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 2005

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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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), 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 Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org.

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 PVPS member and other countries and is largely based on the information provided in the National Survey Reports that are produced annually by each Task 1 participant. The IEA PVPS public website also plays an important role in disseminating information arising from the programme, including national information.

This National Survey Report represents an overview of the key developments and achievements in the Canadian PV sector during 2005 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 the National Survey Reports, 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/m^2, cell junction temperature of 25^{o}C, AM 1,5 solar spectrum – (also see 'Rated power').

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

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of 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: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural 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: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

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 systems 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.

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

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

Please also refer to the internal PVPS report *Writing numerical values, quantities, units and symbols according to International Standards* for guidance.

1 EXECUTIVE SUMMARY

In 2005 jobs grew by 27% to 975 positions with total revenues estimated at CAD 150 million.The weighted average price of PV modules dropped to CAD 4.31 per Watt in 2005 with steady average annual decline of 14% per year since 1999. There has been a 21% decrease in the total public (combined federal and provincial) R&D and demonstration budget, from the previous year's totals, which reached CAD 7.7 million in 2005. This funding focussed on technology and innovation with a 2025 horizon. The Net-Zero Energy Home (NZEH) Coalition, a partnership between the solar industry, home developers and builders, geothermal and solar energy industry associations, local utilities and university research centres was launched in the spring of 2004 with the goal of having all new home construction in Canada by 2030 meet a net-zero electricity standard[1]. The Coalition has proposed a 1500 NZEH early-adopters programme as a first step forward to achieving their goal. As a first stage, the proposal called for the demonstration of 12-15 houses across six regions in Canada. The first stage of the proposal was favourably received by the Government of Canada's Canadian Mortgage and Housing Corporation (CMHC) in 2005. In the Fall of 2005, CMHC expressed their intent to fund a Net Zero Energy Healthy Housing (NZEHH) initiative, which combines passive solar, energy efficient design, construction and appliances, integrated with commercially available renewable energy systems to achieve net zero energy consumption on an annual basis[2].

▪ Installed PV power

Canada's total PV power installed capacity increased by 39% in 2005 to 16.75 MW compared to 14 MW at the end of 2004. The 2005 domestic PV module sales volume totalled 2.862 MW compared to 2.054 MW in 2004 – an increase of 39% in the one-year period. The 2005 export PV module sales totalled 1.773 MW compared to 81kW in 2004 – a twenty-two fold increase from the previous year. Total PV sales in Canada (domestic and export) were at 4.635 MW. The growth of the PV market in Canada has been averaging 32% annually since 1993. In 2005, the largest module sales domestically occurred in the off-grid market (both residential and non-residential) with 79% of market share. The remaining 21% attributed to sales in the on-grid distributed market – a very significant increase from the year's level.

▪ Costs & prices

Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 4.31 in 2005. This represents an average annual price reduction of 14% over the 6-year period.

▪ PV production

There was a 27% increase in manufacturing employment in Canada in 2005 (equipment, PV and balance of system products). The largest manufacturers are Xantrex, Carmanah, Spheral Solar Power and ICP Global. The only module manufacturer in 2005 remains ICP Global with module production capacity of about 2 MW. Spheral Solar Power Inc's 20 MW maximum potential production manufacturing plant opened in June 2004 continues to resolve challenges to actual production.

▪ Public budget for PV

Total public budgets in Canada decreased by 21% to CAD 7.7M in 2005. A significant portion of this decrease is attributed to lower investments in the PV industry as there had been a significant number of projects that were funded between 2002-2004 made possible by Canada's Climate Change Technology and Innovation R&D and demonstration programmes. These programmes have been benefiting the PV sector since 2000 with the first Technology Early Action Measures-

[1] NZEH Coalition: http://www.associations.cc/nzeh/index.htm.
[2] Canadian Mortgage and Housing Corporation: http://www.cmhc-schl.gc.ca/en/inpr/su/neze/neze_001.cfm

funded project to Spheral Solar Power Inc.'s parent company ATS Automation Tooling Systems Inc. There has been no public funding made available for market incentives and deployment programmes.

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 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 (93%) 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 off-grid market represented 57% of PV sales in 2005 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 22% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. Most of the PV-hybrid systems installed in 2005 were used in off-grid non-residential applications, with sizes ranging from 385 W to 1700 W, mainly PV with a small wind turbine or PV with an engine generator, and mostly located in Western Canada in the provinces of 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. Nonetheless, on-grid distributed sales in this market accounted for 21% of total sales in Canada in 2005. The first edition of a national interconnection standard for inverter-based distributed generation systems was completed in 2005[3]. 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 2005 including a new 33.5 kW PV building-integrated federal building in Yellowknife, Northwest Territories. Also, the Canadian government's "On-Site Generation at Federal Facilities" initiative ended in 2005. There were 12 grid-connected PV systems on federal buildings for a total of 91 kilowatts.

