

International Energy Agency



CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Canada **2003**

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Nine tasks have been established, and currently six are active. Information about these tasks can be found on the public website www.iea-pvps.org. The new task concerning urban-scale deployment of PV systems is now underway.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

An important deliverable of Task 1 is the annual International Survey Report (ISR) '*Trends in Photovoltaic Applications*'. The ISR presents summary information on trends in PV power applications in the twenty member countries and is based on the information provided in National Survey Reports on PV power applications and markets, which are produced annually by each Task 1 participant. The IEA PVPS website also plays an important role in disseminating information arising from the programme, and includes national country information.

This National Survey Report represents an overview of the key developments and achievements in the Canadian PV sector during 2003 and is an update to similar National Survey Reports from previous years. The objective of the Report is to analyse data and present trends on the PV system and component market in the context of business, policy and non-technical environments. It is based on confidential data and information supplied through an in-depth survey of PV distributors and manufacturers.

iii Definitions, symbols and abbreviations

For the purposes of this report, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m², cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Peak power').

Rated power: The power produced by a PV module or array under STC, written as W.

PV system: A set of interconnected elements such as PV modules, inverters that convert d.c. current from the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: A system installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: A system used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, *etc.* that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: A system installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers, *etc.* These may also be used for support of the utility distribution grid.

Grid-connected centralised PV power system: A system performing the function of a centralised power station.

Turnkey price: The price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (*e.g.*, If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally, the additional transport costs of installing a telecommunication system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives *etc.* These may be implemented by government, the finance industry, utilities *etc.*

NC: National Currency, which in Canada is the Canadian Dollar, whose symbol is "CAD".

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed. The units are typically kWh·year⁻¹·kW⁻¹, which is numerically equal to h·year⁻¹.

Performance ratio: The ratio of the final annual (monthly or daily) yield to the reference annual (monthly or daily) yield, where the reference annual (monthly or daily) yield is the theoretical annual (monthly or daily) available energy per kW of installed PV power. The units are dimensionless.

1 **Executive summary**

Off-grid applications have continued to dominate the Canadian PV market focus for 2003 comprising 98% of the market. Several grid-connected systems were installed and many more are being planned across the country.

1.1 **Installed PV power**

Canada's total PV power installed capacity increased by 18% in 2003 to 11.8 MW compared to 10.0 MW at the end of 2002. The 2003 internal PV sales volume totalled 1 671 kW compared to 1 171 kW in 2002 – an increase of 43% in the year compared to a decline of 30% the previous year. The average market growth has been 26% annually since 1993.

Total PV Capacity Installed Each Year (kW)

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
280	272	350	700	820	1090	1356	1328	1682	1161	1671

In 2003, the largest module sales occurred in the off-grid non-domestic sub-market (with 61% of total sales) with a growth of 81% from 2002.

In the 11 years to 2003, a sustainable off-grid market with no subsidies has developed, growing by an average of 27% per year.

Exports of PV products and services, which represent 9% of the market volume, decreased by 8% to 162 kW.

1.2 **Costs & prices**

Module prices have gradually declined from CAD 11.09 in 1999 to CAD 6.18 in 2003. This represents an average annual decrease of 14%.

Module prices (CAD/W) for a number of years

Year	1999	2000	2001	2002	2003
Module price	11.09	10.70	9.41	7.14	6.18

1.3 PV production

There was a 23% increase in manufacturing employment in Canada in 2003 (equipment, PV and balance of system products). The largest manufacturers are Xantrex, Carmanah, Spheral Solar Power and ICP Global. The only module manufacturer in 2003 is ICP Global with module production capacity of 2 MW. Spheral Solar's new 20 MW manufacturing plant is expected to come on line in 2004.

1.4 Budgets for PV

Total public budgets in Canada showed a 9% decrease of CAD 810k in 2003 due to changes in support provided by climate change programs to various R&D projects with the industry.

2 The implementation of PV systems

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all their associated installation and control components.

2.1 Applications for photovoltaics

Most PV applications in Canada (98%) consist of stand-alone systems comprising a PV array as the sole generator or as a hybrid system combined with a small wind turbine or diesel generator. These systems are usually sited remotely with or without battery storage, but are increasingly being applied closer to the electricity grid as costs change and design professionals and the public become more aware of opportunities.

The non-domestic stand-alone (also known as off-grid) market represented 61% of PV sales in 2003 for water pumping, road signals, navigational buoys, telecommunication repeaters, and industrial sensing, monitoring, and controlling. Major new corporations and markets continue to emerge in manufacturing and selling stand-alone PV systems for use in bus stop signalling and small illumination.

