Government of Canada
Gouvernement du Canada

Opportunities for Canadian Stakeholders

in the North American Large Wind Turbine Supply Chain

Executive Summary

Canada

Purpose of Study

The federal government partners engaged the services of the Delphi Group and Garrad Hassan (GH) to conduct a study of the North American large wind turbine generator supply chain and technological innovation challenges, and to identify opportunities for Canadian industrial and research stakeholders to increase their participation in the wind industry. The study was conducted in three phases. The first phase of the study focused on identifying the North American turbine supply chain needs and opportunities and its technological innovation challenges. Based on the results of this phase, a second phase was undertaken in order to identify Canadian industrial and research stakeholders, either currently involved in the wind sector or external to it, which have strong transferable skills or capabilities to respond to the specific opportunities. In the third phase, the overall likelihood of Canadian stakeholders being able to respond to specific opportunities within the large wind turbine manufacturing segment of the supply chain was assessed.

Context

Wind energy is the fastest growing source of electricity in terms of annual installed capacity. In terms of economic value, the wind energy sector has now become firmly entrenched as one of the most important players in the energy markets. In 2006, the level of global installed wind power capacity increased by 32% (>15,000 MW) and the worldwide wind energy industry market was estimated to be worth almost US$25 billion. Worldwide cumulative installed wind power capacity now exceeds 75,000 MW.

Due to the traditionally low cost of electricity in Canada, wind energy has not historically been an economically competitive option despite the country's excellent wind resource. Recently however, the increasing cost of fossil fuels and awareness of climate change and pollution costs, combined with new government economic instruments supporting wind, have resulted in a significant increase in wind production in the country. The consequence is that Canada has lagged behind other countries in the development of its corresponding wind energy industry but this is changing rapidly.

The total cumulative Canadian installed wind generation capacity reached 1,460 MW at the end of 2006. The growth in installed wind capacity for the year 2006 alone was 776 MW, representing an increase in capacity of more than 100% over the year 2005. The Canadian wind energy industry presently includes roughly 210 companies. Before the multiplier effect created through indirect jobs is applied, this corresponds to approximately 1200 full time equivalent jobs *nationwide. To put this in perspective, the number of people employed by the industry worldwide is estimated to be 150,000, with 70,000 of these in Germany alone.*

Until recently, Canadian wind turbine manufacturing was primarily limited to tower manufacturing, however, this is changing gradually, with especially significant growth in Quebec where recent provincial wind power requests for proposals (RFPs) have dictated 60% local content requirements. Specific manufacturing and assembly operations that have recently started in Quebec include LM Glasfiber's rotor blade manufacturing plant, Marmen's tower manufacturing and nacelle assembly plant and VCI's nacelle cover manufacturing plant. More recently, AAER Inc. has announced its intention to adapt an existing plant for manufacturing and assembly of large scale turbines ranging from 1 to 2 MW capacities in Bromont. Conversely, the majority of wind farms outside of Quebec, which generally do not have Canadian content stipulations linked to them, import nearly all of their large wind turbine generators (including the components that comprise them). Consequently, the only notable > 1MW turbine component manufacturing operations in the rest of Canada are tower manufacturing facilities in Ontario (DMI) and Saskatchewan (Hitachi).

The European Wind Energy Association estimates that for every MW of large scale wind capacity installed, 10 job/years in manufacturing activities are created or preserved compared to 2 job/years in planning, installation and construction activities. Furthermore, two permanent jobs in service and maintenance are created for every MW of installed wind generation capacity. Considering this and the fact that in large wind farms, wind turbines represent up to 70 percent of the total capital investment, it is clear that the economic benefits to Canada from the rapidly expanding domestic and international wind markets will be heavily tied to Canadian manufacturing capacity.

In addition to developments in Canada, the US market has also grown especially fast. Therefore, Canada will have to compete with the US in its efforts to attract foreign turbine manufacturers to set up operations domestically. The US will present significant competition as it seems that several US States have been very aggressive to provide incentives for foreign wind turbine manufacturers to locate in their state. Canadians will lose out on the economic opportunities and benefits related to the broad potential growth of wind energy in Canada and the US if domestic supply chain capabilities do not continue to increase, or in the case of Quebec continue to be maximized.

