

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS CANADIAN ANNUAL REPORT 2000

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GENERAL FRAMEWORK

Three specific issues on Canada's energy scene are favouring the increased use of solar photovoltaics: first, international commitments to Green House Gas emissions reductions and climate change mitigation given their far-reaching implications for energy and the environment; second, the deregulation and the restructuring of the electricity industry that is leading to an increased acceptance for distributed and on-site micropower generation; third, the coming change in global energy markets in which photovoltaics is among the fastest growing forms of energy and the business opportunities this presents to Canadian industry.

There are still many barriers to the large-scale use of PV in Canada but there is a political will to address many of these barriers. For example, the Government of Canada supported several new initiatives within the Climate Change Action Plan in 2000. Several federal departments have collaborated with the PV industry and regional partners to deliver projects within the Technology Early Action Measures Program. These projects supported the development of new technologies that will contribute to their improvement and cost reduction targets.

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 10 years in Canada. This market continued to show strong growth with an average of 29% per year (Table 1). The installed power capacity was 5.8 MW in 1999 and is expected to exceed 7MW in 2000. This is an unsubsidized market that is growing because PV technology is meeting the remote power needs of Canadian customers particularly for transport route signalling, navigational aids, remote homes, telecommunication, and remote sensing and monitoring. The public perception of solar energy is very positive and the fastest growing sub-sector is the remote homes and recreational power application. Most grid-tied PV building applications are still at the demonstration stage since this technology is not cost-competitive with industrial power generators in Canada. Nevertheless, the economic and environmental arguments for supporting the development and market introduction of PV technology for building applications are quite compelling when we consider its price reduction potential and long-term Green House Gas emission reduction benefits.

Table 1: Cumulative PV power capacity installed in Canada

Year	1993	1994	1995	1996	1997	1998	1999
PV power (MW)	1.24	1.51	1.86	2.56	3.38	4.47	5.83

NATIONAL PROGRAM

The federal Department of Natural Resources (NRCan) is responsible for energy policies and energy R&D in Canada. Within the framework of the Renewable Energy Strategy, NRCan's CANMET Energy Diversification Research Laboratory (CEDRL) is responsible for the management of the federal photovoltaic R&D and technology transfer program. This includes technical support for research on components and systems in collaborations with industry and major end-users, as well as the development of standards and codes. This photovoltaic R&D program is financed by the federal fund allocation by the Program on Energy Research and Development (PERD). In addition, the Renewable Energy and Electric Division (REED) is responsible for policy support and is actively supporting PV training and marketing activities to promote the use of photovoltaic and other renewable energy technologies in Canada.

The strategies of the Canadian R&D, D photovoltaic program is:

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

R&D AND DEMONSTRATION PROGRAM

The Canadian R&D program 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. This work is conducted in collaboration with the industry at the CANMET-Energy Diversification Research Laboratory, a National research facility located near Montreal in the Province of Quebec. Current projects include:

- a comprehensive research program to evaluate the use of small PV-hybrid systems in order to optimize their performance and reduce their life-cycle cost, including the participation in an International Energy Agency task group dedicated to PV-hybrid for remote applications;
- evaluating the energy performance of commercial PV modules operating in Canadian climatic conditions and contributing to the development of international PV module standards;



- supporting the validation of solar radiation models for PV module and system designs at high latitude, including the assessment of available resources from satellite derived data;
- assessing the performance of PV products designed for building integration, including participation in an Internal Energy Agency task group that focuses on PV in the built environment;
- support for the development of performance and safety standards, including participation in the International Electrotechnical Commission working groups that aims to develop international standards.



Figure 1. This PV-hybrid telecommunication station owned by NorthwesTel is being studied as part of the Canadian PV-hybrid R&D program at CANMET-EDRL.