The domestic off-grid market represented 37% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. Most of the PV-hybrid systems installed in 2003 were used in remote residences, with sizes less than 1700 W, mainly PV with a small wind turbine or PV with an engine generator, and mostly located in Manitoba, Saskatchewan, Alberta and British Columbia.

Low electricity prices coupled with restrictive utility regulations and electrical code rules continue to hamper development of the grid-connected market. A national interconnection guideline for distributed generation systems was completed and is now being made into a standard. Considerable work was done to recommend changes to the Canadian Electrical Code's section on utility interconnection. There were several demonstrations of grid-connected PV systems in 2003 including Canada's first PV neighbourhood, and projects being developed for curtain-walls and sunshades. Under the Canadian government's "On-Site Generation at Federal Facilities" program, there were 14 applications for grid-connected PV systems on federal buildings for a total of 130 kW, of which 9 of the projects were initiated in 2003 including buildings in the Arctic.

2.2 Total photovoltaic power installed

A sustainable Canadian PV market in off-grid applications has developed over the last 11 years. This market continued to show the strong annual growth that has averaged 26% for each the last 11 years (Table 1). The installed off-grid power capacity was 9.6 MW in 2002 and 11.4 MW in 2003. This is an unsubsidised market that is growing because PV is meeting the off-grid electrical needs of customers in transportation signalling, navigational aids, off-grid homes, telecommunication, remote sensing, monitoring, and controlling.

In 2003, the modules sales rebounded from the decline in 2002 in all sub-markets. The market is showing significant volatility (both positive and negative) as a result of a number of factors, including the exchange rates of various currencies, consumer confidence arising from other society issues, the increasing use of the internet for on-line shopping and for product support, changing international markets and competitors, increasing recognition of PV technology, more manufacturer importers, and increasing competition among distributors, dealers/retailers and systems installers.

In 2003, the largest module sales occurred in the off-grid non-domestic sub-market (61% of total sales in 2003), with sales up 81% from the previous year. Off-grid domestic sales and distributed grid-connected sales also experienced a revival with a 29% and 42% increase respectively.

Table 1. Cumulative installed PV capacity (kW) in 4 sub-markets

Sub-market application (as of December 31 of each year)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Off-grid domestic	189	312	445	611	853	1378	2154	2536	3322	3854	4539
Off-grid non-domestic	845	993	1193	1698	2263	2825	3375	4303	5162	5775	6886
Grid-connected distributed	194	195	212	241	254	257	287	305	342	368	405
Grid-connected centralised	10	10	10	10	10	10	10	10	10	0*	0
TOTAL	1238	1510	1860	2560	3380	4470	5826	7154	8836	9997	11 830
Total off-grid	1034	1305	1638	2309	3116	4203	5529	6839	8484	9629	11 425

Note: *The single grid-connected centralised system was de-commissioned.

2.3 Major projects, demonstration and field test programmes

The following major projects, demonstration and field test programmes were implemented in Canada in 2003.

2.3.1 Programme: On-Site Generation at Federal Facilities (ONSITE)

The Canadian government's "On-Site Generation at Federal Facilities" program was extended a further year until 2005 March. It received over 30 applications, is oversubscribed, and is supporting the installation of 17 PV systems. This CAD 1.2 million programme is promoting the use of and stimulating the demand for emerging renewable electrical generation systems, focussed on PV, wind, and microhydro, by developing a sustainable market in federal facilities for reliable and cost-effective applications and creating awareness of these systems among Canadians through installations in high-visibility federal buildings mostly in on-grid locations. Federal facilities are eligible for a refund of 25% (for off-grid) to 75% (for grid-connected) of the purchase and installation costs of qualifying systems, up to a maximum refund of CAD 80,000. More details are available at http://cetc-varenes.nrcan.gc.ca/eng/on_site_gen.html.



2.3.2 Demonstration: Canada's First PV Neighbourhood, Kitchener-Waterloo, Ontario

The development of Canada's first demonstration of community-scale PV system is continuing to demonstrate affordable and marketable PV solar home systems to residential customers. A total of 45 kW worth of grid-dependent PV systems are being installed on 10 to 15 new homes. The first solar home was installed in April 2003 using the Uni-solar BIPV technology and the ARISE GX 5000 grid-dependent inverter. In September 2003, the Kitchener Conestoga Rotary Dream Home Lottery officially opened their 2003 Solar Powered Rotary Dream Home to the public. Four solar homes have now been sold showing a consumer acceptance rate of 15% in the subdivision. Negotiations are under way with homebuilders for further development locations. The goal of the project is to develop BIPV rooftop technologies and demonstrate that PV solar homes can be designed, built and marketed to the public. Funding was provided by Canada's Technology Early Action Measures (TEAM) component of the Climate Change Action Fund, an initiative funded by Natural Resources Canada. The partners include ARISE Technologies, TEAM, Cook Homes, The City of Waterloo, Waterloo North Hydro, the University of Waterloo, the Canadian Imperial Bank of Commerce, and Natural Resources Canada's R-2000 energy efficient housing programme.



