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 2002

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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. Eight Tasks have been established, and currently five are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning urban-scale deployment of PV systems is being developed.

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

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual International Survey Report on PV power applications. This report gives information on trends in PV power applications in the twenty member countries and is based on the information provided in the National Survey Reports, which are produced annually by each Task 1 participant.

The International Survey Report is an external publication of the IEA-PVPS Implementing Agreement, while the National Survey Reports are classified as internal reports and are not published within the IEA-PVPS Implementing Agreement. The first three International Survey Reports (and the National Survey Reports) covered the periods 1992-3, 1994-5 and 1996-7 respectively. Since 1998, the reports are produced on an annual basis to reflect the accelerating pace of developments in PV activities.

This 2002 National Survey Report gives a brief overview of progress made in the field of PV power systems in Canada in 2002.

iii Definitions, symbols and abbreviations

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/m^2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Peak power').

Peak power: The power produced by a PV module or array under STC, with units of 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 be used for support of the utility distribution grid.

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

Turnkey price: 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 the same as 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 2002 comprising 98% of the market. Several grid-connected systems were installed and more are in the planning stages.

1.1 Installed PV power

Canada's total PV power installed capacity increased by 13% in 2002 to 10 MW compared to 8.8 MW at the end of 2001. The 2002 PV sales volume totalled 1 171 kW compared to 1 682 kW in 2001 – a decline of 31% in the year compared to an increase of 27% the previous year.

Total PV Capacity Installed Each Year (kW)

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

In 2002, the largest module sales occurred in the off-grid non-domestic sub-market (with 52% of total sales), and, even though this market volume declined by 29% from 2001, it remained higher than most previous years.

In the 10 years to 2002, a sustainable off-grid market with no subsidies has developed, growing by an average of 28% per year.

Exports of PV products and services, which represent 13% of the market volume, increased 8% to 176 kW.

1.2 Costs & prices

Module prices have gradually declined from CAD 11.09 in 1999 to CAD 7.14 in 2002. The largest decrease (24%) occurred in 2002.

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

Year	1999	2000	2001	2002
Module price	11.09	10.70	9.41	7.14

1.3 PV production

There was a significant increase in manufacturing employment in Canada in 2002 (equipment, PV and balance of system products). The largest manufacturers are Xantrex, Carmanah, ATS and ICP Global. The only module manufacturer in 2002 is ICP Global with module production capacity of 2 MW.

1.4 Budgets for PV

Total public budgets in Canada showed a large increase of CAD 6.35M (212%) in 2002 due to additional 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 installation and control components for modules, inverters and batteries.

2.1 Applications for photovoltaics

Most PV applications in Canada consist of stand-alone systems comprising a PV array as the sole generator or as a hybrid system combined with a wind turbine or diesel generator. These systems are usually sited remotely with or without battery storage, but are increasingly 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 53% of PV sales in 2002 for water pumping, road signals, navigational buoys, remote telecommunication repeaters, industrial sensing, monitoring, and controlling. Major new corporations and markets are emerging in manufacturing and selling stand-alone PV systems for use in bus-stop signalling and airport runway illumination.

The domestic off-grid market experienced continued interest in PV systems for remote homes and cottages, remote residential communication (radios), and recreational vehicles, though the market did not expand. Most of the PV-hybrid systems installed in 2002 were used in remote residences, with sizes less than 1120 W, mainly PV-wind or PV-diesel, and mostly located in Quebec, Saskatchewan, Manitoba, 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 is nearing completion. Considerable detailed work has been done to develop a table of recommended changes to the Canadian Electrical Code's section on interconnection. There were several demonstrations of grid-connected PV systems in 2002 including Canada's first PV neighbourhood, the first system on a government legislature building, and projects being developed for curtain-walls and sunshades.

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 strong growth with at an average of 28% per year for the last 10 years (Table 1). The installed off-grid power capacity was 8.5 MW in 2001 and 9.6 MW in 2002. This is an unsubsidized market that is growing largely because PV technology is meeting the remote power needs of Canadian customers particularly for transportation signalling, navigational aids, remote homes, telecommunication, remote sensing, monitoring, and controlling.

In 2002, the modules sales decreased significantly compared to last year in all sub-markets, namely off-grid domestic, off-grid non-domestic, grid-connected distributed, and grid-connected centralized. This weakness is the result of a combination of factors, including continued economic instability, increasing competition among distributors, dealers/retailers and systems installers, and the emergence of Internet and on-line PV merchants as very successful competition.

