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RENEWABLE ENERGY TECHNOLOGY IN CANADA: CURRENT STATUS AND FUTURE PROSPECTS

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ABSTRACT

Canada is estimated to have technical potential for more than 40GW of wind power, 10GW of small hydro, 70GW of solar power, 3GW of tidal power and 10 to 16GW of wave energy. By the end of 2003, Canada has installed 340MW of wind power, 606 thousand square meters of solar thermal, more than 1500MW of small hydro, more than 10MW of solar photovoltaics and 20MW of tidal power. Some provincial governments have set targets and introduced renewable portfolio standards to promote renewable energy technology. Other provinces are expected to follow in the future. This paper presents an assessment of resource potential, current status and future prospects of renewable energy technologies at the national and provincial levels in Canada.

1. INTRODUCTION

Canada is richly endowed with conventional energy resources (i.e., fossil fuels, hydro and nuclear). It is one of the three net energy exporting OECD members. In 2003, energy accounted for 13% of total exports and the energy sector accounted for 6% of gross domestic product. However, conventional energy resources are depleting and the energy sector's contribution to the economy is declining. Moreover, ratification of the Kyoto Protocol and regulations on Criteria Air Contaminants (CAC) are exerting pressure on fossil fuel consumption and production. In addition, there are global initiatives for developing and promoting alternate energy sources, particularly, renewable energy technologies (RETs). Under these circumstances policy makers, researchers, industry players and other stakeholders have an interest both in the current situation in Canada and how efforts in developing and promoting RETs compare with those in other countries.

This paper presents an analysis of renewable energy resource potential, current status of deployment of RETs, government policies, programs and plans for the promotion of RETs. The paper also highlights future prospects of RETs in Canada as well as key barriers to the development of RETs in the country.

2. RESOURCE POTENTIAL

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Wind Energy: Canada is endowed with abundant wind energy resources in all the provinces and territories[2]. The best wind profiles are found in the Prairies (ranch land in Alberta, grain producing areas of Saskatchewan), the Great Lakes, the coastal areas in northern and eastern Ontario, the coast of the Gaspe and the Atlantic provinces [1]. Based on existing meteorological data, Natural Resources Canada estimates 28,000MW of technical potential of wind energy in Canada [2]. This is an initial estimate and covers only those areas near existing transmission lines. More recent assessments indicate that the actual potential could be much higher than this early estimate. Most of the Canadian wind energy potential is onshore, offshore potential is not clearly known[3].

Solar Photovoltaic (PV): The Canadian Solar Industries Association (CanSIA) reports that solar PV has a minimum technical potential of 70,000 MW in Canada. If other solar technologies (such as solar thermal, utility-scale solar PV plants) are considered, the potential could be much larger [3]. The largest solar energy potential is found in southern Ontario, Québec and the Prairies. This potential also depends on the type of technologies employed. For example, if south-facing or solar-tracking (moving) solar panels were used, the largest resource potential could be found in the southern Prairies, as well as the more northern areas of Saskatchewan [4].

Small Hydro: There are more than 5,500 potential small hydro (>30MW) sites throughout Canada, with the technical potential of about 11GW [5]. Québec and Ontario have the largest potential followed by British Columbia and Newfoundland. About 4,000MW of large and small hydro potential has been identified in Ontario [6]. The Independent Power Producers of British Columbia have listed a large number of creeks, with a combined small hydro generation potential of 1,000MW. The Québec Renewable Energy Producers Association lists 53 projects that could deliver a total of 862MW of small hydro. In addition, Alberta and Newfoundland have significant small hydro potential [6].

Biomass: The BIOCAP Canada Foundation estimates that biomass from Canada's forestry, agricultural and municipal solid waste (MSE) sources could provide almost 5505PJ of energy per year. This is equivalent to 27% of Canada's total fossil fuel consumption in 1999. Of this total annual potential, forest residues, agricultural residues, livestock waste and MSW could provide, respectively, 1540, 340, 65 and 290PJ per year [7].

Geothermal: Commercially viable geothermal potential is mainly found in British Columbia. The technical potential of geothermal energy in the province is estimated to be about 3000MW [4].

Ocean Energy (Wave and Tidal): It is estimated that the Canadian west and east coasts have respectively 6.1GW and 10GW of wave power potential [9]. These estimates include only

[2] Canada is the only country in the world to have a coordinated, homogeneous, high resolution wind energy Atlas across its entire territory. A decision support tool called '**W**ind **E**nergy **S**imulation **T**oolkit' (WEST) has also been developed to produce long-term, low-level wind statistics at 5 km spacing throughout the country.