Photo credit: ARISE Technologies

2.3.3 Demonstration: Queen's University BIPV façade, Kingston, Ontario

A 20 kW grid-dependent building-integrated PV array was installed on the façade of the Goodwin Hall at Queen's University. This project is the collaboration of the University's Integrated Learning Centre, Faculty of Applied Sciences, ATS Automation Tooling Systems, Ontario Power Generation, Solar Design Associates, ARISE Technologies, the PV and Hybrid Systems Program of Natural Resources Canada, the Climate Change Action Fund, and Halsall and Associates Limited. The prime



Photo credit: Anton Driesse

motivation for the system is to expose engineering students to the technology so that they will take it out into industry and apply it. The barriers encountered in this system show clearly why the demonstration of PV systems is so important. They include dealing with inexperienced utilities, installers and contractors and others who have fears about the technology and are not aware of how to assess and value the technology's benefits; the need for a champion to push through the barriers; the need for "ownership" of the project; the need to have a clear chain of responsibility, authority, and decision-making.

2.3.4 Demonstration: Red River College BIPV System, Winnipeg

A new building for Red River College in Winnipeg incorporates a 12.6 kW glazed curtain wall BIPV system on its south façade. This leading edge project has been realized with the cooperation of the Manitoba Government, the City of Winnipeg, Manitoba Hydro, Red River College and the building's project team. As a demonstration project, this system provided valuable research information to the public, industry, utilities and governments regarding the application of PV in commercial and institutional buildings. It gave them experience with



Photo credit: Gerry Kopelow

a large-scale PV system, technical knowledge with BIPV in northern climates, experience with the grid interconnection of a micropower system, and a new process for electrical wiring in the exterior of a curtain wall frame.

2.3.5 Project: Teaming with Canadian Architects to Mainstream Grid-Connected PV

Natural Resources Canada, the Royal Architectural Institute of Canada and the University of British Columbia teamed-up to deliver a one-day Workshop on Building Integrated PV designed to heighten the architectural community's understanding of solar PV as an emerging exciting renewable energy technology for integration into

buildings and to give visibility to the architectural and environmental opportunities of BIPV. Sixty participants attended the workshop.

A report "Mainstreaming Building-Integrated Photovoltaics in Canada" identifies the benefits of BIPV and dispel its myths, as well as presents a process by which BIPV can be incorporated into buildings. This will form the basis of a course for the Institute's continuing education program, Sustainable Design for Canadian Buildings.

2.3.6 Programme: Canadian Centre for Housing Technology

The Canadian Centre for Housing Technology (CCHT) is Canada's new advanced housing research and demonstration facility. The Centre has been created to accelerate the development and application of improved technologies for the Canadian housing industry and to facilitate world-market access to Canada's leading edge housing solutions. Built on a fully serviced six-acre site at the National Research Council of Canada (NRCC), the Centre is a working partnership between NRCC, Natural Resources Canada and the Canada Mortgage and Housing Corporation. The Centre currently features two fully monitored test homes and a unique demonstration and showcase facility. Recently two grid-tied PV systems (1.32 kW each) were installed on the roof and as a canopy to the CCHT information centre.



2.3.7 Project: Demonstrating Renewable Energy Integration in Cold-climate Off-grid Residential Applications in the Yukon

A three-day integrated *design charrette* was held in Whitehorse, Yukon in December 2003, to address potential opportunities and technical challenges involved with living off-grid using renewable energy. This was organized by the Canadian PV Programme in collaboration with the Yukon Energy Solution Centre. Thirty experts from the private and public sectors with experience in renewable energy and buildings energy technologies participated, with skills in simulation, renewable energy, architectural, building, construction as well as manufacturing and systems installations. The teams adopted an integrated approach to optimize the use of renewable energy, and provide an analysis of total energy use (including space and hot water heating) and electrical energy use in off-grid houses north of the 60th latitude.



Photo credit: ARISE Technologies

2.3.8 Demonstration: BIPV Atrium at the Waterloo City Hall

In November 2003, the City of Waterloo, Ontario, inaugurated a 1.1 kW grid-connected BIPV system in the atrium of City Hall. The project's objectives include evaluating the barriers to grid-connected PV, understanding the logistics of a retrofitting solar onto an existing building, understanding its performance, evaluating further use of solar technology at other municipal buildings, and exploring further opportunities for public demonstration and education. The project was partially funded through the Green Municipal Enabling Fund established by the Federal Government and Federation of Canadian Municipalities with contributions from ARISE Technologies.