2.2 Total photovoltaic power installed

A sustainable Canadian PV market in off-grid applications has developed over the last 14 years. This market continued to show the strong annual growth that has averaged 24% for each the last 12 years. The installed off-grid power capacity was 15.62 MW in 2005. 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 2005, the modules sales in Canada (excluding subsequent exports) grew by 39% over the previous year. The market is showing significant volatility (both positive and negative) as a result

[3] CANMET Energy Technology Centre-Varennes: http://cetc-varennes.nrcan.gc.ca/en/er_re/pvb/p_p.html?2006-073

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 and the supply/demand dynamics of PV modules because of silicon supply shortages.

In 2005, the on-grid distributed market reported total sales (domestic and exported) of 43% compared to 40% for the off-grid non-residential market, and 16.5% in the off-grid residential market. Whereas about 70% of the on-grid sales were exported to other countries, notably the California market in the United States, 88% of the off-grid sales were sold to customers in Canada.

Table 1. The cumulative installed PV power in 4 sub-markets in Canada in 2005
(As of December 31 of each year)

Sub-market / application	1992 kW	1993 kW	1994 kW	1995 kW	1996 kW	1997 kW	1998 kW	1999 kW	2000 kW	2001 kW	2002 kW	2003 kW	2004 kW	2005 kW
Off-grid domestic	105	189	312	445	611	853	1 378	2 154	2 536	3 322	3 854	4 539	5291	5 903
Off-grid non-domestic	686	845	993	1 193	1 698	2 263	2 825	3 375	4 303	5 162	5 775	6 886	8081	9 719
Grid-Connected distributed	167	194	195	212	241	254	257	287	305	342	368	405	476	1 059
Grid-Connected centralized	0	10	10	10	10	10	10	10	10	10	0*	0	36	65
TOTAL	**958**	**1 238**	**1 510**	**1 860**	**2 560**	**3 380**	**4 470**	**5 826**	**7 154**	**8 836**	**9 997**	**11 830**	**13 884**	**16 746**
Total off-grid	**791**	**1 034**	**1 305**	**1 638**	**2 309**	**3 116**	**4 203**	**5 529**	**6 839**	**8 484**	**9 629**	**11 425**	**13 372**	**15 622**
Cumulative Annual trends	**-**	**29%**	**22%**	**23%**	**38%**	**32%**	**32%**	**30%**	**23%**	**24%**	**13%**	**18%**	**17%**	**21%**

* Decommissioned. \

Table 1a. Trends in Annual Installed PV capacity in Canada (kW as of year end)

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
na	280	272	350	700	820	1090	1356	1328	1682	1161	1671	2054	2862
-	-	-3%	29%	100%	17%	33%	24%	-2%	27%	-31%	44%	23%	39%

2.3 Major projects, demonstrations and field test programs

The following are highlights of some of the major projects, demonstrations and field test programmes undertaken in Canada in 2005.

The most advanced building-integrated photovoltaic installation 'North of 60' in Canada

© Photo: Visionwall.

In partnership with industry, the Government of Canada in 2005 unveiled a new federal building in Yellowknife, Northwest Territories, as an environmental showpiece for the North. The new 7,200 m^2 four-storey building – the *Greenstone Building* - will house about 200 public service employees from approximately 15 different federal departments, and is scheduled to become the first 'North of 60' Leadership in Energy and Environmental Design (LEED®) Silver-certified project. The LEED® standard, originally developed in the United States and recently adopted in Canada, provides an effective and consistent framework for gauging sustainable building design. The building not only incorporates innovative energy conservation measures but actually generates some of its own power - enough electricity to meet five percent of the buildings electrical needs. In this installation 33.5 kilowatts of PV are incorporated into a high performance south-facing curtain wall developed by Canadian-based Visionwall Corporation. Visionwall® PV curtain wall technology integrates PV laminated glass and an interior circuit wiring system into modular frames of energy-efficient glazing systems. This technology has overcome challenges, including high temperatures of the PV modules and access to wiring for maintenance. The electricity produced by the 33.5 kW PV curtain wall will be sold to the local electric utility, Northland Utilities, resulting in notable GHG reductions in an area heavily reliant on fossil fuels (diesel).

Low emissions multi-energy source PV/GENSET hybrid platform for remote area power supply

© Photo: Xantrex.

