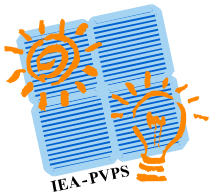
International Energy Agency



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 2007

Prepared by

Josef Ayoub
ExCo from Canada & Task 1 Representative

In collaboration with

Sylvain Martel
&
Dr. Lisa Dignard-Bailey

Photovoltaic Program
Natural Resources Canada
CANMET Energy Technology Centre-Varennes
P.O. Box 4800, Varennes, Québec
CANADA J3X 1S6

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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 21 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia, Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey, the United Kingdom (GBR) and the United States of America (USA). The European Commission and the European Photovoltaic Industry Association are also members.

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 2007 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

- **Installed PV power:** Canada's total PV power installed capacity increased 26% in 2007 to 25.8 MW compared to 20.5 MW at the end of 2006. The 2007domestic PV module sales volume totalled 5.29 MW compared to 3.74 MW in 2006 – an increase of 42% in the one-year period. The 2007 export PV module sales totalled 7.33 MW compared to 990 kW in 2006 – a 640% increase from the previous year. Total PV sales in Canada (domestic and export) in 2007 were at 12.62 MW a 167% increase over the previous year. The growth of the PV market in Canada has been averaging 27% annually since 1993. In 2007, the largest module sales domestically occurred in the off-grid market (both residential and non-residential) with about 73% of market share. The remaining 26% attributed to sales in the on-grid distributed market.

- **Costs & prices:** Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 4.47 in 2007. This represents an average annual price reduction of 10% over the 8-year period.

- **PV production:** There was a 27% increase in full-time, labour place equivalent employees engaged in PV activities in the public and private sectors (manufacturing, distributors, dealers, retailers, system installers, consultants and developers) in Canada in 2007. The largest manufacturers are Xantrex, Cenetennial Solar, Carmanah, Day4 Energy and ICP Global. In 2007 PV module manufactures reported a total PV module production of 6.5 MW with maximum production capacity of at least 93 MW.

- **Public budget for PV:** Total public budgets in Canada showed a jump of CAD 2.25 M (28%) in 2007 over the previous year. This is due to large multi-year federal funding to the Solar Research Buildings Network as well as to a private sector project to develop and demonstrate high purity solar grade silicon.

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 installed PV systems in Canada (89%) consist of stand-alone applications 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 off-grid non-residential market for water pumping, road signals, navigational buoys, telecommunication repeaters, and industrial sensing, monitoring, and controlling represented 53% of domestic PV sales in 2007. 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 remains at about 31% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. Sales in the grid-connected market accounted for 26% of total sales in Canada in 2007. There were several demonstrations of grid-connected PV systems in 2007 including a new 108 kW grid-tied building integrated PV system on a Government of Canada facility in Charlottetown, in the Province of Prince Edward Island. The new Province of Ontario's feed in tariff launched in the fall of 2006 is expected to increase the uptake of the grid-connected market for PV for the foreseeable future.

2.2 Total photovoltaic power installed

A sustainable Canadian PV market in off-grid applications has developed over the last 16 years. This market continued to show the strong annual growth that has averaged 26% since 1993. The cumulative installed off-grid power capacity was 22.86 MW in 2007. 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. The grid-connected distributed market in Canada in 2007 grew by 97% over the previous year. This market sector has been averaging growth rates of 38% since 2000, with the strongest spurts in the last three years.

In 2007 the modules sales in Canada (excluding subsequent exports) grew by 42% over the previous year, and represented an average growth of 25% since 1993. The market is responding (both positively and negatively) to some volatility as a result of a number of factors including; the exchange rates of various currencies; increasing recognition of PV technology; higher consumer confidence; the increasing use of the internet for on-line shopping; and for product support; and changing international markets and competitors

In 2007, total modules sales (domestic and export) reached 12.62 MW, and increase of 167% over the previous year of which 53% were for on-grid applications (distributed and centralised), and 47% for off-grid applications (residential and non-residential).