Photo credit: ARISE Technologies

2.3.9 Saskatchewan Advanced House

The Saskatchewan Advanced House was retrofitted to convert a 1.9 kW stand-alone solar array into a grid-dependent system in order to assess the performance of the ARISE GX 5000 inverter. The project was very successful in demonstrating how important it is to have a champion so that the electric utilities and regulators will be motivated to learn about the technology in order to allow it to be interconnected. Natural Resources Canada, Saskatchewan Research Council, Kelln Solar and SaskPower partnered to demonstrate and monitor this. SaskPower supported this installation as part of their Climate Change Action Plan.



Photo credit: Saskatchewan Research Council

2.3.10 Demonstration: University to Participate in Solar Decathlon Competition

A team of engineering students from Concordia University and design students from the Université de Montréal will be the first Canadian team to participate in the week-long American Solar Decathlon Competition in 2005. The challenge is to design and build a 50 m² solar powered house. The Solar Decathlon is an opportunity to give architecture, engineering and other students real-world experience in energy-efficient design and solar power technologies. Natural Resources Canada worked with the Solar Decathlon Project sponsors and organisers to facilitate the inclusion of the Canadian entry.

Table 2. Summary of major projects, demonstration and field test programmes

Project, Date of plant start up	Technical data, Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
On-Site Generation at Federal Facilities Available for applications from March 2002. Programme ends in March 2005.	<ul style="list-style-type: none"> The programme refunds some of a PV system's cost. 25% refund on a PV off-grid system. 75% refund on a grid-connected system. Maximum refund of CAD 80 000 per project. 	<ul style="list-style-type: none"> Grid-connected: create awareness of emerging renewable energy technologies through installations systems on high-visibility federal buildings. Off-grid: Develop a sustainable market for reliable and cost-effective renewable energy applications. 	<ul style="list-style-type: none"> Has identified 30 potential sites. Is supporting 17 installations. 	Government of Canada Action Plan 2000 for Climate Change <i>"Federal House in Order initiative"</i>	Natural Resources Canada, CETC-Varenes, PV & Hybrid Systems programme	
Canada's First PV Neighbourhood Project started April 2002.	<ul style="list-style-type: none"> Grid-connected 10 to 15 new homes Total of 45 kW of PV capacity Building integrated Roof mounted Programme cost: CAD 1 025 000 	<ul style="list-style-type: none"> Accelerate the acceptance of PV in the marketplace. Develop a framework for expanding the program to other parts of Canada. Understand the impact of solar-powered neighbourhoods on the electrical utility, financial institutions, and municipal planning and bylaws. 	<p>First house on line, April 2003, four solar homes now sold. Consumer acceptance rate is 15%. Other development locations now being considered.</p> <p>Barriers noted include:</p> <ul style="list-style-type: none"> Affordability of solar PV Availability of financing mechanisms Utility electricity that is inexpensive and reliable Technical concerns Utility concerns Consumer awareness and understanding 	<ul style="list-style-type: none"> Government of Canada's Technology Early Action Measures (TEAM) component of the Climate Change Action Fund Natural Resources Canada 	ARISE Technologies	

Project, Date of plant start up	Technical data, Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
<p>Queen's University BIPV façade</p> <p>Project started in 2001, now complete.</p> <p>System start-up in July 2003.</p>	<ul style="list-style-type: none"> • Grid-connected • Building integrated • Mounted as window sunshades on an existing building • 19.8 kW • Will generate 20 MWh of electricity annually • 264 Photowatt PW-750 modules • Xantrex 20 kW PV-20208 3ϕ inverter • Total project costs CAD: 550 000 	<ul style="list-style-type: none"> • Demonstrate Queen's University's commitment to sustainability • Expose engineering students to PV technology so they will take it out into industry and apply it. 	<p>Barriers encountered include:</p> <ul style="list-style-type: none"> • Inexperienced utilities, installers and contractors. • Payback analysis is difficult because people do not know the benefits of the technology and how to value them. • The need for someone within the owner's organisation to be a champion to push through the barriers. • The need for all the stakeholders to have buy-in. • The need to clarify regarding responsibility, authority, and decision-making. • Concerns about room light levels, field of view, view of back of modules, and that heat generated by the array would rise into nearby open windows. • Fear of system maintenance requirements. • Accepting the risks of being on the leading edge. 	<ul style="list-style-type: none"> • Natural Resources Canada • Government of Canada's Technology Early Action Measures (TEAM) component of the Climate Change Action Fund • Queen's University 	<p>Halsall and Associates Limited</p>	