The Government of Canada through a TEAM-funded technology demonstration project assisted the Canadian industry to develop and grow the Canadian market for emerging innovative photovoltaic energy technology. The project led to the development of an advanced control system and platform that can enable photovoltaic, wind, fuel cells and alternative power systems to be optimally integrated into conventional fossil fuel-based power generating systems ("hybrid systems") for remote and off-grid power applications. The project is undertaken by Xantrex Technologies Inc., a world leading manufacturer of innovative power electronic product interfaces and is based in

Burnaby, British Columbia. Six field trials of the hybrid system (which combines a PV array, an engine generator, battery energy storage and power electronic controls) rated at 5 kW are presently underway and are being monitored for performance and refinement.

Canada's "*Northern Light*" solar powered house shines at the Solar Decathlon competition

© Photo: CETC-Varennes.

The Government of Canada in collaboration with private sector partners in the building and solar industry sponsored a Canadian entry into the second Solar Decathlon competition. The Canadian team composed of engineering students from Concordia University and architectural design students from l'Université de Montréal, entered the competition with their *Northern Light* solar house, and were handsomely rewarded for their 2-years of hard work on this project. Their house was judged by an expert panel from the National Association of Home Builders of America as the most energy-efficient house of all the entries. Also, BP Solar awarded the *Northern Light* house with the BP Solar Award for best roof integration of photovoltaic technology. The house is now located on the Loyola Campus of Concordia University, to be used by the engineering school to further R&D advancements into solar optimized homes. Through research and education projects such as the Decathlon Solar House the Government of Canada is partnering with other levels of government, industry and academia, to demonstrate its commitment to building energy-efficient, healthy and sustainable communities.

Federal facilities promoting on-site power generation using solar technology

The Government of Canada's On-Site Generation at Federal Facilities initiative was completed on March 31, 2005. The goal of the initiative was to encourage the use of on-site generation in federal facilities using emerging renewable energy systems such as photovoltaic, wind and small hydro by providing rebates on the cost of purchasing and installing a qualified system for both off-grid and grid-connected applications. There were 17 installations implemented at the end of the project in collaboration with nine federal departments and agencies. Of the 13 PV systems installed at various federal facilities, the following projects were implanted in 2005.

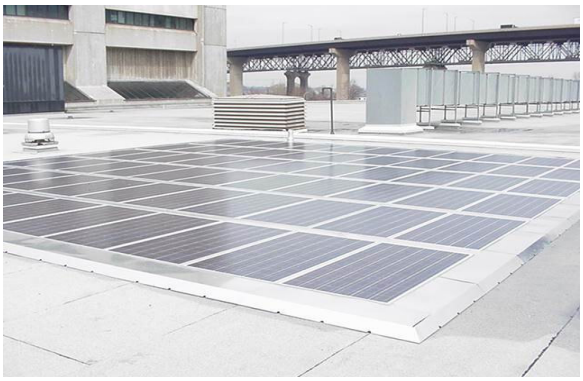
The installation of a grid-connected PV power generating system at the Herzberg Institute of Astrophysics in Victoria, British Columbia

© Photo: Carmanah.

The National Research Council (NRC) is the Government of Canada's premier organization for research and development. NRC divisions are located in every province in Canada and play a major role in stimulating community-based innovation. The NRC Herzberg Institute of Astrophysics provides first-class research facilities in observational astronomy to the national research community. The Institute installed a 7.2 kilowatt grid-connected PV power system on the roof of one of its buildings utilizing an innovative non-penetrating

anchoring system. The energy generated by the PV system will go towards meeting the electric loads in the building. The facility has been modified for energy efficiency. Total project cost was CAD80 000 of which 70% was reimbursed by the On-Site Generation at Federal facilities initiative.

The installation of a grid-connected PV system at the Canada Centre for Inland Waters in Burlington, Ontario



© Photo: Arise.

One of the world's leading water-research complexes, the Canada Centre for Inland Waters (CCIW) is owned and managed by the federal Department of Environment Canada (EC). It provides EC as well as the federal Department of Fisheries and Oceans with shared facilities for environmental research and development, as well as monitoring, resource management and navigational charting. CCIW occupies a large waterfront site in Burlington, Ontario, just inside Hamilton Harbour. CCIW houses the headquarters of Environment Canada's National Water Research Institute - including the National Laboratory for Environmental Testing and the program office for the United Nations' Global Environment Monitoring System (GEMS/Water) - a multi-faceted water science programme oriented towards understanding freshwater quality issues throughout the world. Scientists at CCIW play a critical role in providing the knowledge necessary for the management of the Great Lakes and other aquatic ecosystems. CCIW installed a 10 kilowatt grid-connected PV system on the roof of one of facilities to provide electricity to normal loads in the building. Total project cost was CAD130 000 of which 45% was reimbursed by the On-Site Generation at Federal Facilities initiative.