Phase 1: Identification of Opportunities - Results

The purpose of the first phase of the study was to identify specific near term opportunities for Canadian stakeholders to play a greater role in the significant rapid growth of the wind energy industry. Through the course of the first phase, it was determined that the most important factor affecting the creation of a strong domestic wind turbine manufacturing base is the creation of a strong domestic wind energy market. The single most important factor in realizing a wind energy market is a strong, focused and sustained national wind energy policy. Significant early wind energy markets to-date (Denmark, Germany and Spain) exist where there has been a market mechanism in place to promote renewables for the sake of national greenhouse gas emissions reductions, or wind energy specifically because of its contributions to cost-effective energy independence or other technical or logistical benefits.

It should be noted, however, that there is an ever present trend towards localization of supply chains by the major turbine manufacturers which suggests that inevitably local manufacturing capacity will emerge to respond to increasing competitiveness of wind, even in relatively emerging markets. However, it should not be concluded that the original equipment manufacturers (OEM) will immediately purchase local supplies. Without proximity to a major wind market, localization is not viable. The use of local suppliers will be predicated on the existence of several important conditions.

- There must be a substantial and consistent market in which the OEM can have confidence to invest e.g. Spain and not the USA (until recently).
- High quality components must be available. The manufacturers will not compromise the quality for local manufacture. If the quality is not available the components will not be bought. The components which are presently in short supply are also the most demanding from an engineering point of view.
- Price will also play a critical role.
- Testing of components produced by a new supplier might be required prior to being released for use in series production.
- Shipping cost savings

If these conditions can be fulfilled the research and analysis demonstrates that there is no compelling reason why a local Canadian manufacturing industry could not be created.

In the first phase, interviews were conducted with key executives from major international large wind turbine and component manufacturers in order to gain some perspective on their procurement procedures, specific service, manufacturing and innovation opportunities that exist within the North American supply chain and Canadian regional priorities. The results of these interviews can be summarized as follows.

Procurement Procedures

Based on interviews with the prime contractors and component suppliers in the large wind turbine manufacturing industry, a clear trend toward localization or "North Americanization" of supply chains can be seen. Almost all firms interviewed that had existing manufacturing operations in North America were focused on reducing their dependence on European, and to a lesser extent Asian, suppliers for major components, raw materials and sub-contractor services. Several factors were cited by informants as drivers for this trend towards localization. These include:

- Exchange rates
- Logistic issues
- Shipping costs
- Proximity to suppliers and quality control issues

Furthermore, quality control is a major concern for prime turbine manufacturers and major components suppliers alike. Wind turbines have to survive in operation largely unattended for a very long period – typically the design lifetime for a turbine is 20 years. Any failure of a key operating component of a turbine can lead to major unforeseen costs for both turbine suppliers and wind farm operators.

All new suppliers, whether already proven in the wind turbine market or new to it, must pass through a due diligence phase with prime contractors before being added to their supplier list. Typically, this due diligence phase is broken down as follows:

- Initial contact by supplier or identification by prime contractor of potential supplier:
- Company evaluation
- Sample evaluation
- Continuous monitoring

Supply Chain Opportunities

Opportunities identified through the course of the first phase interviews were categorized in four main areas:

- Operation and maintenance (O&M) service;
- Logistical, transport and construction services;
- Manufacturing; and
- Technical innovation.

O&M Service Needs and Opportunities

In recent years there has been an increasing concern in Canada over the future of service and maintenance options for active wind farms - service contracts with original equipment providers are growing increasingly short and many such contracts will be expiring in the next few years. Furthermore, there is a concern that renewal of such contracts with original equipment suppliers will be prohibitively costly and that there will be a shortage of adequate economic service and maintenance providers within the country. To date, there is no independent operation and maintenance service provider in Canada. However, experience abroad has shown that a well organised group of mechanical and electrical technicians can undertake this work effectively, as long as they are properly trained. There may be knowledge transfer or subsidiary activity opportunities with established European O & M providers.

Logistical, Transport and Construction Service Opportunities

Logistical, transport and construction related service requirements were cited by some of the more vertically integrated prime contractors and component suppliers. In particular, a shortage and a need for resources that can provide the following services were cited by respondents:

- Craning for assembly of turbines and foundation work
- Civil and mechanical engineers for foundation and tower design work
- Transport services, mainly by truck, of large turbine components (towers and blades)
- Geotechnical work for foundations and drilling for foundation enquiries.

