PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
CANADIAN ANNUAL REPORT 2004

Josef Ayoub and Lisa Dignard Bailey, CANMET Energy Technology Centre - Varennes, Natural Resources Canada

GENERAL FRAMEWORK

The federal Department of Natural Resources Canada (NRCan) is responsible for energy policies and energy R&D in Canada. The CANMET Energy Technology Centre–Varennes (CETC–Varennes) is one of NRCan's three energy research and innovation centres[1]. Established in 1992, CETC-Varennes' mission is to encourage targeted sectors of the Canadian economy to reduce their greenhouse gas (GHG) emissions, use energy more sustainably, and improve their innovation capabilities. CETC-Varennes is responsible for the management of the federal photovoltaic R&D and technology transfer programmes. Other Centre activities focus on: buildings, refrigeration, industry and RETScreen™[2].

The Government of Canada is signatory to the Kyoto Protocol to the United Nations Framework Convention on Climate Change. It has invested more than 2.7 billion CAD in climate change programs and to the development of leading edge technologies over the past six years, including 1 billion CAD in its federal Budget 2003 alone to fund the Climate Change Plan for Canada (CCPC)[3]. The CCPC is a five-year national programme based on extensive consultations with provincial and territorial governments, industry, environmental organizations and individual Canadians. It sets out the strategy by which all Canadians and all sectors can work together to meet Canada's Kyoto commitment to reduce greenhouse gas emissions (GHG) to an average of six per cent below 1990 levels during the period 2008-2012.

The CCPC allocated 250 million CAD towards the Technology and Innovation (T&I) Initiative, which is contributing to advancing promising GHG technologies through R&D, demonstration and early adoption initiatives to achieve long-term GHG reductions and strengthen Canada's technology capacity in five key areas: decentralized energy production; advance energy end use in buildings and communities, industry and in transportation; cleaner fossil fuels; biotechnology; and, the hydrogen economy. PV and related activities have been included in the implementation plans of the first two T&I R&D technology areas. Technology Early Action Measures (TEAM)[4] is another initiative that has been renewed under the CCPC with injection of new funding for technology demonstration. TEAM is an interdepartmental technology investment programme that supports projects that are designed to develop technologies that mitigate greenhouse gas (GHG) emissions nationally and internationally, and that sustain economic and social development. TEAM is funding several partnerships between federal partners, the PV industry and regional stakeholders to demonstrate projects to raise the awareness of this emerging technology, as well as contributing to their improvement and cost reduction targets.

In 2004, a multi-stakeholder partnership between the solar industry, home developers and builders, renewable energy associations, energy research centers and academia joined forces to launch the Net-Zero Energy Home (NZEH) Coalition[5] with the aim to establish Canada and Canadian Industry as a world leader in competitive, innovative and sustainable residential building construction for the 21st century. The Coalition envisions all new home construction in Canada to meet net-zero energy standards by 2030, by combining onsite solar and other renewable energy generation technologies and energy efficiency applications and devices. The Coalition builds upon Canada's pioneering work in energy efficient home construction, embodied in the R2000[6] standards by adding residential-scale renewable energy production for household needs and additional energy conservation technologies.

The Government of Canada continued its efforts to work with multi-stakeholder groups in Canada to raise awareness of building-integrated photovoltaics with the next generation of architects and building engineers. It collaborated with the Royal Architectural Institute of Canada's (RAIC), a voluntary national association representing more than 3,000 members, to deliver a full-day professional development course on building-integrated photovoltaics. The workshops were designed to dispel the myths surrounding building-integrated photovoltaics and to heighten the architectural community's understanding this emerging and exciting renewable energy technology in Canadian buildings of the future.

Despite the relatively low price of conventional energy, many Canadians are contributing to the growth of the PV market and industry. A sustainable market for remote and off-grid applications has developed over the last 11years in Canada. The installed power capacity is reached 13.88 MW in 2004, compared to 11.83 MW in 2003 (see Table 1). This is an unsubsidized market that is growing because PV technology is meeting the remote power needs of Canadian customers particularly for transport route signaling, navigational aids, remote homes, telecommunication, and remote sensing and monitoring.