Project, Date of plant start up	Technical data, Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
Red River College BIPV curtain wall System start-up in November 2003.	<ul style="list-style-type: none"> • Grid-connected • Integrated into window glazing as part of a large retrofit • 12.6 kW • 133 St. Gobain laminated modules • 6 SMA Sunny Boy 2500U inverters • Total project costs CAD: 235 000 	<ul style="list-style-type: none"> • Gain information on the application of PV in commercial and institutional buildings. • Gain experience with a large-scale PV system • Gain technical knowledge on the performance of BIPV in northern climates • Gain experience with grid interconnection. 	<ul style="list-style-type: none"> • Capital cost is still the major stumbling block to PV. • An engineering stamp was required to certify the compatibility of using the curtain wall mullion caps as a conduit. • There has been no maintenance required on the system whatsoever. • PV output is directly related to temperature. 	<ul style="list-style-type: none"> • Province of Manitoba • City of Winnipeg • Manitoba Hydro 	Corbett Cibinel Architects	
Royal Architectural Institute of Canada BIPV Workshop, June 2003	<ul style="list-style-type: none"> • 1-day workshop • 60 participants in attendance 	<ul style="list-style-type: none"> • Heighten the understanding of solar PV as an emerging technology for integration into buildings • Give visibility to the architectural and environmental opportunities of BIPV. 	<ul style="list-style-type: none"> • A report "Mainstreaming Building-Integrated Photovoltaics in Canada" identifies the benefits of BIPV, dispel its myths, and presents a process to incorporate BIPV into buildings. • This will form the basis of a course for the Institute's continuing education program, Sustainable Design for Canadian Buildings. 	Natural Resources Canada	Royal Architectural Institute of Canada	
Participation in the American Solar Decathlon Competition	<ul style="list-style-type: none"> • None to report yet 	<ul style="list-style-type: none"> • Give architectural and engineering students experience with energy efficiency and solar power technologies 	Not reported yet	Natural Resources Canada	<ul style="list-style-type: none"> • Concordia University • Université de Montréal 	

Project, Date of plant start up	Technical data, Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
Canadian Centre for Housing Technology, January 2003	<ul style="list-style-type: none"> • Grid-connected • Two systems of 1.32 kW each 	<ul style="list-style-type: none"> • Accelerate the development and application of improved housing technologies • Facilitate access to Canada's PV solutions 	Not reported yet	<ul style="list-style-type: none"> • National Research Council of Canada • Natural Resources Canada • Canada Mortgage and Housing Corporation 	National Research Council of Canada	
Renewables in Cold-Climate Off-Grid Houses Charrette, December 2003	<ul style="list-style-type: none"> • 3-day integrated design charrette • 30 participants 	<ul style="list-style-type: none"> • Address opportunities and technical challenges involved with living off-grid using renewable energy 	Not reported yet	Yukon Energy Solution Centre	Yukon Energy Solution Centre	
Waterloo City Hall BIPV atrium, November 2003	<ul style="list-style-type: none"> • Grid-connected • 1.1 kW • Total project costs CAD: 30 000 	<ul style="list-style-type: none"> • Study barriers to grid-connected PV • Understand the logistics of a solar retrofit • Understand its performance • Understand how to transfer the technology to other buildings 	Not reported yet	<ul style="list-style-type: none"> • Green Municipal Enabling Fund • Canadian government • Federation of Canadian Municipalities 	ARISE Technologies	
Saskatchewan Advanced House PV system, June 2003	<ul style="list-style-type: none"> • Grid-connected • 1.9 kW • Total project costs CAD: ~10 000 	<ul style="list-style-type: none"> • To assess the performance of the ARISE GX5000 inverter 	Need to have a champion to motivate the electric utilities and regulators to learn about the technology so they will allow it to be interconnected.	<ul style="list-style-type: none"> • Natural Resources Canada • Saskatchewan Research Council • SaskPower 	Saskatchewan Research Council	

2.4 Highlights of R&D

The Canadian PV R&D program supports the development of technologies, removal of barriers, evaluation of the performance of PV systems in new applications and their adaptation for use in cold climates. This work is conducted in collaboration with the industry by the CANMET-Energy Technology Centre-Varenes, a National research facility located near Montréal, Québec. On-going projects include:

- Evaluating small PV-hybrid systems to optimize performance and reduce life-cycle cost;
- Increasing the integration of renewable energy technologies in off-grid residences;
- Evaluating the energy performance of commercial PV modules and contributing to the development of international PV module standards;
- Assessing the performance of PV products designed for building integration;
- Conducting research to improve the performance of inverters and balance of systems components used for grid-connected 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.