North American Manufacturing Supply Chain Needs and Opportunities

Global Opportunities

A global observation of the industry indicates that there are several key components which are resulting in turbine shortages at present:

- Gearboxes (largely because of the large bearing used within them);
- Castings for rotor hubs and main frames;
- Large forgings for main shafts and;
- Large bearings.

If Canada has the experience or expertise in these four component areas, then there are immediate opportunities. A cautionary note is important, however, as facilities with these capabilities are rare.

North American/Canadian Opportunities

The following provides a list of specific needs/opportunities gleaned from interviews with key representatives from major international wind turbine and component manufacturing firms to which Canadian stakeholders can respond within North American supply chain:

- Wind turbine generator manufacturing technology license partner
- Tower manufacturing facility
- Rotor blade technology license partner
- Rotor blade manufacturing
- Large gear cutting and grinding
- Large castings/forgings
- Large bearing manufacturing
- Permanent magnet manufacturing and supply for generators
- Sub-component assembly facility
- Generator manufacturing facility
- Nacelle covers
- Hub spinners
- Smaller standard metal components
- Grid connection hardware
- Materials and chemicals for rotor blade manufacturing
- Pre-shaped steel suppliers
- Foundation steel bending facility

North American Supply Chain Innovation Needs and Opportunities

The following provides a list of specific technical innovation needs that Canadian firms and research and development institutions may be able to respond to within the large wind turbine manufacturing supply chain:

- Development of new gearbox
- Design of customized rotor blades
- Establishment or identification of testing facilities for large wind turbine components
- Consolidated strategic approach to the development of turbine and component testing facilities
- Extreme weather technology refinement
- Increasing turbine sizes for smaller manufacturers
- Establishment of a standard approach and resource database for transferring international standards
- Increasing automation
- Optimization of structural design and materials use for towers
- Wind grid-integration and forecasting
- New turbine technology prototype development
- Technical solution to GE patent barrier
- Optimization of concrete use in foundations
- Central information source on all the R&D/Sustainable Development (SD) funding available

Canadian Regional Priorities

The firms interviewed as part of the first phase of this study all stated that their location preference for establishing manufacturing operation in Canada were generally as follows:

- Somewhere in Ontario or Quebec close to wind projects
- Close to the Canada-US border, with extra consideration for proximity to US wind projects
- Close to suppliers (which are also generally located close to major markets) and heavy industry capabilities
- Close to water transport routes and rail transport infrastructure
- Somewhere with good truck transport logistics
- Somewhere with a good skilled labour pool

Overall, it was felt that the most important factor is that the location lead to cost competitive operations.

Desirable Manufacturing Incentives

The biggest goal for most established and emerging North American manufacturers is to establish local (North American) supply chains over the near term. All firms interviewed agreed that if a location does not make sense in terms of market potential, access to customers, access to a skilled labour pool and logistics, there is no point in manufacturing incentives. It is generally felt that incentives only help with capital and start-up costs, but that they do not define the long term viability of operations; operating costs do. If a location has poor access to suppliers, poor shipping logistics, or is far from the wind market or customers (O and M assemblers), significantly higher operating costs will be incurred compared to locations with better characteristics. Assuming the above conditions are satisfied, and that a manufacturer is considering two similar locations, manufacturing incentives do become of interest. The following provides a summary of manufacturing incentives encountered in other jurisdictions or preferred by turbine or component manufacturers:

- Direct infrastructure investments by government organizations
- Assistance with hiring and training
- Tax incentives
- Low interest or forgivable loans
- Export support
- Market introduction assistance

Phase 2: Identification of Canadian Stakeholders that Can Respond to Opportunities - Results

The second phase in the study was undertaken by Delphi and GH in order to identify Canadian industrial and research stakeholders, either currently involved in the wind sector or external to it, which have strong transferable skills or capabilities to respond to the specific opportunities identified in the first phase. As a first step, specific technical requirements and descriptions of each major activity within the large wind turbine supply chain have been compiled and included in this report.

Based on the description of the specific activities in the large wind turbine supply chain and the opportunities identified in the first phase of the study, a preliminary list of Canadian industrial and research stakeholders that may be capable of responding to these opportunities and a brief description of these stakeholders was compiled (included in Appendix C of this report). Canadian stakeholders from several sectors outside of the wind industry were identified as having potentially strong complementary capabilities.