The installation of a grid-connected PV power generating system on the health centres of First Nations communities served by Health Canada in the Southern Ontario Zone

Health Canada (HC) is the federal department responsible for helping the people of Canada maintain and improve their health. In partnership with provincial and territorial governments, Health Canada provides national leadership to develop health policy, enforce health regulations, promote disease prevention and enhance healthy living for all Canadians. Health Canada also ensures that health services are available and accessible to First Nations and Inuit communities in order to assist them to attain a level of health comparable to that of other Canadians living in similar locations. HC installed a 5 kilowatt grid-connected PV system on the grounds of the health centre at the First Nations community of the Mohawks of the Bay of Quinte, in the Southern Ontario Zone. This was a demonstration project for HC to learn more about PV for potential replication in other First Nations community health centres. Total project cost was CAD55 000 of which 65% was reimbursed by the On-Site Generation at Federal Facilities initiative.

The installation of a grid-connected PV system at the Institute of Ocean Sciences in Sidney, British Columbia

© Photo: Carmanah.

Fisheries and Oceans Canada (DFO) is the lead federal government department responsible for developing and implementing policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters. The Institute of Ocean Sciences (IOS) is one of a network of nine major scientific facilities across Canada operated by DFO Canada. Located in Sidney, approximately 30 km from Victoria, the Institute is home to scientists, technicians, support staff and ships' crews whose common interests are the coastal waters of British Columbia, the Northeast Pacific Ocean, the Western Arctic and navigable waters east to the Manitoba, Saskatchewan border. The DFO installed a 7-kilowatt grid-connected PV power generating system on the roof of one of its buildings on the main road facing due south. The building itself is on a slope so that the roof is almost level with the parking lot at the facilities. The public has access to an on-site library that provides resources to support the research activities of the IOS. The IOS receives on average 4000 visitors per annum. Total project cost was CAD80 000 of which 70% was reimbursed by the On-Site Generation at Federal Facilities initiative.

The installation of a grid-connected PV power generating system at the ECO-ED Building in the St. Lawrence Islands National Park, Mallorytown, Ontario.

© Photo: Parks Canada.

Parks Canada (PC) is the federal agency responsible for protecting and presenting nationally significant examples of Canada's natural and cultural heritage and fostering public understanding, appreciation and enjoyment in ways that ensure their ecological and commemorative integrity for present and future generations. The St. Lawrence Islands National Park is Canada's smallest National Park, with a size of 4 square kilometres. It was established in 1904 as the first Canadian National Park east of the Rocky Mountains. Located among the Thousand Islands at the head of the St. Lawrence River, it began with a small piece of waterfront property granted to the Federal Government by the Mallory family with the stipulation that it be used for "park purposes". Nine federally owned islands in the St. Lawrence River were added, and recreational facilities were installed. Today, the Park comprises all or parts of 21 islands and about 90 islets scattered between the cities of Kingston and Brockville, Ontario and a 38-hectare (94 acres) mainland base at Mallorytown Landing. PC installed a 5.6 kilowatt grid-connected PV system mounted on the roof of the ECO-ED Building in Mallorytown as part of the retrofit activities of the building. The primary aim of this installation is to provide actual demonstration of renewable energy use for educational purposes of the many thousands of visitors annually to the park. Total project cost was CAD85 000 of which 38% was reimbursed by the On-Site Generation at Federal Facilities initiative.

2.4 Highlights of R&D

The Canadian PV R&D Programme contributes to research projects in remote regions, undertakes technology development and demonstration projects and participates in the formulation of standards and codes. It also supports the evaluation of the performance of PV systems in new applications and their adaptation for use in cold climate conditions. On-going R&D projects undertaken by the PV Programme include:

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

There has been growing interest in fundamental solar cell R&D at Canadian universities over the past several years. In 2005, a federally-funded study[4] provided an overview of fundamental solar cell R&D capability in Canada as a first step in identifying relevant solar cell research undertaken in the private sector and universities, and the potential of this work in strengthening the global competitiveness of Canadian companies involved in the production of PV technologies in Canada.