NATIONAL PROGRAMME

Within the framework of NRCan's Renewable Energy Strategy, CETC-Varennes is responsible for the photovoltaic R&D and technology transfer programme. In collaboration with Canadian industry and universities, as well as international energy research organizations, the Center undertakes R&D activities and fosters information exchanges to promote the adoption of PV technologies. CETC-V's coordination role keeps policy makers and Canadian industry abreast of developments in the rest of the world.

Table 1: Cumulative PV power capacity installed in Canada

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power (MW)	1.24	1.51	1.86	2.56	3.338	4.47	5.83	7.15	8.83	*10*	*11.83**	*13.88*

(Data: NRCan. * reported as 11.67 in 2003 as per preliminary survey returns.)

The strategies of the Canadian photovoltaic programme are:

1. To conduct R&D that will contribute to the improved performance of PV system components and applications in cold climates;
2. Provide leadership and technical support that will foster the market deployment of PV technology by removing technical, institutional and regulatory barriers;
3. Collaborate with key partners and stakeholders to increase the awareness of the potential and value of PV; and,
4. Provide support to globally competitive PV manufacturers that can significantly contribute to Canada's Climate Change objectives.

Figure 1: *The Toronto Hydro Energy Services high-visibility pilot project in Downtown Toronto will generate 36 kilowatts of electricity. The provincial utility is providing Torontonians with an opportunity to see commercial installations in operation. (Photo credit: Phantom Electron Corporation)*

RESEARCH & DEVELOPMENT

The Canadian R&D programme supports the development of technologies, the evaluation of the performance of PV systems in new applications and their adaptation for use in cold climate conditions. In 2004, it has initiated a four-year programme to effectively address technical, institutional and regulatory barriers and to promote the grid integration of decentralized energy resources (PV, wind, distributed generation)[7]. This work is conducted in collaboration with the industry at CETC-Varennes, a National research facility located near Montréal in the Province of Québec. On-going projects include:

- R&D for the integration of PV-thermal systems in buildings;
- Optimization strategies for Zero Energy Solar Homes;
- Evaluation on the use of small PV-hybrid systems in off-grid applications;
- Integration of renewable energy technologies in off-grid residences in Canadian climatic condition;
- Evaluating the energy performance of novel PV modules operating in Canadian climatic conditions;
- Assessing the performance of PV products designed for building applications;
- Collaboration with Measurement Canada on net-metering to address the regulatory issues;
- Simulation studies on the impact of inverter-based systems and utility interconnected PV systems;
- Championing the development of a national guideline for the interconnection of small distributed generation systems; and,
- Supporting the development and adoption of performance and safety standards for use in Canada, including participation in the International Electrotechnical Commission working groups that aim to develop international standards.

DEMONSTRATION PROJECTS

Largest Pilot Photovoltaic Project in Toronto Reflects Utility Commitment to Energy Alternatives

Toronto Hydro-Electric System Ltd., a subsidiary of Toronto Hydro Corporation, recently installed the largest industrial grid-connected solar power generation system in the city (Figure 1). The photovoltaic system will produce 36 kilowatts of clean, non-polluting electricity for Toronto Hydro's service centre at the company's office in downtown Toronto – a high profile location chosen to increase public awareness of the potential for green power in an urban environment. This is the second green power system to be launched by Toronto Hydro in the past two years, following the downtown wind turbine at the Canadian National Exhibition. The PV system includes 189 Sanyo HIT 190 watt solar modules, and is utilizing a Xantrex 30 kilowatt grid-tie inverter. The PV system generates sufficient electricity to displace annual emission of 38 tonnes of carbon dioxide and provide 12% of the lighting load at the centre, which houses 800 staff and equipment in a 12-acre building. The installation showcases the utility's commitment to alternative energy sources.