CANMET-EDRL also developed a Project Analysis Software Tool, known as RETScreen that can be downloaded from the web free-of-charge. First released in 1998 for on-grid applications, the RETScreen 2000 model was upgraded to cover off-grid PV applications, including stand-alone, hybrid and water pumping systems. RETScreen Training modules presenting case studies will be completed to provide guidance to those interested in assessing the cost and benefits of PV systems in various applications in Canada (<http://RETScreen.gc.ca>).

Demonstration projects

ARISE HOME demonstration: The ARISE home research and demonstration project evaluated the use of a comprehensive solar thermal and electric system for residences in Canada. ARISE Technologies Corporation, based in Waterloo, Ontario, aims to provide total energy solutions for residential homes that will make solar a mainstream energy alternative. As shown in Figure 2, the rooftop demonstration blends both solar thermal and solar electric panels over 117 square-meter on the south-face of this home. The 5kW PV system is grid-interconnected and the solar thermal system may be used to space-heat, pre-heat the domestic hot water and swimming pool. A uniform appearance is obtained by ensuring that the same glass is used for both the solar electric and solar thermal panels.

In addition, six new projects demonstrated the application of PV for grid-tied applications or integration on building applications in Canada. These PV demonstration projects benefited from the Government of Canada Climate Change Action Fund as part of the Technology Early Action Measure (TEAM) program.



Figure 2. ARISE HOME Research and demonstration covering the surface of this rooftop with both solar thermal and 5kW of PV panels. The objective is to develop a comprehensive solar energy system that will provide much of the electricity and heating needs for new homes. (Photo: ARISE Technologies Corp.)

The British Columbia Institute Technology (BCIT) contributed to three demonstration projects with the goal of demonstrating the seamless integration of PV panels into office and residential building envelopes to create an on-site link between the supply and demand of electricity. These three collaborative projects with BCIT are summarized below:

- **Ventilated façade for TELUS office tower building:** The renovation of this 52-year-old building incorporated a new façade that provides waste heat recovery and maintains an energy balance. Designers laid the building's new glazed façade over the old, creating an aesthetically pleasing, insulating airspace. The integration of twenty PV façade modules now powers twelve DC fans that ventilate this air space. The PV modules were manufactured in Germany by Saint-Gobain by laminating Photowatt solar cells between two 6-mm thick tempered glass sheets. These were installed as part of the new external façade by Advanced Glazing Systems. The 2.5kW system and maximum power point controller was designed by BCIT.
- **CMHC Home 2000 healthy/flex demonstration:** In collaboration with the Canadian Mortgage and Housing Corporation, BCIT demonstrated the use of PV module as a skylight on the roof of a sophisticated, three-story pre-fabricated house. Blue Photowatt solar cells are arranged in glass-on-glass panels with 1 cm to 1.6 cm spaces to allow day-lighting of the third floor attic, creating a beautiful liveable space. The CMHC Home 2000 was exhibited at the Vancouver Home show and then moved to the BCIT campus for future research. The 2KW PV array incorporated into this residential roof could provide most of the electrical demand of this energy efficient home.
- **BCIT Technology Place building:** A 3.5kW PV array was integrated into the glass façade overlooking the entrance to the new BCIT Technology Place building on the east side of the Burnaby Campus. A combination of opaque and semi-transparent thin-film amorphous silicon modules dress the south-west corner of the modern office building, blending seamlessly with the standard window glass. Ninety custom modules were assembled into a curtain wall that conceals the module wiring in mullions. The array was connected to two grid-tied inverters and offsets some of the lighting requirements of the building.