In 2002, the largest module sales occurred in the off-grid non-domestic sub-market (53% of total sales in 2002), even though this market's sales had declined 29% from the previous year. Off-grid domestic sales and grid-connected distributed sales also experienced a downturn with a 32% and 30% drop respectively.

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

Sub-market application (as of December 31 of each year)	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Off-grid domestic	105	189	312	445	611	853	1 378	2 154	2 536	3 322	3 854
Off-grid non-domestic	686	845	993	1 193	1 698	2 263	2 825	3 375	4 303	5 162	5 775
Grid-connected distributed	167	194	195	212	241	254	257	287	305	342	368
Grid-connected centralized	0	10	10	10	10	10	10	10	10	10	0*
TOTAL	**958**	**1 238**	**1 510**	**1 860**	**2 560**	**3 380**	**4 470**	**5 826**	**7 154**	**8 836**	**9 997**
Total off-grid	**791**	**1 034**	**1 305**	**1 638**	**2 309**	**3 116**	**4 203**	**5 529**	**6 839**	**8 484**	**9 629**

Note: *The single grid-connected centralized 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 2002.

2.3.1 Programme: On-Site Generation at Federal Facilities

The Canadian government developed a subsidy programme for national government buildings called the "On-Site Generation at Federal Facilities" programme. In this programme, eligible applicants include certain Canadian government departments, divisions or branches, or departmental corporation. The subsidy amounts to a refund of 25% on the cost of purchasing and installing a PV off-grid system, or up to 75% refund on the cost of purchasing and installing a grid-connected system to a maximum refund of CAD 80 000. The project criteria include high visibility, the potential for developing into a sustainable market, and the technical appropriateness. More details are available at http://cetc-varennes.nrcan.gc.ca/eng/on_site_gen.html.

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

The solar engineering company, ARISE Technologies (www.arisetech.com), is developing Canada's first demonstration of "community-scale photovoltaic systems in a Canadian neighbourhood" along with several commercial partners and a contribution from the Government of Canada of CAD 1 025 000.

ARISE will lead the team to design and install a total of 45 kW worth of grid-dependent PV systems on 10 to 15 new homes.

The project's aim is to accelerate the acceptance of PV in the market and to develop a framework for expanding the program to other parts of Canada. This project will also study the impact of solar-powered neighbourhoods on the electrical utility, financial institutions, and municipal planning and bylaws.

Photo: ARISE Technologies

Funding was provided by the Government of Canada's Technology Early Action Measures (TEAM) component of the Climate Change Action Fund, and by Natural Resources Canada (www.climatechange.gc.ca). The partners with ARISE and TEAM include Cook Homes, Genstar Development Corporation, Waterloo North Hydro, the Canadian Imperial Bank of Commerce, the University of Waterloo, and Natural Resources Canada's R-2000 energy efficient housing programme.

2.3.3 Demonstration: Alberta Government Centre, Edmonton, Alberta

The Alberta government's Environment department installed a 2.9 kW grid-dependent PV system on the roof of the power plant at the Alberta Legislature as part of the Alberta Government's plan for climate change called "Albertans and Climate Change: Taking Action". The cost of this system was CAD 38 500, funded by Alberta Environment. One purpose of this system was to participate in the government's action to "partner on the removal of administration and procedural barriers to distributed generation" in support of its core climate change objectives.

Photo: Alberta Environment

The system was designed and managed by SPS Energy Solutions and incorporated 24 AstroPower 120 W modules with a 2.5 kW Xantrex SunTie inverter. A case study was prepared for this system detailing the accomplishments, lessons learned, and barriers identified and resolved. Copies are available from Alberta Environment <sarah.waddington@gov.ab.ca>.

2.3.4 Demonstration: City of Airdrie Environmental Education Centre, Airdrie, Alberta

The City of Airdrie established its Environmental Education Centre as a single-stop location to demonstrate solar PV, solar water heating, solar air heating, solar daylighting, lighting efficiency, building envelope and water efficiency, indoor air quality, straw bale construction, and native landscaping. The centre's systems include a 2 kW grid-dependent solar PV system, 30-tube evacuated tube solar water heating system, Solarwall air heater, straw bale walls, and the new Aussie dual-flush toilet.