[3] Canadian Hydro Developers estimate that about 500MW of offshore wind power could be developed using existing transmission lines on each of Canada's coasts (e.g., Prince Rupert in BC and Cape Breton in Nova Scotia), and an additional 500MW each could be developed in the three Great Lakes, bringing the overall offshore wind power potential in the country to 2,500 MW [8].

onshore wave power and do not include any offshore wave power potential, which is expected to be much higher. In the case of tidal energy, the west and east coasts are estimated to have 3GW and 1GW of potential respectively [9]. Discovery Passage (near Campbell River in British Columbia) exhibits some of the largest tidal resources in the world, which could be enough to operate 600 to 800MW capacity tidal power plants [4].

3. CURRENT STATUS

This section briefly highlights the status of RET deployment in Canada and investigates the federal and provincial governments' policies and programs to develop and promote RETs.

Deployment of RETs in Canada

Wind power: By the end of 2003 39,294MW of total wind power capacity has been installed worldwide [10]. Canada stands in 14th position with total installed capacity of 340MW[4]. Countries with installed capacity greater than Canada include Germany, 14,609MW; USA, 6,374MW; Spain, 6,202MW; Denmark, 3,110MW; India, 2,110MW; Netherlands, 912MW; Italy, 904MW; Japan, 686MW; United Kingdom, 649MW; China, 568; Austria, 415MW; Sweden, 399 and Greece, 375MW [10]. In Canada, about half of the total wind power capacity has been installed in Alberta and about 28% in Quebec (see Table I).

Solar Thermal: About 94 million square meters (equivalent to 350 MW) of solar thermal capacity has been installed world wide as of 2003. China tops the world with total installed capacity of 52 million square meters (i.e., 55% of the capacity installed globally). The European Union (EU)[5], Turkey, Israel and USA occupy the 2nd, 3rd, 4th and 5th positions with installed capacities of 12, 9.3, 4.5 and 2.1 million square meters, respectively [11]. In Canada, the total installed capacity of solar thermal is estimated to be 606 thousand square meters, of which 81% is used for residential pool heating, 12% for domestic hot water, and 7% for heating and ventilation in commercial and industrial buildings [2]. Most of this capacity is installed in Ontario (see Table I).

Solar Photovoltaic (PV): Worldwide production of solar PV system was 3,120MW as of the end of 2003 [11]. Japan, Germany and the United States are the three countries leading in the installation of PV systems with the total installed capacity of 860MW, 410MW and 275MW respectively [12]. In Canada, 11.8MW of PV systems have been installed as of the end of 2003.

Small Hydro: As of the end of 2002, the current capacity of all small hydropower projects (>30MW) in Canada was about 2,200MW, of which more than 60% are located in Quebec and Ontario. Other provinces with significant small hydro capacity (more than 5% of the total small hydro capacity in Canada) are Newfoundland and Labrador (8%), Nova Scotia (8%), British Columbia (12%MW) and Alberta (6%) [13].

[4] As of September 2004, total installed capacity in Canada is 439 MW.

[5] Within the EU, Germany and Greece have the largest shares, with 4.9 and 2.8 million square meter capacities, respectively.

TABLE I: INSTALLED NRE CAPACITIES IN CANADA (AS OF 31ST DECEMBER 2003)

Province	Solar PV	Solar Thermal	Wind	Small Hydro	Biomass[c]
	(kWp)	'000 Sq.m.	MW	MW	MW
Nova Scotia	10	0	4.8	169	165
Prince Edward Island	0	0	13.6	0	2.0
New Brunswick	0	0	0.0	60	395
Newfoundland	0	0	0.0	169	23
Quebec	30	0	113.3	706	286
Ontario	181	606	14.6	625	2,140
Manitoba	0	0	0.0	11	23
Saskatchewan	5	0	21.8	23	537
Alberta	19	0	170.7	131	503
British Columbia	12	0	0.0	259	3,861
Territories	7	0	0.8	30	0.3
Canada	**11.83**	**606**	**339.5**	**2182**	**7,935**

[c] includes hog fuel, fuel wood, spent pulping liquor, municipal solid waste and landfill gas; does not include ethanol and biodisel.