Other projects in the initial stages include:

- Forming a collaborative research network on “Solar Energy and Buildings” with Canadian universities and solar testing facilities;
- Building an R&D laboratory with design, fabrication and characterization capability for advanced PV devices and systems at the University of Waterloo;
- Investigating the integration and optimization of BIPV technologies to include power windows and the design of novel building integrated products;
- Exploring new methods of improving the solar energy conversion of amorphous silicon PV devices;
- Developing and demonstrating a multi-energy source distributed generator control system to enable PV, wind, fuel cells and alternative power systems to be integrated into conventional fuel-based generators;
- Developing remote diagnostic and control tools for inverters;
- Constructing a test facility for grid-connected inverters to simulate a utility grid;
- Developing knowledge about the management and impact of inverter-based grid-connected micropower systems;
- Assessing the operation parameters required by utilities to ensure safe and stable distributed power production; and
- Reviewing monitoring hardware, communication means and user interface to allow utilities to diagnose remote generation issues and allow people to monitor their own electricity production.

2.5 Public budgets for market stimulation, demonstration/field test programmes and R&D

Total public budgets in Canada showed a decrease of CAD 810k (9%) in 2003 following from the 212% increase the previous year. There are no public subsidies or other market incentives for PV at any level of government.

Table 3. Public budgets (in CAD) for R&D, demonstration/field test programmes and market incentives

2003 TOTAL		R & D	Demo/ Field test	Market Incentives
National	(\$7 840k)	\$6 400k	\$600k	\$840k
Provincial	(\$700k)	\$200k	\$300k	\$200k
Total	(\$8 540k)	\$6 600k	\$900k	\$1 040k

3 Industry and growth

The Canadian PV industry continues to grow steadily serving both its internal off-grid market and the export market (which represented 9% of the internal market). The largest export market is in off-grid non-domestic systems. While domestic sales were up 43% from the previous year, export sales declined by 8% to below the 2001 levels.

There are approximately 150 organisations promoting PV power in Canada. 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 or Énergie Solaire Québec.

System suppliers and installers have developed specific knowledge and products for PV systems operating in harsh climates and many have a very good expertise in PV hybrid power systems.

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

3.1 Production of feedstock and wafers

There is no production of feedstock and wafers to report in Canada.

3.2 Production of photovoltaic cells and modules

ICP Global Technologies, a leading supplier of user-friendly consumer PV products in North America, has a diverse line of portable and power-on-the-go PV battery charging systems. It now employs approximately 75 people in its manufacturing and sales operations.

Table 4. Production and production capacity information for the year for each manufacturer

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum Production Capacity (MW)	
		Cell	Module	Cell	Module
ICP Global	sc-Si and mc-Si, cells purchased internationally	--	0.5 MW	--	2 MW capacity in 2002
Spherical Solar Power	silicon spherical solar technology	n/a	n/a	n/a	n/a
TOTALS		--	n/a	--	2 MW

Spherical Solar Power, a subsidiary of ATS Automation Tooling Systems, employs about 150 people at its new 20 MW manufacturing plant near Cambridge, Ontario, Canada's first vertically-integrated solar PV manufacturing facility. Spherical Solar™ Power (SSP) technology is a revolutionary low-cost flexible PV product that can readily be adapted to a wide range of applications. It is expected to accelerate the adoption of PV and open new mainstream applications. SSP PV cells are pliable, lightweight, and durable and can be produced in a variety of colours that suit seamless integration with traditional building materials. ATS also owns Photowatt of France and has levered its automation expertise and high-volume manufacturing in the production of silicon solar cells and modules. In 2003, the Government of Canada invested CAD 29.5 million to leverage CAD 67 million in private sector spending to commercialise the Spherical Solar™ technology.

The most popular foreign module suppliers included BP Solar, Kyocera Solar, Unisolar, Shell, GE Solar, and SunWize Technologies. There are several Canadian suppliers included SPS Energy, Generation PV, ARISE Technologies, Solar Solutions, and ETI Solar.

Table 4a. Module prices (CAD/W) for a number of years

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
– Current							11.09	10.70	9.41	7.14	6.18
– Constant											

Canadian module prices dropped an average of CAD 0.96 per Watt, or 13% in 2003, down to CAD 6.18 per Watt from CAD 7.14 in 2002. This represents an average annual decrease of 14% since 1999.

3.3 Manufacturers and suppliers of other components

Balance of Systems products manufacture continued to grow in 2003, and new products emerged.