Photo: City of Airdrie

The PV system was supplied by Soltek Energy, and consists of 20 roof-mounted Siemens SR-100 PV modules connected to a grid-dependent Xantrex 2.5 kW inverter. Total PV system cost was CAD 22 000, or CAD 11/W, with funding from the Alberta Government's Municipal 2000 Sponsorship programme.

The PV system encountered grid-connection metering issues where it was being required to install interval kWh meters (costing some CAD 3000). In order to sell its excess electricity amounting to some CAD 70 per year, the City needed to join the Power Pool of Alberta at a cost of CAD 150 per year.

2.3.5 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 result of the collaboration between the University's Integrated Learning Centre, Faculty of Applied Sciences, ATS Automation Tooling Systems, Ontario Power Generation, Solar Design Associates, the PV and Hybrid Systems Program of Natural Resources Canada, the Climate Change Action Fund and Halsall and Associates Limited.

Photo: Queen's University

This installation consists of a PV sub-array above the windows on each of the 4th to 7th floors for the width of the building's south elevation and is expected to generate 20 MWh of electricity per year. It is a visible and attractive demonstration of Queen's commitment to new energy technologies and sustainability in support of its Integrated Learning Centre. The system is strictly an educational tool. The prime motivation for it 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 are quite typical of the first application of such systems and show clearly, why the demonstration of these systems is so important. The barriers include:

- Dealing with inexperienced utilities, installers and contractors;
- Dealing with people who are not aware of the technology's benefits and how to assess a value of them;
- The need for someone within the owner's organisation to be a champion to push through the barriers;
- The need for all stakeholders to feel an "ownership" of the project;
- The need to have a clear chain of responsibility, authority, and decision-making;
- Concerns of tenants regarding light levels, field of view, the looks of the back of modules, and that heat generated by the array would rise into nearby operable windows;
- Fear of high maintenance and associated costs, and
- Issues around accepting the risks of being on the leading edge of technology.

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 2002/problems and lessons learned	Funding	Project management	Remarks
On-Site Generation at Federal Facilities Available for applications from March 2002. Programme ends in March 2004.	• The programme refunds a portion of the cost of purchasing and installing a PV system. • 25% refund on a PV off-grid system. • 75% refund on a grid-connected system. • Maximum refund of CAD 80 000 per project.	• 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.	Identified close to 25 potential sites. No installations yet.	Government of Canada Action Plan 2000 for Climate Change	Natural Resources Canada, CETC-Varennes, PV & Hybrid Systems programme	
Canada's First PV Neighbourhood Project started April 2002.	• 10 to 15 new homes • Total of 45 kW of PV capacity • Grid-connected • Building integrated • Roof mounted • Programme cost: CAD 1 025 000	• To accelerate the acceptance of PV in the marketplace. • To develop a framework for expanding the program to other parts of Canada. • To study the impact of solar-powered neighbourhoods on the electrical utility, financial institutions, and municipal planning and bylaws.	First house on line, April 2003. Too early in the programme to have public reports available. Barriers noted include: • Affordability of solar PV • Availability of financing mechanisms • Utility electricity that is inexpensive and reliable • Technical concerns • Utility concerns • Consumer awareness and understanding	• 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 2002/problems and lessons learned	Funding	Project management	Remarks
Alberta Government Centre Project started in March 2002.	• Grid-connected • Roof mounted • 2.9 kW • 24 AstroPower AP-120 single crystal modules • Xantrex 2.5 kW SunTie inverter • Cost: CAD 38 500	• To participate in the government's action to "partner on the removal of administration and procedural barriers to distributed generation".	System start-up in February 2003. • Several regulatory and code issues were identified relating to utility acceptance of grid-connected inverters, and inspector acceptance of approved switchgear. • Other industry-related issues regarding equipment specification and lines of responsibility are being resolved.	Alberta Environment as part of the Alberta Government's plan for climate change called "Albertans and Climate Change: Taking Action"	SPS Energy Solutions	
Airdrie Environmental Education Centre Start-up, June 2002.	• Grid-connected • Roof mounted • 2 kW • 20 Siemens SR-100 single-crystal modules • Xantrex 2.5 kW SunTie inverter	• To demonstrate environmental responsibility and sustainable technologies at the centre. • To be a model of sustainable and environmental culture.	• Changes to interconnection regulations need to be better communicated to the regulatory stakeholders so that they do not hold up the interconnection approvals process. • Some inspectors approve a system without it meeting the letter of the electrical code, as long as the inspector is satisfied that it is safe.	Government of Alberta Municipal 2000 Sponsorship programme	Soltek Energy	