Source: Wind [1], solar [2], small hydro [13] and biomass [15]

Geothermal: North Pacific Geopower, one of the companies developing geothermal power projects at Meager Creek, British Columbia, is aiming to have the first geothermal capacity of 100 MW by 2007 [14]. Moreover, there are approximately 30,000 residential earth energy systems (EES) in Canada, mainly installed in Ontario [2].

Biomass: With about 7,935MW of total capacity installed in Canada by the end of 2003, biomass is one of the country's main sources of renewable energy, particularly for electricity generation. Almost half of the total biomass capacity in Canada is in British Columbia. This is due to the fact that the province has the largest forestry and pulp and paper industry in the country. About 27% of the total capacity has been installed in Ontario. Other provinces with significant biomass capacity are Saskatchewan, Alberta, New Brunswick, Quebec and Nova Scotia [15].

Ocean Energy: The 20 MW Annapolis tidal power station in Nova Scotia is the second largest tidal power plant in the world.[6] It is the only tidal power plant in Canada [2]. There are no wave power plants built in Canada to date except the British Columbia Vancouver Island Green Energy Demonstration plant.

RET Supporting Policies and Programs

Various policies and programs have been launched to support the development and commercialization of RETs. These include financial incentives (e.g., cost sharing or grants for research, development and demonstrations), renewable portfolio standards (RPS), green power procurement programs, regulatory measures and so on [16]. These policies and programs are briefly discussed below.

Key Policies

[6] The 240 MW plant in La Rance River, France is the largest tidal power plant in the world.

Economic and financial Incentives: The Ontario government has introduced a retail sales tax rebate program for residential solar energy systems. Owners of residential premises who purchase and install a new solar energy system, or expand or upgrade an existing system qualify for a retail sales tax rebate. The government provides a provincial sales tax rebate on building materials purchased for the construction of RET facilities. An immediate 100% corporate income tax write-off and a ten-year property tax holiday are provided to RET facilities. For newly acquired RET facilities, capital tax is also exempted. Manitoba Hydro, the provincial electric utility of Manitoba, offers low interest loans to customers wishing to install a ground source heat pump (geothermal energy).

Renewable Portfolio Standards (RPS): Prince Edward Island's provincial government has recently committed to the first RPS in Canada and decided to have at least 15% of their total electricity generation from RETs by 2010. Nova Scotia's provincial government will adopt a mandatory RPS to take effect in 2006. Ontario's government is planning to secure an additional 1% of its current electricity needs from RETs for eight consecutive years, starting in 2006. In British Columbia, BC Hydro, the provincial electric utility, has made a voluntary commitment to meet 10% of increased demand for electricity through "green" energy sources by 2010. Electricity distributors in the province have also voluntarily committed to generate 50% of new supply from green sources by 2013. In New Brunswick, the electricity market design committee has recommended a progressive RPS based on a percentage of total customer electricity use.

Green energy procurement: The Alberta government has signed long-term contracts for about 210GWh (90% of the electricity used in its facilities) annually from green sources starting from 2005. SaskPower, the electric utility owned by the provincial government of Saskatchewan, issued a Request for Proposals for wind power projects, up to a total capacity of 150MW, under their green procurement program. The utility is also planning to issue a solicitation for technologies to produce up to 15 MW of environmentally preferred power (e.g., flare gas, wind, low-impact hydro, biomass, biogas, heat recovery from an existing waste heat source and solar) under its environmentally preferred electrical program. Electric utilities in Newfoundland and Labrador have policies to purchase energy from alternate energy sources. The purchase price is tied to residual oil (Type 6) displacement value for grid connected facilities and residual oil (Type 2) for isolated communities.

Promotional Market Mechanism: In Nova Scotia, the provincial government has put a tag on electricity generated from RETs. The tag certifies that a quantity of electricity is renewable and that it can be generated and traded separately from the electricity itself. By 2010 each load serving entity will be required to obtain tags certifying that the fraction of their electric energy generated from renewable sources is equal to the 2001 base level of renewable electric energy plus 3.2%. Any seller offering electricity from RET facilities constructed in Nova Scotia after 2001 will be able to sell directly to electricity consumers. In Alberta, the electricity retailers (i.e., ENMAX and EPCOR) provide a rate offering for a small premium for electricity from RETs.

Other Regulatory Measures: The provincial government of Quebec is proposing legislation that will require Hydro Quebec, the provincial electric utility, to bring 1,000MW of wind

power and 200MW of biomass fired power on line over the next 10 years. In the case of wind power, the government requires that all of the wind turbines be produced within the province.