Table 1 - The PV power (kW) installed in 4 sub-markets during 2007.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2007 (kW)	1408	2480	1403	0	**5 291**

Table 2. The cumulative installed PV power in 4 sub-markets in Canada in 2007
(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	2006 kW	2007 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	6 680	8 088
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	12 296	14 776
Grid-Connected distributed	167	194	195	212	241	254	257	287	305	342	368	405	476	1 059	1 443	2 846
Grid-Connected centralized	0	10	10	10	10	10	10	10	10	10	0*	0	36	65	65	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**	**20 484**	**25 775**
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**	**18 976**	**22 864**

* Decommissioned.

Table 2a. 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	2006	2007
958*	280	272	350	700	820	1090	1356	1328	1682	1161	1833	2054	2862	3738	5291
-	-	-3%	29%	100%	17%	33%	24%	-2%	27%	-31%	58%	12%	39%	31%	42%

* Cumulative installed capacity as of 1992

2.3 PV Implementation highlights, major projects, demonstrations and field test programmes

The following are highlights of some of the PV implementation, major projects, demonstrations and field test programmes undertaken in Canada in 2007.

The Provincial Government of Ontario's Renewable Energy Standard Offer Program

The Province of Ontario's Renewable Energy Standard Offer Program (RESOP)[1] launched in the fall of 2006 by the Ontario Power Authority (OPA) and the Ontario Energy Board (OEB) is designed to encourage and promote the greater use of renewable energy sources including solar photovoltaic. The target is to help achieve Ontario's renewable energy supply targets of 2,700 megawatt of electrical power generated by new renewable energy sources by 2010. At the end of calendar year 2007, contracted capacity reached over 900 MW of renewable power.

Summary of the province of Ontario RESOP Contracts in 2007 (January-December)[2]

RE Source	# Contracts	Capacity (kW)
Solar PV	145	252,140
Wind	65	572,827
Water Power	14	31,829
Bio-Energy	17	58,178
TOTAL	**241**	**914,974**

The RESOP rules establish a "market-based pricing system for all technologies except solar photovoltaic that provides a Base Rate to be paid to Generators for each kilowatt-hour (kWh) of electricity delivered, plus a performance incentive for Generators who can control their output to meet peak demand requirements reliably over time. It also provides for price escalation to the Base Rate paid to some Generators, linked to the Consumer Price Index in Ontario. The rules also establish a cost-based price for solar PV production in order to conduct price discovery. A cost-based price recognizes that PV Projects cannot be successful at this time under a pricing regime suitable for other renewable generation sources. PV Projects will be paid $0.42 per kWh but will not be eligible for inflation indexation or the peak-hour premium."

The RESOP has attracted several large energy developers in 2007. For example Skypower Corporation[3], a subsidiary of Lehman Brothers, a US-based private equity business, and one of Canada's leading independent renewable energy developer, entered into a joint venture with SunEdison Canada LLC, a subsidiary of SunEdison LLC the largest solar energy service provider in North America, on two 10 MW RESOP solar projects in Ontario.

Solar programme strategic plan for the Province of British Columbia

In 2007, an independent technology advisory council in British Columbia (BC) reporting directly to the Premier of the province has issued a report[4] on Greening BC Energy Purchasing Policies recommending that the province "support the development of feed-in-tariffs that decline over time to assist the commercialization of renewable emerging energy sources and their associated technologies". The work of the Premier's Technology Council builds on the BC Hydro standing offer for small power generation and suggests for more aggressive options such as a feed-in-tariff system that "varies by the source of renewable energy and the maturity of the technology". The Technology Council's report opens the possibility for renewable tariffs in British Columbia. Further developments are expected in 2008.

Also in 2007, the BC Ministry of Environment in partnership with federal and provincial energy departments, the provincial utility BC Hydro as well as the participation of public and private sector financial institutions convened a multi-stakeholder team to develop a plan that will help British Columbia achieve the goal of having 100,000 solar roofs in place province-wide. The target includes both solar photovoltaic and solar hot water systems. The solar roofs program supports the BC Energy Plan's goal for electricity self-sufficiency and 90 percent clean or renewable electricity generation. The plan is expected to be completed in 2008 and submitted to the provincial government for consideration.