ATS Automated Tooling Systems, in collaboration with Soltek Solar Energy and other regional partners contributed to three grid-tied PV demonstration projects. These three collaborative projects, supported in part by TEAM funds, are summarized below:

- *Victoria Solar House:* SOLTEK, in collaboration with BC Hydro, Trace Engineering, East Penn Battery and ATS, designed and installed a 1kW PV rooftop system on a residence in Victoria. The Victoria Solar House is the first urban residence in the province of British Columbia to generate a significant portion of its own electricity needs. The PV system is synchronized with BC Hydro power and excess could be fed back through the power lines for other customers to use. For consumers that want to use green power generated from the sun, the demonstration shows how individuals can have their own power system with a further benefit of backup power in the event of a power outage. A useful web page was created to inform Canadians of the benefits of a solar energy house (<http://www.soltek.ca/news/vicsolarhouse.html>).
- *Solar Power for the Banff Operational Center:* In the first phase of this project a 1kW PV array and a management energy system developed by Sustainable Energy Technologies based in Calgary were installed on the operation Center for the Town of Banff, Alberta. This is part of a larger project to upgrade the Banff Operational Center and is also incorporating energy efficient technologies.
- *Solar Power at new ATS Systems Building:* ATS, in collaboration with ARISE Technologies Corporation, SolSource Consulting, and Cambridge Hydro, designed and installed a 5.4kW PV rooftop on its new systems manufacturing facility in Cambridge Ontario. The output of the system is synchronized with the Cambridge Hydro grid through a utility interactive inverter developed by ARISE Technologies.



Figure 3. The renovation of this 52-year-old building incorporated a new façade that provides waste heat recovery and the 2.5kW PV panels now power DC fans that ventilate this air space. (Photo: BCIT)

IMPLEMENTATION

In the post “Kyoto Protocol” setting, Canada is developing a National Implementation Strategy in order to reduce its greenhouse gas emission by 6% from 1990 level. In 1998, the federal government established a Climate Change Secretariat and Climate Change Action Fund. Within this framework, several initiatives have been created to respond to Canada’s commitment to reduce greenhouse gas emissions:

- **Technology Early Action Measures:** Cost-shared support for the development and deployment of emission-reducing technologies;
- **Foundation Analysis:** The development of a national implementation strategy via a multi-stakeholder consultation process. This includes the “Horizontal Tables” vast consultative process with stakeholders representing forty sectors in Canada;
- **Science, Impacts and Adaptation:** Targeted research to better understand climate processes and to assess the impact of climate change on the regions of Canada and the options for adaptation;
- **Public Outreach:** Public education and outreach activities directed at informing Canadians about climate change and encouraging them to take action.

Within the Technology Early Action Measure Program, Automation Tooling Systems Inc. and the government of Canada are partnering on a 5 million CAD project to develop advanced photovoltaic module manufacturing equipment. The project will develop automated manufacturing equipment, and undertake 50 kW of demonstration projects of PV products in Canada and in China. The goals of the project are to lower the cost of PV modules, promote the use of PV electricity production, contribute to job creation in Canada and abroad, and contribute to Canada’s commitments to the Kyoto Protocol for CO₂ emission reductions.

Canada has committed to initiatives that will increase penetration of renewable technologies on the market. Three are of particular interest for PV. The tax system provides incentives to PV investments in two ways: Early intangible expenses are 100% deductible and these can be financed through flow-through shares since December 1996; and, equipment for systems of at least 3 kW of capacity can be written off at an accelerated rate under the Capital Cost Allowance Class 43.1 (30% declining balance). Before 1997, only PV systems of at least 10kW of capacity were eligible.

The restructuring of the electricity market in North America is drawing more interest in providing customers a power choice. Much of the regulation for electricity in Canada is under provincial jurisdiction. Alberta is the first province to deregulate the electricity industry and the price is sold as a commodity on the Alberta power pool. Two major utility companies in Alberta, ENMAX in Calgary and EPCOR in Edmonton, are offering green energy options to their customers. These initial offers have demonstrated that the public is willing to support the use of renewable energy, and this has supported a growing number of wind farms in Alberta. To date these green energy options have not included PV rooftop financing programs that are critical to the successful market implementation of PV for the grid-tied building market.

