported to other nations with similar climatic conditions. It is anticipated that a fund in the order of one hundred million dollars would be required to enable the investments necessary to achieve the outlined goals.

| Action item | When | Who |
|---|---|---|
| Wind ‘firming’ technology demonstration projects | | |
| Demonstrate and pilot promising storage technologies | 1-3 years | Government, NGOs, Utilities, Industry |
| Forecasting pilot building on Alberta and Quebec experience | | |
| These types of demonstration projects across other jurisdictions can significantly advance the industry. | 1-3 years | Government, Industry, NGOs |
| Community scale wind diesel demonstration project | | |
| Public outreach by the deployment of demonstration projects. | 1-5 years | Government, Industry and NGOs |
| Probabilistic modeling pilot | | |
| As transmission planning tools are developed there will need to be pilots or demonstrations in order to prove their acceptability to system planners and operators. | Ongoing | Industry |

*How These Actions Will Contribute to Achieving the Vision*

Support for innovative demonstration projects will clearly illustrate the economic and environmental feasibility of, and returns on investments in, wind energy, thereby enabling the full realization of benefits from all action areas.

# Annex A: List of Attendees for WindTRM Workshops

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 1. | Bouaziz | Ait-Driss | Hélimax | Engineering / Consulting |
| 2. | Bill | Appleby | Environment Canada | Federal Gov |
| 3. | Eric | Barker | Industry Canada | Federal Gov |
| 4. | Cory | Basil | Skypower | Developer |
| 5. | Jean-Francois | Beland | AREVA Canada Inc | Manufacturer |
| 6. | Liliana | Benitez | Natural Resources Canada | Federal Gov |
| 7. | Serge | Besner | Environment Canada | Federal Gov |
| 8. | Sarah Jayne | Blair | Natural Resources Canada | Federal Gov |
| 9. | Chris | Boivin | Sustainable Development Technology Canada | Non-Profit |
| 10. | Mario | Boucher | Hydro Québec | Utility |
| 11. | Claude | Bourget | Énergie PGE Inc | Manufacturer |
| 12. | Mike | Bourns | TransAlta Wind | Developer |
| 13. | Jonathan | Brady | Natural Resources Canada | Federal Gov |
| 14. | Rob | Brandon | Natural Resources Canada | Federal Gov |
| 15. | Bill | Breckenridge | New Brunswick Department of Energy | Provincial Government |
| 16. | Carl | Brothers | Frontier Power Systems | Developer |
| 17. | Matthew | Bulmer | Aerojoule | Manufacturer |
| 18. | Michael C. | Burns | Naikun Wind Development Inc | Developer |
| 19. | Kelly | Cantwell | Nova Scotia Power Inc. | Utility |
| 20. | Laura | Carlson | Lethbridge College | Academic |
| 21. | Rupp | Carriveau | University of Windsor | Academic |
| 22. | Paul | Champigny | Gamesa Wind | Manufacturer |
| 23. | Liuchen | Chang | University of New Brunswick | Academic |
| 24. | Stephen | Cheeseman | Chinook Power Corp. | Developer |
| 25. | Paul | Choudhury | British Columbia Transmission Corp | Utility |
| 26. | Jenny | Chuang | Natural Resources Canada | Federal Gov |