Government Embraces Onsite Solar Power Generation

The Government of Canada is committed to climate change reduction efforts through efficient use of energy and the use of energy from renewable sources. Under funding from the Government of Canada's On-Site Generation at Federal Facilities initiatives attracted nine federal departments and agencies demonstrating PV, wind and micro hydro technologies on seventeen federal facilities throughout Canada. Of the seventeen projects, thirteen are grid-tied PV applications totaling 100 kilowatts nominal capacity. For example, the Royal Canadian Mounted Police are using PV power supply systems for their border detachment facilities across Canada, Health Canada is demonstrating PV power generation on native health clinics under their jurisdiction, Environment Canada is demonstrating roof mounted systems on its National Centre for Inland Waters research facility in Ontario, and Parks Canada is also demonstrating a roof-mounted systems on its Ecologic/Education Building in its St. Lawrence National Park also in Ontario. In the western Province of British Columbia, the Department of Fisheries and Oceans and the National Research Council are also demonstrating roof-mounted systems on their Institute of Ocean Sciences and the Herzberg Institute of Astrophysics. In 2005, the Customs and Revenue Agency Customs will be demonstrating two building-integrated PV projects on their border crossing facilities in the provinces of Quebec in eastern Canada and British Columbia in the west. The initiative provided total subsidies of 850,000 CAD to leverage about 2 million CAD of total project costs to realize about 850 kilowatts of total nominal generating capacity, expected by the planned completion of this initiative in 2005. These results far exceed the planned target of 125 kilowatts from PV, wind and micro hydro generating sources.

Arts Fellowship Supports Energetic Exploration in Glass

Noted Canadian glass artist Sarah Hall was recently awarded an Arts Fellowship from the Canadian-based Chalmers Foundation to support her innovative work in photovoltaic art glass. This technique, which uses solar cells in the glass to generate electricity, adds an exciting new dimension to the relationship between a building and its windows. As she integrates these systems into her art glass windows, Sarah Hall will explore the connections between light, colour, imagery and energy and her own deep concerns for our natural world and our future. Her proposal for the Chalmers Foundation was for six new major works that integrate original, expressive designs with working photovoltaic systems over the next year (Figure 2). One of her current projects involves contributing to the Canadian entry in the USDOE-sponsored Solar Decathlon, a competition for energy-efficient housing design, in Washington, DC this September. Since establishing the studio in 1980, Sarah Hall has built an international reputation for her technical and artistic exploration. She has collaborated with world-renowned German architect Dr. Ingo Hagemann, Saint Gobain Glass in Aachen and with Mr. Wilhelm Peters of Glasmalerei Peters to develop and demonstrate artistic applications of stained glass and PV, and she will be working with them on these demonstration projects in Canada. Her work has garnered Honor Awards from the American Institute of Architects, the Allied Arts Award from the Ontario Association of Architects, and election to the Royal Canadian Academy of Art.

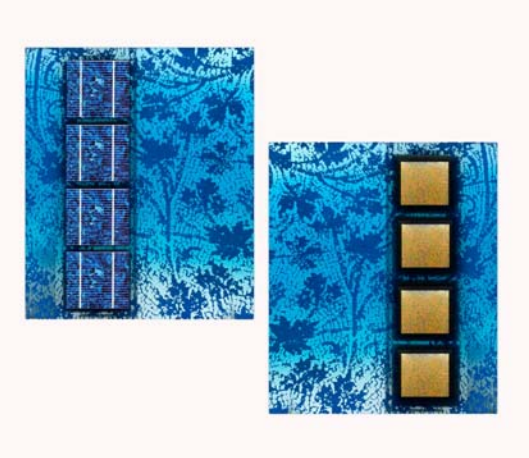

Figure 2: *"Blue Vine"; H 70cm, W 45cm; art glass panel created in 2 layers; interior - screen printed and air-brushed with fired glass enamels; exterior - photovoltaic cells integrated into the glass. An opportunity to integrate emerging energy technology and stained glass art in the buildings of the future. (Photo credit: Sarah Hall Studio)*

IMPLEMENTATION

Canada has developed and approved a number of climate change mitigation schemes in support of its National Implementation Strategy to enable it to meet its commitments under the Kyoto Protocol. Support for collaborative public and private sector efforts are provided through some of the following initiatives:

Federal Leadership through Federal House in Order Initiative & On-Site Generation at Federal Facilities

In 2000, the Government of Canada launched the Federal House in Order (FHIO)[8] initiative with Natural Resources Canada and Environment Canada as the lead departments. The FHIO initiative is the Government of Canada's plan for reducing greenhouse gas (GHG) emissions within its own operations.FHIO recognizes that the Government of Canada's operations produce GHG emissions and, as a result, must meet their share of the responsibility for honouring the Kyoto commitment. Through the FHIO initiative, the Government of Canada is demonstrating that it is taking a leadership role in getting its own "house in order." Reducing its own emissions may ultimately encourage others to do their part in addressing the issue of climate change. An investment of $44.2 million has been allocated to federal operations, including $30 million for the purchase of electricity from renewable resources and $1.2 million for on-site electricity generation demonstration projects in federal buildings using PV, wind and micro-hydro technologies. Through these initiatives the Government of Canada developed a target for reducing GHG emissions within its own operations.