The Government of Canada, through the National Science and Engineering Research Council (NSERC) is investing CAD 5M over a 5-year period to create a Solar Buildings Network[5] – a research consortium with the aim of advancing multi-disciplinary collaboration to innovate solar energy production and efficiency of its use in commercial, institutional and residential buildings in Canada. The federal research centres at NRCan and CMHC, industry and 10 Canadian Universities are participating in the Network to facilitate collaborative research in four subject theme areas: the integration of solar energy systems into buildings; solar thermal systems for heating and cooling; solar electricity generation in buildings; and simulation tools for solar building design. This collaborative R&D effort will provide in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions. It will help to support innovation in the residential construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

2.5 Public budgets for market stimulation, demonstration/field test programmes and market incentives

Total public budgets in Canada showed a decrease of CAD 2.1M (21%) in 2005. This is due to large multi-year projects that were completed in 2004.There are no public subsidies or market incentives for PV at any level of government.

[4] CANMET Energy Technology Centre-Varennes: http://cetc-varennes.nrcan.gc.ca/en/er_re/pvb/p_p.html?2005-077
[5] Solar Buildings Research Network: http://www.solarbuildings.ca/

Table 2. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2005 (CAD x 1000)

	R & D	Demo/ Field test	Market Incentives	Total
Federal	6 700	600	0	**7 300**
Provincial	100	200	100	**400**
Total	**6 800**	**800**	**100**	**7 700**

Table 2a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2005 (CAD x 1000)

Year	1999	2000	2001	2002	2003	2004	2005
Total combined (Federal, provincial)	890	1500	1950	5955	8540	9800	7700
Annual trends	-	68%	30%	205%	43%	15%	- 21%

3 *INDUSTRY AND GROWTH*

The Canadian PV industry continues to grow steadily serving both its internal off-grid market and the export market (which was 38% less than internal market in 2005). The largest export market for the fist time, was the on-grid distributed systems. While domestic sales were up 39% from the previous year, export sales also increased twenty two fold over the previous year's level.

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. The PV hybrid systems[6] and total related sales in Canada increased significantly in 2005 compared to last year (about 142 systems compared to 50 systems sold in 2004) with total generating power of 108 kW mainly for the off-grid residential applications.

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, ingots and wafers

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

[6] PV with other fuel types: wind, gasoline, diesel propane, various fuels.

Table 3: Production and production capacity information for 2005 for silicon feedstock, ingot and wafer producers

Producers	Process & technology	Total production (tonnes or MW)	Maximum production capacity (t/yr or MW/yr)	Product destination	Price (CAD)
Spheral Solar Power Inc.	Silicon spheral solar technology	The company continues to move forward aggressively on numerous fronts to achieve the 20 MW maximum production capacity.			

3.2 Production of photovoltaic cells and modules

ICP Solar Technologies Inc.[7] is a leading manufacturer of solar-powered products that respond to the needs of consumer, commercial and OEM clients. Founded in 1988, ICP is a privately-owned company headquartered in Montreal, Canada with additional operations (distribution networks and manufacturing) in Asia and Europe.

Table 4: Production and production capacity information for 2005

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)			Maximum Production Capacity (MW)		
		Cell	Module	Concen.	Cell	Module	Concen.
ICP Global Inc.	sc-Si and mc-Si, cells purchased internationally	-	0.5	-	-	2	-
Spheral Solar Power Inc	Silicon spheral solar technology	NA			**-**	**20**	
TOTALS			**0.5**	**-**		**22**	**-**

Part of ATS Automation Tooling System's Solar Group, Spheral Solar™ Power[8] is in business to develop, manufacture and market the Company's next generation solar photovoltaic technology referred to as Spheral Solar™ Technology (SST). SST is a proprietary technology with many advantages including the fact that it uses less silicon and because of its durability, flexibility and ability to seamlessly integrate into other structures, SST is expected to unlock vast new commercial and residential construction markets for solar and have multiple applications in both on and off grid installations. Spheral Solar™ Power employs about 150 people at its new 20 MW manufacturing plant near Cambridge, Ontario, Canada's first vertically-integrated solar PV manufacturing facility.

Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 4.31 in 2005. This represents an average annual price reduction of 14% over the 6-year period.