Xantrex Technology, based in Vancouver, British Columbia, one of the world's leading suppliers of advanced power electronics, develops, manufactures and markets advanced power electronic and control products for the distributed, mobile and programmable power markets. In 2003, it continued to bring out new inverter products, and launched a customer-financing program for renewable energy products. This is the first renewable energy industry player to offer financing packages to residential, municipal and commercial customers. This joint initiative with Thalman Financial based in California, America, pro-actively assists customers to move forward with a purchase by using a regular payment plan.

Carmanah Technologies based in Victoria, British Columbia, continues to expand its manufacturing line of self-contained solar-powered LED lighting products to serve the marine, aviation, transit, roadway, obstruction, address lighting, railway, and landscape sectors in its requirements for reliable safety, navigation, or hazard marker lighting. It has now installed 90 000 units around the world.

3.4 System prices

There are no system prices to report. System prices vary widely because 98% of Canada's PV market is off-grid, and so embraces a wide range of PV system sizes, complexities, and system configurations.

3.5 Labour places

The number of labour places in PV-related activities in Canada continues to grow, as indicated in the following table. Positions include those in manufacturing, sales installation, R&D, and *etc.* For the 615 jobs reported, 414 jobs are for manufacturing, 35 are in distribution, retail, and installation, and the others are in consulting and R&D.

YEAR	1996	1997	1998	1999	2000	2001	2002	2003
Positions	169	201	220	250	260	275	535	615

3.6 Business value

The total commercial activity from Canadian PV companies was estimated to be CAD 100 million in 2003 up from CAD 95 million in 2002. The Canadian PV industry revenue is the sum of the PV related turnover of all the businesses working in the PV sector, which is presented in the following table. This includes the revenues of consultants, installers and manufacturers of both modules and balance of system components. This 5% growth is mainly due to manufacturing revenues reported by twelve manufacturers that increased by 8% to CAD 62 million. This increase is reflected in increases in manufacturing labour places as well as overall increases in manufacturing capacity.

Table 5. PV industry revenue in CAD, 1993-2003

PV industry revenue	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Millions CAD	17	17	25	28	33	38	40	42	45	95	100

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

In 2003, Canada announced the details of CAD 1 billion of investment towards the implementation of the Climate Change Plan for Canada (CCPC) to reduce its greenhouse gas emission by 6% from 1990 level. Within this framework, two key climate change initiatives are being supported that will benefit the PV industry:

- *On-site Generation at Government Facilities* – As part of its climate change action plan, the government of Canada is supporting the installation of approximately 17 PV

systems, with preference being given to highly visible projects that demonstrate the application of building-integrated PV products. This project has been extended by one year to 2005 March. It received over 30 applications and is oversubscribed.

- "*Technology and Innovation*" has CAD 250 million to advance climate change mitigation technologies through R & D, demonstration, and early adoption initiatives in five key areas. PV and activities related to it have been incorporated into two of these areas: decentralized energy production and advanced end-use efficiency technologies.

The restructuring of provincial electricity markets in Canada is increasing the interest in providing customers a power choice. Alberta's electricity industry is the only fully competitive market and electricity is traded over the Alberta Electric System Operator's Energy Trading System. Ontario is re-developing its electric power industry. In it, they are planning to have a conservation and renewable energy secretariat that will have the authority to purchase more demand side management and renewable energy measures. Several major utility companies are offering green power as a premium to their customers, including Enmax (mainly wind power) and EPCOR (biomass, wind, and micro-hydro) in Alberta, and Ontario Power Generation with its Evergreen Energy division, and BC Hydro's Green Power Certificates.

4.2 Indirect policy issues

No significant policy issues are being found with stand-alone PV systems, which comprise 98% of Canada's PV market. The opposite can be said for grid-connected systems however.

Net metering of grid-connected PV systems and other micropower generators is not offered in Canada because no meters are certified for reverse metering. Some provinces also prohibit net metering through electricity regulations that were intended for large generators but are being applied to micropower generators. The British Columbia Utility Commission asked BC Hydro to prepare a net metering policy, which they did, though it is actually a net billing policy that applies equal rates to imported and exported electricity. Manitoba Hydro discontinued their net metering policy once they found out that it was against metering regulations. Ontario is looking seriously at it. There are several guerrilla PV systems installed that net meter. Other net metering may be happening by utility companies that ignore PV systems.

The interconnection of PV systems continues to contain many barriers to mass marketing, particularly in lengthy, complex, multiple steps required to obtain approvals. Often due to a general lack of awareness and experience with the technology, significant barriers to grid-connected PV systems and other micropower generators are raised by various stakeholders including utility companies, inspectors, and unions that perceive a life-threatening risk by it and don't want to accept the risk. Québec, for instance, only got its 1st interconnected PV system in 2003! Knowing how fast the grid-connected market is growing in the IEA countries has been a great value in helping to push the stakeholders forward to resolve the barriers.