Federal Investments In Technology-To-Market Support

Through continued support to *Technology Early Action Measures (TEAM)*, now in its third phase of funding (2003-2008), The federal government is continuing to provide financing for the late stage development and first demonstration of new technology with strategic partnering through the zone between R&D and market implementation. TEAM is an interdepartmental technology investment program established under the federal government's Climate Change Action Plan. TEAM supports projects that are designed to develop technologies that mitigate GHG emissions nationally and internationally, and that sustain economic and social development. TEAM's unique approach brings together industry, community, and international partners to encourage additional investment in innovative technology. TEAM's position in the technology innovation process has enabled the Government of Canada to support a wide range of technology options and paths for mitigating greenhouse gases. To-date there are about 98 projects that are being funded by TEAM in consort with federal departments totaling some 960 million CAD of which the federal share is 20% of the total cost.

Technology Partnerships Canada (TPC)[9] is a special operating agency of Industry Canada with a mandate to provide funding support for strategic research and development, and demonstration projects that will produce economic, social and environmental benefits to Canadians. TPC's main R&D program is geared to pre-competitive projects across a wide spectrum of technological development. The program focuses on key technology areas such as Environmental Technologies, Aerospace and Defence Technologies and Enabling Technologies, which includes biotechnology and health related applications, as well as manufacturing technologies. TPC and TEAM are funding the development and commercialisation of *Solar Spheral™* technology (Figure 3).

Figure 3: *Innovative PV technology at Solar Spheral™ Power Inc., Cambridge, Ontario. Coloured silicon spheres appeal to architectural applications. (Photo: SSP Inc.)*

Sustainable Development Technology Canada (SDTC)[10] is a foundation created by the Government of Canada that operates a $550 million fund to support the development and demonstration of clean technologies — solutions that address issues of climate change,

clean air, water quality and soil remediation to deliver environmental, economic and health benefits to Canadians. An arm's length, not-for-profit corporation, SDTC fills the void in the innovation chain between R&D and commercialization — helping clean technology developers move through the development and demonstration phases, in preparation for commercialization. In 2002 SDTC awarded 500,000 CAD to a consortium lead by Carmanah Technologies Corporation, Vancouver, British Columbia, to demonstrate and adapt solar powered LED technology to edge-lit signage, which will lead to the development of a more diverse and robust solar industry in Canada. This project is enabling solar powered lighting to enter mainstream applications.

Net Metering Initiative

Deregulation of the Canadian electric utility industry is creating opportunities for distributed power generation to occupy a significant share of the electricity markets of the future. PV has an important role to play in this market, and appropriate policies to promote investments in PV are being pursued. One such area is to compensate system owners feeding power to the grid through net metering and net billing practices. This is relatively a new policy area for Canadian power utilities to consider and nascent activities are happening across Canada. To date, approximately eight Canadian utilities have policies in place that allow small renewable energy generators to be compensated at the retail rate and another seven utilities provide below retail compensation. The federal government is leading a working group composed of stakeholders from the electricity industry (manufacturers and utility) and federal regulatory branches to identify and eliminate barriers to the introduction of net metering in the electricity sector[11].

INDUSTRY STATUS

There are over 150 companies and organizations promoting PV power in Canada and may are active in the Canadian Industry Association and Energie Solaire Quebec[12]. The Canadian Solar Industry Association released a "Solar Plan for Canada" at its annual meeting in November 2004. It aims to insure a solar future for Canada and targets 25 million megawatt-hours by 2025[13].

The Canadian PV manufacturing sector has grown significantly in the last three years to serve both the domestic and export market. In 2004 significant investment in the manufacturing sector were announced. In June 23rd, 2004, ATS Automation Tooling Systems Inc. opened Canada's first fully integrated 20-megawatt *Spheral Solar Technology* manufacturing plant in Cambridge Ontario. It now employs approximately 200 people and has been developing innovative products using its flexible, lightweight solar technology[14].