Project, Date of plant start up	Technical data, Economic data	Objectives	Main accomplishments until the end of 2002/problems and lessons learned	Funding	Project management	Remarks
Queen's University BIPV façade Project started in 2001.	• Grid-connected • Building integrated • Mounted as window sunshades on an existing building • 19.8 kW • 264 Photowatt PW-750 modules • Xantrex 20 kW PV-20208 3ϕ inverter • Total project costs CAD: 550 000	• Very visible demonstration of Queen's University's commitment to sustainability • Educational tool to expose engineering students to the technology so that they will take it out into industry and apply it.	System start-up in July 2003. Barriers encountered include: • 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 clarity regarding responsibility, authority, and decision-making. • Concerns of tenants regarding 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.	• Natural Resources Canada • Government of Canada's Technology Early Action Measures (TEAM) component of the Climate Change Action Fund • Queen's University	Halsall and Associates Limited	

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-Varennes. Current 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;
- Supporting the development and adoption of performance and safety standards.

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

Total public budgets in Canada showed a large increase of CAD 6.35M (212%) in 2002 due to support provided by Industry Canada to various R&D projects with the industry.

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

2002 TOTAL		R & D	Demo/ Field test	Market Incentives
National	**($8 600k)**	$8000k	$300k	$300k
Provincial	**($750k)**	$200k	$300k	$250k
Total	**($9 350k)**	$8200k	$600k	$550k

3 Industry and growth

The Canadian PV industry has grown steadily serving both its internal off-grid market and the export market (which represented 13% of the internal market). The largest export market is in off-grid non-domestic systems. Although domestic sales suffered a 30% drop from the previous year, export sales experienced a modest 8% increase.

There are approximately 150 organisations actively 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.

Most of the 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, AstroPower, 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 photovoltaic cells and modules

ICP Global Technologies, a leading supplier of consumer products in North America, has expanded its operations to manufacture a new line of PV panels. It now employs approximately 75 people dedicated to its solar product line and won a design and engineering award for its *iSun Power Charger* at the Consumer Electronics Show.

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
TOTALS		--	N/A	--	2 MW

The newly created subsidiary of ATS Automation Tooling Systems, Spheral Solar Power, will employ about 175 people at a new manufacturing plant near its head office in Cambridge, Ontario. Spheral Solar technology is a low-cost flexible PV product that can readily be adapted to a wide range of applications. Industry Canada's Technology Partnership Canada and Canada's Climate Change TEAM programs are partners in this project. 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.

The most popular foreign module suppliers included BP Solar, Kyocera Solar, Unisolar, Shell, AstroPower, and SunWize Technologies. Top Canadian suppliers included SPS Energy and Generation PV.

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

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Module price – Current								11.09	10.70	9.41	7.14
– Constant											

Canadian module prices dropped an average of CAD 2.27 per Watt, or 24% in 2002, down to CAD 7.14 per Watt from CAD 9.41 in 2001. This represents an average annual decrease of 14% since 1999.

3.2 Manufacturers and suppliers of other components

Balance of Systems products manufacture continued to grow in 2002, and new products emerged from several companies.

Xantrex Technology, based in Vancouver, British Columbia, Canada, the world's leading supplier of advanced power electronics, 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, is a pro-active way to assist customer to move forward with a purchase using a regular payment plan.

Carmanah Technologies based in Victoria, British Columbia is expanding its manufacturing efforts with a range of specialized products. This manufacturer of solar-powered LED lights estimates that it has now installed 50 000 units around the world since it expanded its business to serve the transportation sector. Carmanah is collaborating with the City of Victoria to demonstrate a new bus transit stop, the I-STOP™, which includes backlit schedule information, a safety light and a flashing beacon that alerts the bus driver when a customer is waiting at the stop.

The total commercial activity from Canadian PV companies was estimated to be CAD 95 million in 2002 up from CAD 45 million in 2001. 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 111% growth is mainly due to manufacturing revenues reported by fourteen manufacturers that increased by 586%. This significant increase is directly related to the increase in labour place equivalents in the sector as well as to overall increases in manufacturing capacity.

Table 5. PV industry revenue in CAD, 1992-2002

PV industry revenue	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Millions CAD	18	17	17	25	28	33	38	40	42	45	95

3.3 System prices

(None to report)

3.4 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, *etc*. For the 535 jobs reported, 335 jobs are for manufacturing, 40 are in R&D and the others in sales, installation and consulting.