These other sectors include:

- Shipbuilding;
- Aeronautics;
- Heavy industry equipment manufacturing (pulp and paper, mining, oil and gas);
- Power generation project construction (fossil, hydro, nuclear);
- Complex metal fabrication, foundries and forging;
- Industrial service and maintenance firms; and
- Research.

Interviews were conducted with key representatives from some of the most promising of these stakeholder organizations to assess and verify their ability to respond to the North American wind supply chain opportunities. Based on these interviews, a description of some of the most suitable stakeholders for responding to specific opportunities was compiled and has been provided in this report. Specific Canadian stakeholders that have the capability to respond to the following large wind turbine supply chain opportunities identified in the first phase immediately, or potentially in the near future, were identified through this analysis.

- Cranage for assembly of turbines and foundation work;
- Transport services for large turbine components (towers and blades);
- Wind turbine manufacturing technology license partner;
- Tower manufacturing facility;
- Rotor blade manufacturing technology license partner;
- Large gear cutting and grinding;
- Large casting and forging;
- Nacelle cover manufacturing;
- Large bearing manufacturing;
- Gearbox manufacturing;
- Smaller standard metal component manufacturing;
- Manufacture and supply of materials and chemicals for rotor blade manufacturing; and
- Provision O&M Service.

Specific Canadian stakeholders that have the capability to respond to, or participate in, the following large wind turbine technical innovation opportunities identified in Phase 1 immediately, or in potentially in the near future, were identified through this analysis.

- Design of customized rotor blades;
- Establishment of testing facilities for large wind turbine components;
- Extreme weather technology refinement;
- Wind grid-integration and forecasting; and
- New turbine technology prototype development.

Phase 3: Feasibility Assessment - Results

In the third phase of this study, the overall feasibility of Canadian stakeholders being able to respond to opportunities in specific activity areas in the manufacturing segment of the large wind turbine supply chain was assessed. Several barriers were identified as affecting the feasibility of establishing large wind turbine manufacturing operations in Canada. These barriers include the following:

- Process Technologies and Design Ownership;
- Actual Demand;
- Existence of Competitors;
- Technical Requirements;
- Financial Constraints; and
- Cost Competitiveness:
    - Competitiveness of Various Throughputs and Size of Orders;
    - Learning Curve and Production Efficiency;
    - Purchasing Power;
    - Regional Labour Costs;
    - Currency Exchange Rates;
    - Shipping Distance to Clients;
    - Financing Costs/Interest Rates; and
    - Competition from Low Cost Markets.

Based on a comprehensive evaluation of these barriers for each area of manufacturing activity the following were identified as the most promising for Canadian stakeholders:

- Towers;
- Rotor Blades;
- Nacelle Assembly;
- Castings;
- Forgings; and
- Nacelle Covers.

Moderately promising opportunities for Canadian stakeholders were identified as being the following:

- Gears; and
- Generators.

The least promising opportunities for Canadian stakeholders were determined to be the following:

- Gearboxes; and
- Bearings.

Storage Technologies

To provide an indication of potential future opportunities for Canadian stakeholders, a description of the emerging energy storage technologies that may be useful for balancing the intermittent nature of wind energy has also been provided in this report. These storage technologies include:

- Vanadium Redox Batteries;
- Hydrogen Production;
- Supercapacitors;
- Flywheels; and
- Pumped Hydro Storage.

Recommendations Going Forward

- Maintain and strengthen wind market policies and create long term market signals
- Establish and maintain an open line of communications with key contacts within prime contractor and component manufacturer organizations.
- Establish a formal information exchange forum between the various international trade associations and Canadian government stakeholders at all levels.
- Focus on attracting major nacelle assembly operations
- Stay on top of regional developments
- Conduct an assessment of the feasibility of establishing wind turbine or component manufacturing operations in Southern Manitoba and in the Maritime provinces
- Establish an inventory of commercial sites that are suitable for specific activities within the supply chain
- Develop an R&D funding strategy for supporting the specific North American innovation needs of prime contractors and component manufacturers.
- Explore the operation and maintenance service issue (opportunity)
- Grow from within and support domestic technology developers
- Compile a list of Canadian suppliers that can meet the needs of the wind turbine manufacturing industry.