[7] ICP Solar Technologies Inc.: http://www.icpsolar.com/
[8] Spheral Solar Power Inc.: http://www.spheralsolar.com/
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Table 4a. Module prices (CAD/W) for 1999-2005

Year	1999	2000	2001	2002	2003	2004	2005
Weighted Average prices	11.09	10.70	9.41	7.14	6.18	5.53	4.31
Trend in Price reduction	-	3.5%	12%	24%	13%	10%	22%

3.3 Manufacturers and suppliers of other components

Balance of Systems products manufacture continued to grow in 2005, 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 2005 Xantrex introduced three new solar grid tie inverters at the Solar Power 2005 Expo event in Washington, DC. Xantrex expanded its line of solar grid tie inverters for the North American residential and commercial markets with the launch of the Xantrex GT 2.5, GT 3.3 and GT 3.3 (208 volt) Solar Grid Tie Inverters. The new 3.3 kilowatt and 2.5 kilowatt technology is based on the 3 kilowatt Xantrex GT 3.0 Solar Grid Tie Inverter platform, which was launched in North America late 2004. Xantrex also introduced a new line of inverters designed for tow-able recreational vehicles. The new Xantrex PRO Series Inverters were created specifically for use on travel trailers, fifth-wheel trailers and sport utility trailers.

Formed in 1999, Sustainable Energy Technologies Ltd.[9], based in Calgary, Alberta, develops, manufactures and markets advanced power electronics products for the emerging alternative and renewable energy markets. In 2005 the Company commenced production of the SUNERGY 5 inverter for the solar PV market. Also, in 2005 the Company entered into partnership with Gabriel Benmayor SA of Spain to manufacture the solar inverters in Barcelona for the PV market in Spain.

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. In 2005 Carmanah announced that the Company has achieved Tier 1 status on the Toronto Stock Exchange Venture Exchange. This reclassification recognizes the management experience and current financial strength of the Company. This increased status should ease Exchange procedures, and facilitate transaction approvals and reporting requirements, as well as allow more flexibility with respect to future financings. Carmanah reported annual growth rate of approximately 70% over recent years while retaining healthy average gross margins and record profitability.

ICP Solar Technologies Inc., headquartered in Montreal, Quebec, continues to innovate solar products for the consumer, commercial and OEM markets. In 2005, ICP introduced its Sunsei™ line of solar products (Sunsei™ Solar, Sunsei™ Construct, and Sunsei™ Industrial). These brands feature solar panels and accessories for maintenance and charging applications in RVs, boats, trucks, cars, ATVs, motorcycles and other vehicles, as well as reliable backup power and innovative construction materials for homes, cottages, farms and much more.

[9] Sustainable Energy Technologies Ltd.: http://www.sustainableenergy.com/SET-home/index.html

3.4 System prices

The industry reported system prices for the two submarkets, namely off-grid residential and on-grid distributed. The data gathered from the survey has been used to provide an approximation of prices reported have System prices vary widely because 93% of Canada's PV market is off-grid, and so embraces a wide range of PV system sizes, complexities, and system configurations.

Table 5: Turnkey prices (CAD) of typical applications in 2005

Category/Size	Typical applications in Canada	Current prices (CAD/W)
Off-Grid (≤ 1 kW)	Mainly remote cottage power supply	15
Off-Grid (>1 kW)		na
Grid-Connected Specific case	5 x 3.2 residential integrated rooftop PV systems (Unisolar PVL)	12.50[1]
Grid-Connected (≤ 10 kW)	Commercial, institutional roof-mounted	10
Grid-Connected (>10 kW)	Not typical (Saint-Gobain glass on glass BIPV) – a Federal building in Yellowknife, NWT (33.5 kW)	12.60 [2]

1. ARISE-TEAM funded project in 2005, 5 PV systems of 3.2 kW each at a cost of 40,000CAD/system)
2. RETScreen analysis of GOC Greenstone Green building in Yellowknife – a TEAM-funded project.

Table 5a: National trends in turnkey prices (CAD) of typical applications from 1999-2005

CAD/W	1999	2000	2001	2002	2003	2004	2005
Off-Grid (≤ 1 kW)	17	17	20	18	21	18.5	15
Off-Grid (>1 kW)							
Grid-Connected Specific case						13.50	12.50
Grid-Connected (≤ 10 kW)	21	20	Insufficient data	Insufficient data	Insufficient data	14.50	10
Grid-Connected (>10 kW)							12.60

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by 27% in 2005 to 975 jobs. These positions include those in manufacturing, sales and installation, R&D, and other positions in the PV-value chain including company R&D.

Labour places (source: Canada's National PV Market Survey)

Year	2005
R&D (public) [1]	25
Manufacturing [2]	627
Other[3]	323
Total	**975**

Notes:
1- Includes R&D network in public research centres and universities.
2- Labour positions throughout the PV value chain including company R&D.
3- Distributors of PV products, system and installation companies, utilities and government (not involved in R&D) and PV private consultants.