Interconnection of Distributed Generation to the Electricity Grid

CANMET Energy Technology Centre – Varennes, in partnership with key industry players and associations, has undertaken a number of activities in the area of interconnection in order to avoid multiplication of regional requirements across the country. This included the development of harmonized national interconnection standards, the conduct of research and field-testing addressing concerns raised by electricity distributors, and the implementation of changes in the Canadian Electrical Code[5] (refer to review by Martel and Turcotte, October 2007).

As for the installation of the distributed generators in Canada, PV Systems must be installed in accordance with all applicable general rules of the Canadian Electrical Code; to Part I for low voltage installations at load centers such as residences and commercial buildings, and to Part III for medium to high voltage on Part III of the electricity distribution and transmission systems. Continuing concern during the electricity network interconnection "impact assessments" by utilities delays projects and leads to additional costs to large scale PV projects planned in Ontario. Large inverter-based PV systems (up to 10 MW) are compared to both induction and synchronous generators that are more commonly known to utility personnel. Improved simulations tools used by planning engineers, such as CYMDIST, now include examples for inverter, induction and synchronous generators. In 2007, specific case studies have been added to the CYMDIST tutorial material to promote and educate utility personnel that are tasked with conducting these interconnection "impact assessments" in Canada[6]. There is a need to support specialized courses designed under continuing education programs to support the training needs of the electricity industry in Canada.

***Demonstration of the* ÉcoTerra™ EQuilibrium - New housing for a changing world, Alouette Homes, Eastman, Quebec**

In 2007, Alouette Homes[7], a Canadian leader in the residential building industry, mainly as a manufacturer of modular and panel homes, built their first ÉcoTerra™ home in the province of Quebec. Alouette's ÉcoTerra™ housing concept (Fig. 1), one of the winning proposals in CMHCs EQuilibrium housing competition, is based on the principals of occupant health and comfort, energy efficiency, renewable energy production, resource conservation and reduced environment impact. The concept is an innovative way to create and build a home that combines the ideas of sustainable development, environmental harmony and personal health and well-being. The ÉcoTerra™ house consumes only 10% of the energy used by a standard house with the same

surface area. It uses a grid-tied 3 kW Unisolar PV laminates integrated into the roof that includes a Solar PV-thermal hybrid system.

Figure 1: A 3 kW roof-integrated PV system on the ÉcoTerra™ net zero energy house, Alouette Homes, Eastman, Quebec (Photo credit – The Solar Buildings Research Network and Alouette Homes)

The Jean Canfield Government of Canada Building, Charlottetown, Prince Edward Island

In 2007, the federal government through the Department of Public Works and Government Services Canada (PWGSC) installed a 108 kW grid-tie photovoltaic system on the newly constructed Jean Canfield Building (JCB) in downtown Charlottetown, in the Province of Prince Edward Island (Fig. 2). The solar array, designed and installed by Carmanah Technologies Corporation is the largest building integrated in Canada and is comprised of 500 Sanyo solar modules connected to the grid. The JCB is one of the most environmentally friendly buildings ever constructed by PWGSC as it strives to attain a LEED Gold certification from the Canadian Green Buildings Council. The PV system is designed to supply an estimated 10 percent of the building power needs.

Figure 2: Newly installed 108 kW grid-tie solar power system on the Jean Canfield Government of Canada Building, Charlottetown, PEI (Photo credit – Carmanah Technologies Corp.)