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 27. | Tony | Claroni | DMI Canada Inc | Manufacturer |
| 28. | Doug | Coleman | CN – Marketing – Metals & Minerals | Engineering/ Consulting |
| 29. | Nancy | Cowan | FPL Energy | Developer |
| 30. | Michael | Dang | Hydro One Networks Inc. | Utility |
| 31. | Kayla | Dawson | Finavera Renewables | Developer |
| 32. | Johan | de Leeuw | Wind Energy Solutions Canada | Manufacturer |
| 33. | Paul | Dockrill | Wind Energy Institute of Canada | Test Site |
| 34. | Marc | Dorion | McCarthy Tétrault LLP | Finance |
| 35. | Will | Dubitsky | Canada Economic Development for Quebec Regions | Federal Gov |
| 36. | Dariush | Faghani | Hélimax Energie Inc. | Engineering/ Consulting |
| 37. | Dawn | Farrell | TransAlta Corporation | Industry Chair |
| 38. | Stuart | Fee | Industry Canada | Federal Gov |
| 39. | Simon | Ferguson | Garrad Hassan Canada Inc | Engineering/ Consulting |
| 40. | Laetitia | Fiere | AAER | Manufacturer |
| 41. | Suzanne | Flannigan | Lethbridge College | Academic |
| 42. | Alain | Forcione | Hydro-Quebec (IREQ) | Utility |
| 43. | Yves | Gagnon | Université de Moncton | Academic |
| 44. | Tracy | Garner | Ontario Power Authority | Engineering/ Consulting |
| 45. | Brett | Gellner | TransAlta | Developer |
| 46. | Dan | Goldberger | Canadian Electricity Association/ New Paradigm Capital Corp. | Industry Association |
| 47. | John | Gorjup | Natural Resources Canada | Federal Gov |
| 48. | Peter | Grover | Innergex énergie renouvelable inc. | Developer |
| 49. | Berk | Gursoy | Brookfield Power Corporation | Developer |
| 50. | Kent | Gustavson | Stantec | Engineering/ Consulting |

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 51. | Cynthia | Handler | Natural Resources Canada | Federal Gov |
| 52. | Horia | Hangan | University of Western Ontario | Academic |
| 53. | Jana | Hanova | BC Hydro | Utility |
| 54. | Scott | Harper | Wind Energy Institute of Canada | Test Site |
| 55. | Christopher | Holz | Campbell Strategies | Engineering/ Consulting |
| 56. | Robert | Hornung | Canadian Wind Energy Association (CanWEA) | Industry Association |
| 57. | Paul | Huebener | Macquarie Capital Markets Canada Ltd | Finance |
| 58. | Saif | Imran | Shell Canada Ltd | Developer |
| 59. | David | Jacobson | Manitoba Hydro | Utility |
| 60. | Jeff | Jenner | Suez Energy North America | Developer |
| 61. | Paul | Jensen | DMI Industries, Inc | Manufacturer |
| 62. | Joanne | Johnson | PricewaterhouseCoopers | Facilitator |
| 63. | Heather | Johnstone | Ministry of Energy, Mines and Petroleum Resources | Provincial Gov |
| 64. | Tim | Karlsson | Industry Canada | Federal Gov |
| 65. | Robert | Kelly | Precision Wind | Engineering/ Consulting |
| 66. | Khaqan | Khan | Independent Electricity System Operator (IESO) | System Operator |
| 67. | Juliane | Kniebel-Huebner | NaturEner Energy Canada Inc. | Developer |
| 68. | Anthony | Kosteltz | Environment Canada | Federal Government |
| 69. | John | Kourtoff | Trillium Power Wind Corporation | Developer/ Offshore |
| 70. | Pierre | Lacombe | Genivar | Engineering/ Consulting |
| 71. | Antoine | Lacroix | Natural Resources Canada | Federal Gov |
| 72. | Marc-André | Laflamme | McCarthy Tétrault LLP | Finance |
| 73. | Simone | Lalande | Natural Resources Canada | Federal Gov |