Trends in total PV labour places in Canada for 1996-2005

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total labour	169	201	220	250	260	275	535	615	765	975
Annual growth	-	19%	10%	14%	4%	6%	94%	15%	24%	27%

3.6 Business value

The total commercial activity from Canadian PV companies was estimated to be CAD 150M in 2005 up from CAD 125M in 2004. 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 20% growth is mainly due to manufacturing revenues reported by eleven manufacturers that increased by 25% to CAD 105M of which about CAD 80M were revenues obtained from export activities. This increase is reflected in increases in manufacturing labour places as well as overall increases in manufacturing capacity.

Table 6: Trends in PV business in Canada from 1992-2005

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Million CAD	18	17	17	25	28	33	38	40	42	45	95	100	125	150
Annual growth	-	-6%	0	47%	12%	18%	14%	5%	5%	7%	111%	5%	25%	20%

4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

4.1 New initiatives

In 2005 the Government of Canada released a new national climate change plan entitled, "Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment." The plan combines regulatory, negotiated, and incentive-based approaches. It anticipates mandatory emission intensity caps for major GHG-producing sectors but also relies heavily on government-funded purchases of emission reductions, both domestically and through the Kyoto Protocol's market-based mechanisms. The Plan is the first phase of *Project Green* – a national project to create a healthier environment and a stronger economy by combining the efforts of governments, non-governmental organizations, businesses and all Canadians to build a more sustainable future[10]. It is estimated that the approaches outlined in the Plan, with an associated federal investment in the range of 10 billion CAD, could reduce GHG emissions by about 270 megatonnes annually in the 2008-2012 period.

Also in 2005, the Government of Canada, through Canada Mortgage and Housing Corporation, launched the first phase of a Canadian Net Zero Healthy Housing Initiative[11], a government/industry partnership to build a vision for a sustainable living environment. The initiative, part of Project Green, will initially see the construction of 14 demonstration homes across Canada, and hopefully lead to a broad based deployment of Net-Zero Energy Homes in Canada. Industry participation in this initiative is coordinated by the Net-Zero Energy Home (NZEH) Coalition[12]. The initiative is intended to significantly increase consumer interest in and awareness of the important role that solar and other renewable energy technologies can play in meeting Canada's commitment for a clean energy future and healthy communities.

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. 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 micro-power 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. 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.

In 2005 a collaborative effort between the Government of Canada, through the Departments of Natural Resources and Industry Canada, and the Electrical Equipment Manufacturers Association of Canada Council within Electro-Federation Canada, led to the creation of Power Connect[13] - a new umbrella organisation. Together these bodies have committed to support the manufacturers of alternate energy (including. photovoltaic, wind, fuel cells, clean combined heat and power) technologies with the objective to help support and establish the renewable and distributed generation industry.

Power Connect will provide technical and regulatory support concerning the implementation of distributed energy resources in a competitive electricity market. Several high priority areas require technical research to address the current regulatory barriers facing the implementation of distributed energy resources in Canada. These include the need to study the cost-benefit of distributed energy resources integration into the electrical network; address urgent issues

[10] http://www.climatechange.gc.ca/english/newsroom/2005/plan05.asp
[11] CMHC NZEHH: http://www.cmhc-schl.gc.ca/en/inpr/su/neze/index.cfm
[12] Zero Energy Home Coalition: http://www.associations.cc/nzeh/aboutthecoalition.htm
[13] Power Connect: http://www.powerconnect.ca/index.html

concerning net-metering, reverse-metering, time-of-day pricing to improve peak-shaving value, and standard integration procedures and contracts. There are three project aresa under the umbrella of Power Connect: MicroPower Connect; Net Metering; and, Decentralized Energy Management Advisory Council.

A working group composed of stakeholders from the electricity industry (manufacturers and utility) and federal regulatory branches in collaboration with the Government of Canada is continuing work on the Net-Metering Project[14] to identify and eliminate barriers to the introduction of net metering in the electricity sector. Deregulation of the Canadian electric utility industry is creating opportunities for distributed power generation to occupy a significant share of the electricity markets of the future. PV has an important role to play in this market, and appropriate policies to promote investments in PV are being pursued.

4.3 Standards and codes

In 2005, collaborative projects with the Canadian Standards Association (CSA) have led to significant improvements with respect to the interconnection of distributed system with the grid. The Canadian Standards Association (CSA) Technical Committee on the Canadian Electrical Code - Part I has approved a number of changes submitted by the Alberta Safety Code Council Task Force on Micropower and the MicroPower Connect Committee (published in 2006 Edition). These changes facilitate the interconnection of micro-power generation systems. In addition, the MicroPower Connect (www.powerconnect.ca) guideline was reviewed and adopted as a National Standard of Canada for the interconnection of small distributed electrical generators such as PV.