Preferred Treatment Approach: The Ontario government is proposing that all projects with a generation capacity under 100MW, that will generate electricity from cleaner energy sources, be exempted from environmental screening or other requirements under Ontario's Environmental Assessment Act. The provincial government is also planning to have a policy on granting access to Crown lands for wind energy resource testing and project development.

Notable Programs

Wind Power Production Initiative (WPPI): This initiative is a $260 million federal government funding program, announced in 2001, to reduce GHG emissions through the promotion of wind electricity generation. Initially WPPI aimed to add 1000 MW of wind power by 2005; recently the federal government has made a commitment to quadruple its contribution under WPPI. The program was expected to leverage $1.5 billion in investments and displace three tons of GHG emissions annually by 2010. To be eligible under this program, a wind farm has to be (i) commissioned between April 1, 2002, and March 31, 2007; (ii) independently metered at the point of interconnection with the electricity grid; and (iii) minimum 500 kW in installed capacity[7].

Green Power Purchase Plan: Starting in December 1997, NRCan purchased green power from ENMAX, an electric utility located in Calgary, Alberta. The 10-year agreement with ENMAX aims to produce 10GWh of green power annually for NRCan's Alberta facilities. Environment Canada also signed an agreement with ENMAX for 2GWh of green power for their electricity requirements in Alberta. Together NRCan and Environment Canada are expected to avoid more than 10,000 tonnes of CO_2 annually. In September 2000, NRCan signed a 10-year agreement with SaskPower, Saskatchewan´s electric utility, to purchase about 32GWh wind power annually. Similarly in 2001, NRCan signed a 10-year agreement with Maritime Electric from Prince Edward Island for 13GWh electricity from Emerging Renewable Energy Sources. These purchase agreements in Saskatchewan and Prince Edward Island will result in an annual reduction of 40,000 tonnes of GHG emissions.

Renewable Energy Deployment Initiative (REDI): This 6-year, $24 million program was started in 1998 to stimulate the demand for commercially reliable, cost-effective RET space and water heating and cooling. Under this scheme, Natural Resources Canada undertook market development activities in cooperation with RET industry associations and other partners. Businesses were refunded 25% of the purchase and installation costs of a qualifying system (e.g., solar hot water, solar air heating and high-efficiency biomass combustion system), up to maximum refund of $80,000.

Market Incentive Program (MIP): This is a $25-million federal government initiative, being administered by NRCan through the Action Plan 2000 on Climate Change, to stimulate emerging markets for renewable electricity. By providing financial incentives to electricity

[7] In northern and remote locations, the minimum capacity is 20 kW.

retailers this program aims to develop RETs as full-fledged competitors in the electricity market by 2010 and to reduce GHG and other atmospheric emissions. Funding is available until March 31, 2006. The federal government provides a short-term financial incentive of up to 40% of the eligible costs of an approved project, to a maximum contribution of $5 million per recipient.

CEDRL Photovoltaic Program: This program is focused on the development and implementation of PV technologies in domestic and international markets. The majority of the projects are conducted on a cost-shared and/or task-shared basis between industry, universities, research institutions and utilities.

Renewable Energy Technologies Program (RETP): This program supports Canadian industry in developing and commercializing advanced RETs that can serve as cost effective and environmentally responsible alternatives to conventional energy generation.

Technology Early Action Measures (TEAM): A program under the Climate Change Action Fund to help accelerate the demonstration and commercial deployment of new technologies for the purpose of reducing GHG emissions.

4. KEY BARRIERS AND CHALLENGE

There are several barriers and challenges to the rapid deployment of RETs in Canada.

Competitiveness: In general, RETs cannot compete with fossil fuels because of their high up-front costs. Although RETs are 'renewable' in nature and environmentally clean, they do not receive any premium for these qualities. RETs could be competitive with fossil fuels if the environmental benefits associated with RETs or the environmental costs associated with fossil fuels were accounted for. To date, however, no such accounting practice is considered in the decision-making process. No value is placed on moving away from conventional fuels to RETs [2].
Due to high latitude and long winters most of Canada is not suitable for large-scale solar technologies. Solar PV cannot compete with other electricity supply technologies in areas where high solar irradiation does not coincide with daily peak demand and retail electricity prices are not high enough.