A Heavenly light shines on Regent College, University of British Columbia

In 2007, Canadian stained glass artist Sarah Hall[8] designed a unique art exhibit called "Lux Nova" which consists of solar cells encased between double layers of tempered glass installed on the façade of a 14-meter high ventilation tower for the underground theology library at Regent College. The college is a graduate school of Christian studies affiliated with the University of British Columbia in Vancouver. The photovoltaic cells power the installations shimmering blue, purple, and white flames produced by a rear column of color-changing LED lights. The Lord's Prayer is etched into the painted and textured glass structure in its original Aramaic script**.**

Figure 3: Sarah Hall's *Lux Nova* exhibit of stained glass embedded with solar cells and LED lighting grace the wind tower of Regent College, British Columbia (Photos credit - Sarah Hall)

2.4 Highlights of R&D

The federal Photovoltaic Programme is managed by the Department of Natural Resources Canada (NRCan) and is funded by the Programme of Energy Research and Development and the Technology and Innovation Research and Development initiative which support the energy-related R&D activities of federal departments. The Programme's primary mandate has not changed since its inception - to help develop and deploy photovoltaic energy technologies in Canada. It does so by accelerating the deployment of this technology domestically, while supporting R&D activities that exploit the technology's potential, both nationally and internationally. NRCan through one of its technology science and technology centres located in Varennes, Quebec, promotes and facilitates the use of photovoltaic systems in off-grid and grid-connected applications, by carrying out research and demonstration projects, serving on international standards committees and developing information and training tools. The PV Programme also actively contributes its expertise to innovative partnerships with key players in the field. Most research projects are carried out on a cost-sharing basis with industry, universities, research groups, quasi-public agencies and other departments or governments.
On-going activities undertaken by the PV Programme in 2007 include:

- R&D for the integration of PV-thermal systems in buildings;
- Solar optimisation on Net-Zero Energy Homes;
- Implementing strategies to planning sustainable solar cities;

- Participating in the Canadian Solar Buildings Research Network;
- Solar potential forecasting and analysis[9];
- Undertaking PV system performance, reliability and cost analysis;
- Facilitating R&D activities between universities and the private sector involved in fundamental solar cell research;
- Establishing standards and codes for the certification and installation of PV systems and their components;
- Establishing national guidelines for the connection of small, distributed power sources to the public power system[10];
- Undertaking simulation studies on the impact of utility interconnected PV systems within mini-grids and micro-grids;
- Representing Canada in the International Energy Agency Photovoltaic Power Systems Programme; and,
- Partnering with the solar power industry through the development of federally-funded demonstration projects.

The Government of Canada, through the National Science and Engineering Research Council (NSERC) is continuing its investment of CAD 5M over a 5-year period to the Solar Buildings Research Network – 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. This collaborative R&D effort provides 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. Research results were presented at the Solar Energy Society of Canada Inc. and the Solar Buildings Research Network joint annual conference. In 2007, midway through the Network's mandate, it has achieved substantial progress in its objectives as demonstrated by its publications, graduates that have taken up positions in Universities and industry, innovative demonstration projects, enhanced collaboration and partnerships, workshops organized in collaboration with its partners and other dissemination and promotional activities. It was also awarded a financial contribution of CAD 900,000 from the federal government to demonstrate combined solar photovoltaic-thermal systems in two net-zero energy solar houses designed by the Network and its partners, as well as in a new university building.

In 2007, spurred by increasing emphasis on renewable energy development programs, both overall funding and staffing in solar cell R&D have more than tripled since 2003. Canadian capability is for the most part funded by the federal government through the NSERC and the Ontario Centre of Excellence at a level of about 3 million CAD per annum since 2006. This funds a broad range of basic research including organic solar cells, dye sensitized solar cells, thin silicon devices, high efficiency III-V multi-junctions, and advanced crystalline silicon solar cells. An NRCan scoping analysis of leading universities in Canada shows that about 120 professional staff and graduate students in various science (chemistry, physics, materials science) and engineering (physics, chemical, electrical, computer, information technology, etc.) disciplines are involved in photovoltaic solar cell research and development. Sixty percent of the groups surveyed reported working in collaboration with a national or international manufacturing partner.

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

Total public budgets in Canada showed a significant increase of CAD 28% in 2007 over the previous year. This is due to large multi-year federal funding to the Solar Buildings Research Network and to university-based research, as well as technology demonstrations.