Also in 2005, Canadian experts participated in the development of international standards within the International Electrotechnical Commission's Two new PV module-related international standards have been published: the IEC 61730 on Photovoltaic (PV) module safety qualification and the 2nd edition of the IEC 61215 on Design qualification and type approval of crystalline silicon terrestrial PV modules. Canada is working on adopting them.

5 HIGHLIGHTS AND PROSPECTS

The Solar Buildings Research Network, which will begin its R&D mandate in 2006, will generate Canadian opportunities for demonstrations of innovative PV projects and will expand the knowledge base to the benefits and added value of PV technology in the buildings of the future. This Network is expected to dominate Canadian university research in this field for the next five years. An important feature of the Network is to ensure that the knowledge and R&D outputs are delivered to the public and private sector through technology demonstration projects and public awareness and promotional activities. The Network is expected to produce about 100 Masters and PhD students knowledgeable in solar buildings research. This collaborative R&D effort will provide in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions and it will help to support innovation in the residential construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

The federal Photovoltaic and Hybrid Systems Programme at the CANMET Energy Technology Centre – Varennes is planning a solar photovoltaic housing mission to Japan in February 2006 aimed at offering Canadian housing manufacturers the opportunity to visit state-of-the-art facilities of leading housing manufacturers in Japan such as Sekisui, Misawa, Sanyo and PanaHome, tour a housing park (i.e. sales centre) composed of a number of model homes, and visit a solar community of more than 50 two-storey prefabricated houses equipped with solar systems. Also, in a related development, CMHC is planning in 2006 to invite selected builder/developer-led multi-disciplinary design and development teams to participate, through a national competitive process,

[14] Net metering initiative: http://www.micropower-connect.org/NetMeteringProject/index.htm

in the Zero Energy Healthy Housing initiative. This initiative is a unique opportunity to demonstrate the teams' capabilities to develop innovative solutions and best practices that will demonstrate their visions of sustainable housing - housing that can be built to meet societal and environmental needs of present and future Canadians and set a new standard for Canadian, and international housing in the near future.

The Canadian Solar Industries Association[15] and Énergie Solaire Québec[16] have continued their promotional and marketing activities. CanSIA in particular has been very active in 2005 in developing the foundation for significant changes in polices and programs that will support the solar industry in the coming years.

Private sector investments in the development and marketing of solar PV power systems in Canada will continue to drive the domestic PV market for the foreseeable future. This is reflected by steady growth in the installed base, as well as the significant private-sector investment in manufacturing. Several Canadian PV companies have invested significantly in both the development and promotion of solar PV power systems in Canada as well as in growing their own business. For example, in 2005 Carmanah Technologies Corporation completed its acquisition of Soltek Powersource Ltd. (SPS), a leading manufacturer/supplier of solar power systems for industrial, government, residential and retail applications and a master reseller for a number of world leading equipment suppliers, headquartered in Victoria, British Columbia. This acquisition joins two successful and complementary companies - Carmanah with its self-contained solar packages and proprietary LED technology, and SPS with its large-scale solar power systems – to form a new and significant leader in solar power markets both domestically and internationally. The effect of this and other industry developments 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.

[15] Canadian Solar Industries Association: http://www.cansia.ca/
[16] Énergie Solaire Québec: http://www.esq.qc.ca/

Annex A. Method and accuracy of data

A telephone survey was conducted to obtain information from 45 PV industry players of which 35 provided responses. Products imported over the internet were not measured. A questionnaire was used to obtain information in the following areas for systems in the category of over 40 Wp:

- 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 (kWp) sold inside and outside Canada.
- Sales (inside and outside Canada) to four PV sub-markets (kWp), namely off-grid residential, off-grid non-residential, on-grid distributed and on-grid centralized.
- Sales ($), average capacity (Wp), and turnkey price per application ($/Wp) for off-grid residential and on-grid distributed applications.
- PV-hybrid systems installed in Canada.
- Total revenues (and the percentage 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 investments 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 (kWp) of solar products from solar product manufacturers.
- Factors that had a significant impact on businesses in 2005 as well as the positive and negative effects of the Internet on PV business.
- Revenues, percentage of revenues from export activities and total PV power sales (kWp) for systems in the 40Wp or less category.
- Typical module prices.
- Turnkey prices of typical applications.
- Factors that had a significant impact on businesses in 2005.

The estimated PV module capacity installed in Canada in 2005 is estimated to be 2.86 MW (±10%). An additional 1.77 MW (±15%) were exported.