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

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

Canada is developing a National Implementation Strategy in order to reduce its greenhouse gas emission by 6% from 1990 level. In 2000, the National government committed an additional CAD 500 million to accelerate progress towards the reduction of greenhouse gas emissions. There has also been a commitment to provide investments in technologies that will have impacts in the post 2010 period. Within this framework, several climate change measures have been initiated that should benefit the PV industry and other stakeholders:

- *Technology Early Action Measure Program* – This is a cost-shared program for the development of innovative technologies and their demonstration in the market place. Several PV technology proposals were approved under this program;
- *MicroPower-Connect Initiative* – This initiative aims to develop and harmonize the requirements for the interconnection of emerging technologies, such as PV, wind, fuel cells, and microturbines;

- *On-site Generation at Government Facilities* – As part of its climate change action plan, the government of Canada will support the installation of approximately 15 PV systems over the next year. Preference will be given to high visibility projects that demonstrate the application of building-integrated PV products;
- *Climate Change Technology and Innovation Program* – As part of this measure, the National Science and Engineering Research Council will manage a research fund for novel next-generation energy technologies related to greenhouse gas mitigation. This program targets early-stage and exploratory research in Canadian Universities and will enhance the knowledge base for longer-term solutions to climate change;
- *Federation of Canadian Municipality (FCM) Green Fund* – The National government provides funding to the FCM to initiate green energy projects. By partnering with a local community champion, PV companies have an opportunity to propose PV deployment projects.

The restructuring of the electricity market in Canada is increasing the interest in providing customers a power choice. The regulations for electricity in Canada are under provincial jurisdiction. Alberta was the first province to deregulate the electricity industry and electricity has been traded on the Power Pool of Alberta since January 1996. In May 2002, the Province of Ontario also deregulated their electricity industry sector. Several major utility companies now offer green power as a premium to their customers, including as Enmax (mainly wind power) and EPCOR (biomass, wind, and micro-hydro) in Alberta, and Ontario Power Generation with its Evergreen Energy division.

SaskPower in Saskatchewan is the only provincial electricity company that has an incentive program that targets farmers who wish to purchase small PV or wind powered water-pumping systems.

4.2 Indirect policy issues

There is no provincial legislation mandating net-metering options be offered to customers in Canada. Manitoba Hydro is the only electric utility to offer net metering to its customers, and it has allowed net metering since 1989. Other electricity distribution companies quietly permit net metering or net billing on a limited basis. It is not permitted in Alberta under the re-regulation of the electrical utility industry.

4.3 Standards and codes

A committee has completed a review of the Canadian Electrical Code and recommended changes to facilitate the interconnection of micro-power generation systems. The MicroPower Connect committee (described at www.micropower-connect.org) has completed the preparation of a national guideline for the interconnection of small, distributed power sources.

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 safety standard IEC 62109 is also in development.

Canada has updated the PV installation requirements in the Canadian Electrical Code in 2002 (Section 50). The IEC 61215 standard is now the national PV module performance standard. Canada has adopted the ULC-1703 module safety standard as an interim measure until an IEC standard is available.

5 The Future

Several Canadian PV companies have invested significantly in both the development and promotion of solar PV power systems in Canada. Though this is not indicated in the market growth this year, it is however reflected by the very strong growth in the labour places as well as the significant private-sector investment in manufacturing.

PV power systems have demonstrated that they are a reliable source of electrical energy. The public perception of this technology is not well informed though it is favourable. Increased knowledge of this energy choice is required to maintain the growth of the domestic market. Both the Canadian Solar Industries Association and Énergie Solaire Québec have continued their promotional and marketing activities in Canada.

More significant effort will be required to encourage the development of the grid-connected market sector. CANMET Energy Technology Centre-Varennes completed a study examining the benefits of on-site generation using photovoltaic technologies on buildings in Canada. Several new activities have been initiated as part of an action plan that aims to build on Canadian 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 38 major PV industry players or 90% of the total PV market was conducted for the 2002 calendar year. 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 installation 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 centralized.
- PV-hybrid systems installed in Canada.
- Total revenues from manufacturers of modules, inverters, storage batteries, controllers and equipment for PV systems.
- General trends in the industry relating to applications in high demand and factors that affected the market during 2002.

The estimated PV module capacity installed in Canada in 2002 is estimated to be 1 171 kW (±10%). An additional 176 kW (±15%) were exported.