Table 3. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2007 (CAD x 1000)

	R & D	Demo/Field test	Market Incentives	Total
Federal	4 500	3 900	0	**8 400**
Provincial	1 000	500	500	**2 000**
Total	**5 500**	**4 200**	**500**	**10 400**

Table 3a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2007 (CAD x 1000)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total combined (Federal, provincial)	890	1500	1950	5955	8540	9800	7700	8 150	10 400
Annual trends	-	68%	30%	205%	43%	15%	- 21%	6%	28%

3 *INDUSTRY AND GROWTH*

3.1 Production of feedstock, ingots and wafers

There is production of solar grade silicon feedstock in Canada for 2007.

Table 4: Production and production capacity information for 2007 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)
Bécancour Silicon Inc. (Subsidiary of Timminco Ltd.)	Solar grade Si feedstock	3 production lines each at 1200 t/y all coming on stream in the t quarter of 2008	Expansion plans to 14400 t/yr production capacity to be completed mid 2009	Export (Q-Cells, Germany, other)	NA

3.2 Production of photovoltaic cells and modules

Table 5: Production and production capacity information for 2007

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)			Maximum Production Capacity (MW)		
		Cell	Module	Con.	Cell	Module	Con.
Centennial Solar	sc-Si a-Si CIGS	-	1.20 0.10 0.20	-	-	3	-
Day4 Energy Inc.	sc-Si	-	5.4	-	-	90 (expansion plans for end of 2008)	-
ICP Global Inc.	sc-Si a-Si CIGS	-	NA	-	-	NA	-
TOTALS	sc-Si a-Sci CIGS		**6.20+** **0.10+** **0.20+**	**-**	**-**	**93+**	**-**

Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 4.47 in 2007 (weighted average of price range from CAD 3.90 to CAD 10.00). This represents an average annual price reduction of about 10% over the 8-year period.

Table 6. Module prices (CAD/W) for 1999-2007

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Standard module price (weighted average)	11.09	10.70	9.41	7.14	6.18	5.53	4.31	5.36	4.47
Trend in Price reduction	-	3.5%	12%	24%	13%	10%	22%	-24%	17%

3.3 Manufacturers and suppliers of other components

There are over 200 solar energy organizations (sales companies, wholesalers, product manufacturers, private consultants, systems installers and industry associations) driving the PV market in Canada. A majority of them are active in the Canadian Solar Industry Association[11] and Énergie Solaire Québec[12.] The Canadian PV manufacturing sector has grown significantly in the last five years to serve both the domestic and export markets.

Canadian-based Timminco Limited[13], a leader in the production of silicon metal for the electronics, chemical and aluminum industries has commenced production of solar grade silicon through its wholly-owned subsidiary, Bécancour Silicon Inc. (BSI) in its new facility in Bécancour, Québec. The facility will be comprised of three production lines, each with an annual capacity of 1,200 metric tons. The production lines are being brought into production in series with the first starting in fourth quarter 2007, with the second and third lines anticipated to be coming on stream in the first quarter of 2008. In 2007 BSI also announced that it has entered into several long-term commercial agreements for the sale of approximately 6,000 metric tons of solar grade silicon to solar cell manufacturers beginning in 2009.

In 2007 witnessed several growth-developments of Canadian solar manufacturers. Burnaby-based Xantrex Technology Inc.[14], a world leader in the development, manufacturing and marketing of advanced power electronic products and systems for the renewable, portable, mobile and programmable power markets, expanded its programmable power business by acquiring California-based Elgar Electronic Corporation. This acquisition will enable Xantrex to become a leading player in the global programmable power market with a significantly expanded product line and customer base. Also Day4 Energy Inc.[15] formed in 2001 in Burnaby, British Columbia, as a manufacturer of PV modules announced in 2007 that it has raised over 115 million CAD in public investment into the company to enable to expand its production. It was also the lead PV modules supplier to the 1 MW solar energy project in the German county of Sigmaringen with EnBW one of Germany's largest energy suppliers. EnBW has extended its contract with Day4 Energy for two additional large-scale projects set for construction in 2009 and 2010.