Lack of Confidence: Prospective customers as well as investors have little to no knowledge and experience with RETs. Even if consumers have the knowledge and experience, they appear to be less confident in the new technologies and are hesitant to invest in RETs. Decision-makers are often not aware of all the benefits of RETs and hence are reluctant to try them. Negative experiences with earlier implementation of RETs, introduced in the late 1970s and early 1980s, contribute to the lack of consumer and investor confidence. Among these issues were the absence of financial savings due to the mid-1980's drop in oil and gas prices and system reliability issues related with some technologies [2].

Government support: Although the federal and provincial governments have introduced a number of policy measures and implemented several programs to develop and promote RETs, these measures and programs are much smaller than those provided in other countries.

For example, Finland, Sweden and Spain provide, respectively, 10-35%, 15-25% and 10-40% investment cost subsidies to RET projects. Germany, Japan and Netherlands provide up to 75% subsidies to PV panel installation costs [4]. Although governments and private businesses invest a total of about $220 billion in research and development and $3.58 billion in venture capital funding each year in Canada, not all RETs have access to these funds [17].

Regulatory and institutional barriers: There exist a number of regulatory and institutional barriers to RETs in Canada. Examples include the exclusion of renewable energy producers from Canada's greenhouse gas offset system and full-scale environmental assessment requirements for RETs, even for smaller projects.

Transmission barriers: The best resources for renewable energy, particularly wind and small hydro, are often located in remote and difficult topography, far away from existing transmission systems. As RETs are available mostly in small scale, electricity generation from RETs is not economically viable if new transmission lines must be built. Transmission access is a key barrier; even in some larger scale RET projects [4].

5. FUTURE DEVELOPMENTS

The future of RETs appears bright in Canada for a number of reasons. Canada has already ratified the Kyoto Protocol and RET is one of the key options in reducing GHG emissions. Canada's main conventional energy resources (i.e., large hydro, oil and natural gas) are continuously depleting. Although new reserves, particularly, coal bed methane (CBM) will help stem the decline, the increase in supply will not match that of demand [18]. Hence, the implementation of RETs is an option for the future. As the capital costs of RETs, particularly wind and geothermal, have been declining significantly in recent years, these technologies are becoming more and more competitive with conventional energy technologies. It is argued that a variety of RETs are highly viable for space heating and cooling. When needed, most RETs can be used as modular technologies and provide further cost economies, particularly, in meeting peak electricity demand [19][8]. RETs are more suited for distributed generation and hence could help reduce transmission congestion, a growing issue in electricity markets.

Targets for RETs have been set at the federal and provincial level. Some of these targets are as follows [4, 19]: The federal government is planning for 10% of the new electricity generation through RETs by 2010 as one of the strategies to meet its Kyoto commitment. Alberta has a goal of increasing RET capacity by 3.5% by 2008. British Columbia has set the target of having 50% of new generation from RETs during 2003-2013. Nova Scotia has committed to add 50MW of renewable energy – or about 2.5% of current capacity. The North West Territories has a plan to increase the use of RETs to meet 10% of total energy supply by 2010 and 25% by 2025 thereby reducing their reliance on imported fuel products and stabilizing imports at the 2002 levels by 2010, and 25% less by 2025. In Ontario, 2,700MW of RET capacity will be added by 2010, which is about 10% of the province's current total installed capacity.

[8] For example, wind power plants can be built within a year thereby enabling developers to respond electricity demand more quickly than by conventional electricity technologies [19].

6. CONCLUSIONS

Canada possesses more than 100GW of technical potential for renewable energy resources, particularly wind, solar and small hydro. Less than 10% of the potential, particularly, biomass, small hydro and wind has been exploited to date. A number of programs such as the Wind Power Production Initiative, the Green Power Purchase Program and the Market Incentive Program have been undertaken to facilitate the deployment of RETs. Policies designed to promote RETs include financial incentives (e.g., cost sharing or grants for research, development and demonstrations), renewable portfolio standards (RPS), and green power procurement policies. Federal and provincial governments are planning for 10-50% of electricity capacity additions to come from RETs in the next 10 years. Although the federal and provincial governments have implemented programs, designed policies and developed plans for the promotion of RETs, these are less aggressive than in other OECD countries such as Germany, Japan, Netherlands and the US. The development of RETs faces a number of barriers and challenge including competition from conventional energy technologies; lack of customer and investors' confidence, regulatory and institutional barriers; and technical barriers, particularly, transmission access.

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