INDUSTRY STATUS

The Canadian PV industry has grown steadily serving both its domestic off-grid market and the export market. There are approximately 150 organisations actively promoting PV power. These are mostly system suppliers and installers but approximately 15 companies are involved in manufacturing. Many of them are members of the Canadian Solar Industries Association (<http://www.cansia.ca>).

Automation Tooling Systems (ATS), based in Cambridge Ontario is a North American leader in automated manufacturing and test systems, and a large volume producer of precision components.

It has developed automated manufacturing equipment for manufacture of solar cells and modules. In 1997 it acquired its subsidiary, Photowatt International S.A, that has grown into one of the world's largest solar module manufacturers. ATS/Photowatt is also conducting research and development for a next-generation, flexible and lightweight technology, known as Spherical SolarTM.

Xantrex Technology Inc. based in Vancouver, British Columbia, Canada has acquired and formed an alliance with Statpower, Heart interface, Cruising Equipment and Trace to create the world's leading supplier of advanced power electronics. The company is positioned to serve a growing photovoltaic market worldwide, and has products ranging from DC/AC inverters, battery chargers, and grid-interactive power conditioners that targets mobile, recreational, industrial and distributed power applications.

ICP Global technologies, a leading supplier of consumer products in North America, has expanded its operations to manufacture a new line of PV panels. Its new manufacturing facility in Montréal, Québec was inaugurated in October 2000. Custom equipment for the new facility was supplied by NewSun Technologies, based in Ottawa, Ontario.

Vortek Industries Ltd., a manufacturer of high power arc lamps, based in Vancouver, British Columbia, has developed a continuous solar simulator and has adapted its equipment to offer a Rapid Thermal Process furnace.

A network of systems integration companies has established distribution and dealer networks that effectively serves a growing Canadian PV market. These include distributors for Siemens Solar, BP-Solarex, Kyocera, and Photowatt. These module manufacturers offer PV module product warranties ranging from 10 to 25 years and have certified their products to international standards.

MARKET

The Canadian PV installed capacity is now 5.8 MW with a sustained domestic market growth that has averaged 29% over the last 7 years. In 1999, the annual PV module market past the 1.3MW/yr mark. This market is mainly off-grid applications where PV has proven to be a reliable and a cost-effective solution. Most of the growth in recent years is due to the impressive increase in the cottage and recreational PV application market (Table 2). The commercial and industrial applications market showed that sales have stabilized, although it remains the largest total installed sub-market application in Canada. PV power for grid-tied applications is not cost-effective in Canada, therefore most of the projects completed have been supported by government contributions. It is estimated that the Canadian PV industry generated revenues of 40 million CAD and employed approximately 250 people in 1999.

Table 2: Annual PV power sales within three sub-markets

Applications markets	1995 kW	1996 kW	1997 kW	1998 kW	1999 kW
Off-grid residential	133	166	242	525	776
Off-grid commercial/ industrial	200	505	565	562	550
Grid-tied demonstration	17	29	13	3	30
Total Power	350	700	820	1090	1356

FUTURE OUTLOOK

PV power systems have demonstrated that they are a reliable source of electricity and the public perception of this technology is favourable. Nevertheless, increased knowledge of this energy choice is required to maintain the growth of its domestic market. NRCan, through its Renewable and Electrical Energy Division, supported the development of a marketing strategy, with the collaboration of the Canadian Solar Industries Association, to help remove barriers or perceived barriers to a wider penetration of off-grid PV systems in the domestic market. The implementation of the proposed action plan is currently being evaluated in light of budgets and priorities established by the different government programs. In the near term, the favoured approach is to begin with an initiative targeted at the Parks' sector since it has the most outreach potential.

Although the low cost of electricity has delayed the implementation of PV technology for the grid-tied market, activities to remove barriers to the use of PV are continuing. Research and development of building integrated PV technology, support for the development of a technical guideline for the interconnection of small power supplies, and adoption of product safety standards will contribute to facilitating the market introduction of PV technology for grid-tied applications in the medium to long term.

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