Utility companies are generally suspicious of PV primarily because it is competition revenue for them, it is perceived to threaten the life of their line workers, it does not

provide the grid support and peak load reduction functions that are required by distribution systems.

4.3 Standards and codes

The ability to purchase products certified to Canadian standards continues to be a large issue. Many provincial regulations prohibit the sale of non-certified electrical components though the PV industry continues to import and sell many components that only have American certification. The PV industry has not been strongly pro-active in raising this issue with their supply chain.

Collaborative projects with standard development associations, Canadian Standards Association International and Underwriters' Laboratories of Canada are underway. A Canadian Standards Association (CSA) committee is reviewing a number of Canadian Electrical Code changes prepared by the Alberta Safety Code Council Task Force on Micropower and the Canadian Electrical Code that will facilitate the interconnection of micro-power generation systems. In addition, MicroPower Connect (described at www.micropower-connect.org) has submitted its national guideline for the interconnection of small, distributed electrical generators to the Canadian Standards Association for implementation as a Canadian interconnection standard.

Canadian experts participate in the development of international standards within the International Electrotechnical Commission's TC82. A major project to develop a safety module standard is being drafted (IEC 61730) with the objective of harmonizing requirements worldwide. A project to develop an inverter and charge controller safety standard IEC 62109 is also in development.

CETC-Varenes is coordinating the development of international PV products standards in collaboration with others with the aim of developing a standard that takes into account the effects of Canadian climatic factors in the rating of PV modules. The results of this work will bring an important contribution to the design of the IEC 61853, a new standard on the energy performance of PV modules.

5 Highlights and Prospects – The Future of PV in Canada

Several Canadian PV companies have invested significantly in both the development and promotion of solar PV power systems in Canada. The effect of this is starting to be felt in the market growth this year in a number of areas, including the continued steady growth in the labour places and in the private-sector investment in manufacturing. The industry is particularly aware of the progress made with the Spheral Solar™ technology and its impending production.

Though the public continues to not be well informed about PV, it is increasingly aware of it and is strongly desiring of it until they find out its costs. Increased awareness, knowledge, training, and demonstration of PV is required to maintain the growth of the domestic market. The two major industry associations, the Canadian Solar Industries Association and Énergie Solaire Québec, are expanding their promotional and marketing activities.

A much more significant effort will be required to encourage the development of the grid-connected market sector. Since CETC-Varenes released the study examining the benefits of on-site generation using PV technologies on buildings, several new activities have been initiated as part of an action plan that aims to build on industry experience base and address some of the market place barriers that currently exist. New government investments in R&D for Building-Integrated PV technology, support for the development of a technical guideline for the interconnection of micropower systems, and support for demonstrations of PV on building in high-visibility sites throughout Canada will contribute to facilitating the market introduction of PV technology for grid-connected applications in the medium to long term.

Annex A. Method and accuracy of data

A telephone survey of 47 major PV industry players was conducted for the 2003 calendar year, of which 37 provided responses. Products imported over the internet were not measured. The survey filled out a questionnaire to obtain information in the following areas:

- Business segment.
- Full-time, labour place equivalents engaged in PV activities.
- Canadian and foreign module suppliers.
- Total revenues from sales and installations inside and outside Canada.
- Average price per Watt.
- Modules (in kW) sold inside and outside of Canada.
- Sales to four PV sub-markets (in kW): off-grid domestic, off-grid non-domestic, grid-connected distributed and grid-connected centralised.
- Sales (in \$), average capacity (W), and turnkey price per application (\$/W) for off-grid residential and on-grid distributed applications.
- PV-hybrid systems installed in Canada.
- Total revenues (and the portion related to export activities) from manufacturers of modules, inverters/power conditioners, storage batteries, controllers, equipment for PV systems, manufacturing and test equipment, and consumer products.
- Total investment in R&D, increased manufacturing capacity, and acquisitions in PV-related business over the last two years from manufacturers of modules, inverters/power conditioners, storage batteries, controllers, equipment for PV systems, manufacturing and test equipment, and consumer products.
- Average PV power (kW) of consumer products from consumer product manufacturers.
- Factors that had a significant impact on businesses in 2003.

A special question addressed the market for systems that were 40 W or less. The aim was to obtain revenues, portion of revenues from export activities and total PV power sales (kW) for these systems in 2003.

A question was added to assess the impact of the internet on sales.

The estimated PV module capacity installed in Canada in 2003 is estimated to be 1 671 kW ($\pm 10\%$). An additional 162 kW ($\pm 15\%$) were exported.