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 74. | Mathieu | Landry | Université de Moncton | Academic |
| 75. | Mark | Lauby | NERC | Utility |
| 76. | David | Lawlor | ENMAX Corporation | Developer |
| 77. | Marc | LeBlanc | Garrad Hassan Canada Inc | Engineering/ Consulting |
| 78. | Tanya | Leger | Natural Resources Canada | Federal Gov |
| 79. | Robert | Leth | Precision Wind | Engineering/ Consulting |
| 80. | Derek | Lim Soo | General Electric (GE) Canada | Manufacturer |
| 81. | Steve | Lindenberg | U.S. Department of Energy | Federal Gov |
| 82. | Doug | Little | British Columbia Transmission Corp | Utility |
| 83. | Malcolm | Lodge | Entegrity Wind | Manufacturer |
| 84. | Matthew | Lynn | Garrad Hassan Canada Inc | Engineering/ Consulting |
| 85. | Wayne | MacQuarrie | PEI Energy Corporation | Utility |
| 86. | John | Marrone | Natural Resources Canada | Federal Gov |
| 87. | Christian | Martel | Aerojoule | Manufacturer |
| 88. | Christian | Masson | École de technologie supérieure | Academic |
| 89. | Margaret | McCuaig-Johnston | Natural Resources Canada | Federal Gov |
| 90. | Pamela | McKinnon | Nova Scotia Power Inc. | Utility |
| 91. | Joyce | McLean | Toronto Hydro | Utility |
| 92. | Roslyn | McMann | GE Energy – Power Generation | Manufacturer |
| 93. | Tom | Molinski | Manitoba Hydro | Utility |
| 94. | Wilfried | Moll | Private Consultant | Engineering/ Consulting |
| 95. | Geoff | Nimmo | Industry Canada | Federal Gov |
| 96. | Alastair | Nimmons | PricewaterhouseCoopers | Facilitator |
| 97. | Steve | O’Gorman | Canadian Hydro Developers | Developer |
| 98. | Morel | Oprisan | Natural Resources Canada | Federal Gov |

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 99. | Chris | Padfield | Natural Resources Canada | Federal Gov |
| 100. | Steven | Pai | British Columbia Transmission Corporation | System Operator |
| 101. | Al | Paulissen | Wenvor Technologies | Manufacturer |
| 102. | Richard | Penny | Nova Scotia Department of Energy | Provincial Government |
| 103. | Jaime | Peralta | BC Hydro | Utility |
| 104. | Roger | Peters | Canadian Renewable Energy Alliance | Non-Profit |
| 105. | Greg | Peterson | Lethbridge College | Academic |
| 106. | Franco | Petrucci | Environment Canada | Federal Gov |
| 107. | Jean-Paul | Pinard | JP Pinard Consulting | Engineering/ Consulting |
| 108. | Blaine | Poff | Manitoba Hydro | Utility |
| 109. | George | Porter | NB System Operator | System Operator |
| 110. | Mark | Riley | Natural Resources Canada | Federal Gov |
| 111. | Louis-Omer | Rioux | Hydro-Québec TransÉnergie | Utility |
| 112. | Susanne | Ritter | Canadian German Chamber of Commerce | Manufacturer |
| 113. | Pierre | Rivard | Magenn Power Inc. | Manufacturer |
| 114. | Marc | Rousseau | General Electric (GE) Canada | Manufacturer |
| 115. | Magdalena | Rucker | BC Hydro | Utility |
| 116. | Jim | Salmon | Zephyr North Ltd. | Engineering/ Consulting |
| 117. | Scott | Sasser | Precision Wind | Engineering/ Consulting |
| 118. | Brian | Schmeisser | Atlantic Canada Opportunities Agency | Federal Gov |
| 119. | Randy | Seager | Wenvor Technologies | Manufacturer |
| 120. | Bob | Singh | Hydro One Networks Inc. | Utility |
| 121. | Bill | Sutherland | Manulife Financial Corporation | Finance |
| 122. | Jeff | Sward | PricewaterhouseCoopers | Facilitator |
| 123. | Paul | Taylor | Naikun Wind Development Inc | Developer |

| | First Name | Last Name | Organization | Stakeholder Group |
|---|---|---|---|---|
| 124. | David | Timm | AIMPowerGen | Developer |
| 125. | Jim | Titerle | McCarthy Tétrault LLP | Finance |
| 126. | Daniel | Van Vliet | Indian and Northern Affairs Canada | Federal Gov |
| 127. | George | Vegh | McCarthy Tétrault LLP | Legal |
| 128. | Tony | Verrelli | Cleanfield Energy Corp. | Manufacturer |
| 129. | Leslie | Welsh | Environment Canada | Federal Gov |
| 130. | Sean | Whittaker | Canadian Wind Energy Association (CanWEA) | Industry Association |
| 131. | Corey | Wilson | ENMAX Corporation | Developer |
| 132. | Helge | Wittholz | SYNOVA | Engineering/ Consulting |