Xantrex Technology Inc.[15] is a world leading manufacturer of innovative power electronic product interfaces with its headquarter in Burnaby, British Columbia. Xantrex has developed a platform for advanced multi-energy control for hybrid power systems that are being demonstrated at six sites in Canada. It has also initiated a project for a new integrated variable-speed drive system for larger wind turbines in 2004.

Carmanah Technologies Corporation[16] continued to expand its innovative solar powered LED lighting solutions for marine, aviation, transit, roadway, railway and mining markets. Since 1997 it has sold more than 80,000 units in 110 countries.

A network of systems integration companies has established distribution and dealer networks that effectively serve a growing Canadian PV market. These include distributors for Sanyo, BP Solar, Shell Solar, Kyocera, Photowatt, Sharp and UniSolar. These modules are sold with PV module product warranties ranging from 10 to 25 years and have certified their products to international standards.

MARKET

The Canadian PV installed capacity in 2004 was 13.75 MW with a sustained domestic market growth that has averaged 23% annually since 1992. In 2004, the annual PV module market was 2.136 MW (of which 81 kW were exported) compared to 1.83 Megawatts in 2003. Twelve manufacturers reported revenues from manufacturing operations related to modules and BOS sales of 84 million CAD and the addition of 150 new jobs in 2004. It is estimated that the PV business (sales and investments) in Canada was valued at 125 million CAD and employed approximately 765 people in 2004.

FUTURE OUTLOOK

Several Canadian PV companies have invested significantly in both the development and promotion of solar PV power systems in Canada. This is reflected by steady growth in the installed base, as well as the significant private-sector investment in manufacturing. Both the Canadian Solar Industries Association and Énergie Solaire Québec have continued their promotional and marketing activities in Canada. However, more significant effort will be required to encourage the development of the grid-connected market sector in Canada.

The Net-Zero Energy Home Coalition is calling for leveraged support from the federal and provincial governments to participate in a project to construct 1500 net-zero energy homes across 5 or more regions in Canada within 3 to 5-years period as a pilot demonstration of the concept. This pilot phase would be followed by a full scale, incentive-based, early-adopters deployment program. This is a first step to enable the Coalition to reach the target by 2030 that all newly built homes in Canada meet Net Zero Energy standards.

---

1 CETC-Varennes: http://cetc-varennes.nrcan.gc.ca/eng/accueil.html

2 RETScreen International Clean Energy Decision Support Centre http://www.retscreen.net/

3 Climate change: http://www.climatechange.gc.ca/english/publications/announcement/climatechange_investment.html

4 Technology Early Action Measures (TEAM): http://www.climatechange.gc.ca/english/team_2004

5 Net Zero Energy Home Coalition: http://www.associations.cc/nzeh/aboutthecoalition.htm

6 R2000 Program: http://oee.nrcan.gc.ca/r-2000/english/public/index.cfm

7 CETC-Varennes DER: http://cetc-varennes.nrcan.gc.ca/en/er_re/inter_red.html

8 Federal House in Order: http://fhio.gc.ca/default.asp?lang=En&n=A78D906F-11

9 Technology Partnerships Canada: http://tpc-ptc.ic.gc.ca/epic/internet/intpc-ptc.nsf/en/HomeSustainable Development Technology Canada: http://www.sdtc.ca/en/index.htm

10 Sustainable Development Technology Canada: http://www.sdtc.ca/en/index.htm

11 Net-Metering Project: http://www.micropower-connect.org/NetMeteringProject/index.htm

12 Canadian Solar Industries Association: http://www.cansia.ca; Énergie Solaire Québec: http://www.esq.qc.ca/

13 PDF report available from the CanSIA website: http://www.cansia.ca/downloads/sunnydaysahead%20V1.5.pdf

14 Spheral Solar Power Inc.: http://www.spheralsolar.com/

15 Xantrex Technology Inc.: http://www.xantrex.com/

16 Carmanah Technologies Corporation: http://www.carmanah.com/

For more information contact:
Josef.Ayoub@nrcan.gc.ca

(2005-090 PVPSTR)