3.4 System prices

The industry reported system prices for the two submarkets, namely off-grid residential and on-grid distributed. System prices vary widely because 89% of Canada's PV market is off-grid, and so embraces a wide range of PV system sizes, complexities, and system configurations.

Table 7: Turnkey prices (CAD) of typical applications in 2007

Category/Size	Typical applications in Canada	Current prices (CAD/W)
Off-Grid (≤ 1 kW)	Mainly remote cottage power supply	15
Off-Grid (>1 kW)	28 kW (distributed systems) remote community demonstration site, British Columbia, (Crystalline Silicon)	7.70
Grid-Connected Specific case		
Grid-Connected (≤ 10 kW)	3 kW PV system on a net zero demonstration house, Quebec (Triple junction amorphous PV	8.50
Grid-Connected (>10 kW)	108 kW PV, Government building demonstration, Prince Edward Island (Crystalline silicon)	10

Table 7a: National trends in turnkey prices (CAD) of typical applications from 1999-2007

CAD/W	1999	2000	2001	2002	2003	2004	2005	2006	2007
Off-Grid (≤ 1 kW)	17	17	20	18	21	18.5	15	17.3	15
Off-Grid (>1 kW)									7.70
Grid-Connected Specific case						13.50	12.50	NA	NA
Grid-Connected (≤ 10 kW)	21	20	Insufficient data	Insufficient data	Insufficient data	14.50	10	10	8.5
Grid-Connected (>10 kW)							12.60	10	10

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by about 21% in 2007 to 1370 jobs. These positions include those in manufacturing, sales and installation, R&D, and other positions in the PV-value chain including company R&D, and provincial and municipal government positions, as well as utility PV dedicated labour.

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

Year	2007
R&D (public) [1]	60
Manufacturing [2]	780
Other[3]	530
Total	**1 370**

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 1996-2007

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total labour	169	201	220	250	260	275	535	615	765	975	1 080	1 370
Annual growth	-	19%	10%	14%	4%	6%	94%	15%	24%	27%	11%	21%

3.6 Business value

The total commercial activity from Canadian PV companies was estimated to be CAD 290M in 2007 up from CAD 201M in 2006. 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, as well as silicon feedstock producers. Overall manufacturing revenues increased by about 44% in 2007. Manufacturing revenues from export activities accounted for about 90% of total manufacturing revenues in 2007 (CAD 175M) - a significant additional impetus came from module manufacturers.

Table 8: Trends in PV business in Canada from 1992-2007

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Million CAD	18	17	17	25	28	33	38	40	42	45	95	100	125	150	201	290
Annual growth	-	-6%	0	47%	12%	18%	14%	5%	5%	7%	111%	5%	25%	17%	34%	44%

4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

Table 9: PV support measures (Canada 2007)

	National / Regional (State) / Local
Enhanced feed-in tariffs	Yes (Province of Ontario)
Direct capital subsidies	No
Green electricity schemes	Yes – federal program: ecoENERGY for Renewable Power will invest $1.48 billion CAD to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, solar photovoltaic and ocean energy.
PV-specific green electricity schemes	No
Renewable portfolio standards (RPS)	No
PV requirement in RPS	No
Investment funds for PV	Yes (private sector)

Tax credits	Yes (federal, Province-specific)
Net metering	Yes (Province-specific)
Net billing	Yes (Province-specific)
Commercial bank activities	No
Electricity utility activities	Yes
Sustainable building requirements	Yes (through voluntary action to attain LEED-level certification for commercial and institutional buildings

4.1 New initiatives

There have been no new initiatives supporting PV development that have been announced in 2007. However, the Province of Ontario's Renewable Energy Standard Offer Program continues to attract significant interest from the private sector.

4.2 Indirect policy issues

No significant policy issues are being found with stand-alone PV systems, which comprise 89% 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.

Power Connect[16] is continuing to 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 concerning net-metering, reverse-metering, time-of-day pricing to improve peak-shaving value, and standard integration procedures and contracts.

Since electricity power in Canada is a provincial jurisdiction and the connection are usually done according to the local distribution company's requirements. Net metering regulations have been put in place in several provinces that establish rules for the flow of electricity between utilities and distributed PV systems. The implementation of these regulations is challenging, requiring the installation of new equipment (for example, proper meters) and new billing systems. Some utilities have developed and implemented programs that streamline the application process specify net metering requirements and set out approved tariffs (BC Hydro, Toronto Hydro, and Hydro Quebec Distribution) (Figure 4). Where local distribution companies do not have streamlined application processes, the approval process can be complex for individual consumers responsible for their installation. Canadians in those regions must deal with different types of approval or verification to install a rooftop system that are handled on a case-by-case basis. 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.

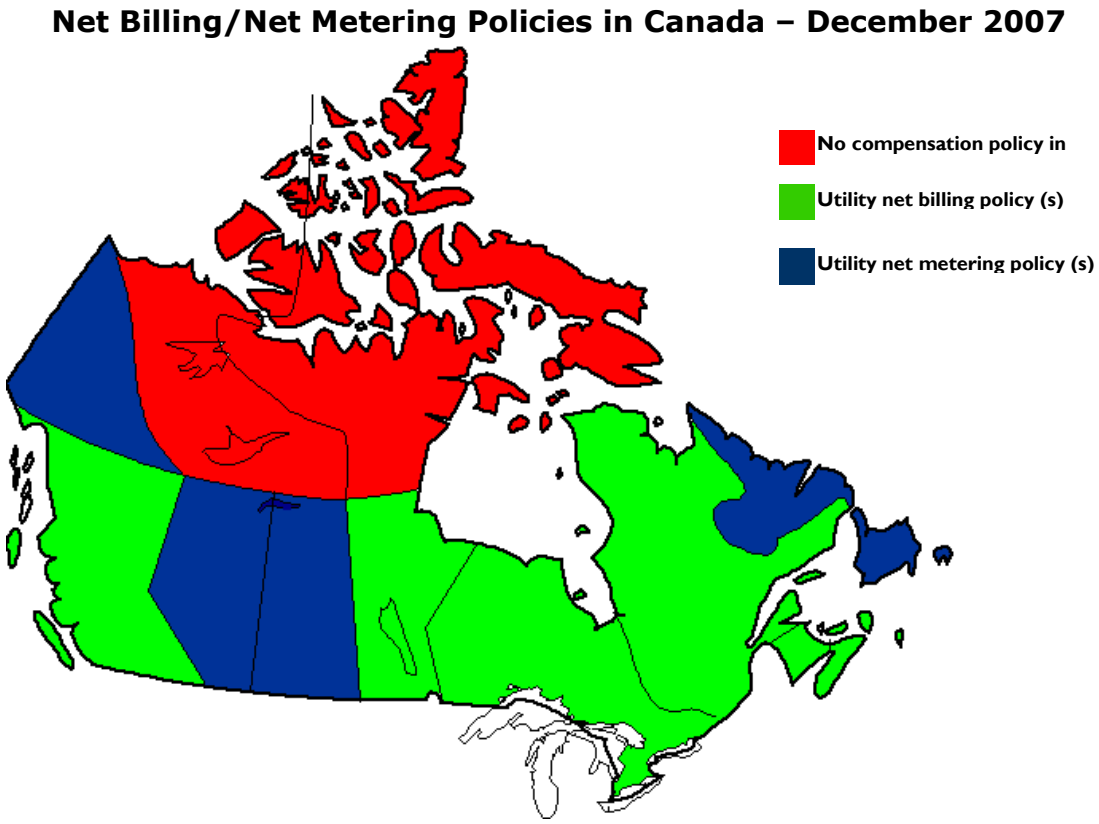

Figure 4: Net-metering landscape in Canada – 2007

4.3 Standards and codes

In 2007, Canadian Standards Association (CSA) has completed the draft of a second Canadian interconnection standard entitled "Interconnection of distributed resources and electricity supply systems". This new Canadian standard, one of a series of standards issued by the CSA under Part III of the Canadian Electrical Code, specifies the electrical requirements for safe interconnection of distributed generation to distribution systems up to 50kV and complements the existing CAN/CSA-C22.2 No. 257-06 "Interconnecting inverter-based micro-distributed resources to distribution systems". This standard will be published by mid-2008 as a National Standard of Canada (CAN/CSA-C22.3 No. 9-08).

Canadian experts participated in the development of international standards within the International Electrotechnical Commission. Two new standards were published: the IEC 62108 on Concentrator photovoltaic (CPV) modules and assemblies - Design qualification and type approval, and the 2nd edition of the IEC 60904-9 Ed.2 on Solar simulators. At the national level, a consultation session on the adoption of the IEC 61730 on PV module safety was held with partners from the Canadian solar industry and certification bodies within the CANSIA annual forum.

5 HIGHLIGHTS AND PROSPECTS

The Province of Ontario's Renewable Energy Standard Offer Program is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. By the end of 2007, the SOP has reached its 5-year target in its first year of implementation and is presently looking into planning and upgrading the infrastructure for transmission to the grid. The

RESOP is attracting investment in the Canadian Solar industry with Ontario possibly becoming the economic centre of the solar industry in North America. The Program provides a platform for all sectors of the society to work together towards finding solutions to the energy challenges that the Province of Ontario will face in the coming years.

The Solar Buildings Research Network is generating opportunities for demonstrations of innovative PV projects in Canada and is expanding the knowledge base to the benefits and added value of PV technology in the buildings of the future. In 2007, the SBRN championed a federally co-funded project to demonstrate innovative combined solar heat and power technologies (PV/T) on new institutional and net zero energy residential homes. The SBRN is dominating Canadian university research in this field while ensuring 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 collaborative R&D focus is providing in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions and is helping to support innovation in the residential construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

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 and in silicon feedstock production. The Canadian Solar Industries Association and Énergie Solaire Québec have continued their promotional and marketing activities. CanSIA in particular has been very active in 2007 in developing the foundation for significant changes in polices and programs that will support the solar industry in the coming years.

Annex A. Method and accuracy of data

A telephone survey was conducted to obtain information from 60 PV industry players of which 35 provided responses. Products imported over the internet and through direct orders 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 2007 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 2007.

The estimated PV module capacity installed in Canada in 2007 is estimated to be 5.291 MW (±10%). An additional 7.234 MW (±15%) were exported.

ENDNOTES

[1] Renewable Energy Standard Offer Program website: http://www.powerauthority.on.ca/sop/
[2] Information extracted from OPA, *"A Progress Report on Renewable Energy Standard Offer Program, December 2007".*
[3] Skypower Corporation website: http://www.skypower.com
[4] "Premier's Technology Council 10th Report, September 2007" website: http://www.gov.bc.ca/premier/attachments/ptc_10th_report.pdf
[5] S. Martel and D. Turcotte, Review of Distributed Generation Product and Interconnection Standards for Canada http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2007-172/2007-172e.pdf
[6] Cyme T&D technical engineering courses: http://www.cyme.com
[7] Alouette homes website; http://maisonalouette.com
[8] Sarah Hall website: http://www.sarahhallstudio.ca
[9] Photovoltaic (PV) potential and insolation web-based maps: https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php
[10] Micropower Connect Website: http://www.powerconnect.ca/mpc/index.htm
[11] Canadian Solar Industries Association website: http://www.cansia.ca
[12] Énergie Solaire Québec website: http://www.esq.qc.ca
[13] Timminco Ltd. Website: http://www.timminco.com
[14] Xantrex Technology Inc. website: http://www.xantrex.com
[15] Day4 Energy Technology Inc. website: http://www.day4energy.com/
[16] Micro-power Connect website: http://www.power-connect.ca/english/index.htm