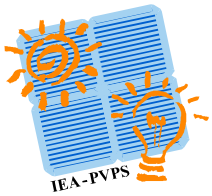
International Energy Agency



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 2006

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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

- **Installed PV power**

Canada's total PV power installed capacity increased by 31% in 2006 to 20.5 MW compared to 16.75 MW at the end of 2006. The 2006 domestic PV module sales volume totalled 3.74 MW compared to 2.86 MW in 2005 – an increase of 31% in the one-year period. The 2006 export PV module sales totalled 990 kW compared to 1.77 MW in 2005 – a 44% decrease from the previous year. Total PV sales in Canada (domestic and export) in 2006 were at 4.73 MW a 2% increase over the previous year. The growth of the PV market in Canada has been averaging 25% annually since 1993. In 2006, the largest module sales domestically occurred in the off-grid market (both residential and non-residential) with about 90% of market share. The remaining 10% 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 5.36 in 2006. This represents an average annual price reduction of 9% over the 7-year period.

- **PV production**

There was a 11% increase in manufacturing employment in Canada in 2006 (equipment, PV and balance of system products). The largest manufacturers are Xantrex, Carmanah, Day4Eenergy and ICP Global. In 2006 there were two additional module manufacturers to ICP Global that registered some level production. Together the 3 manufactures reported total PV module production of 2.35MW with maximum production capacity of 15 MW.Day4Energy and Centennial solar together produced some 2 MW of PV modules.

- **Public budget for PV**

Total public budgets in Canada showed a slight increase of CAD 450,000 (6%) in 2006 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 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 68% of PV sales in 2006 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 remains at about 21% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. Sales in the grid-connected market accounted for 21% of total sales in

Canada in 2006. There were several demonstrations of grid-connected PV systems in 2006 including a new 100 kW PV building-integrated at Exhibition Place in Toronto, Ontario. The new Province of Ontario's feed in tariff – the Renewable Energy Standard Offer Program - launched in the fall of 2006 is expected to increase the uptake of the grid-connected market for PV.

2.2 Total photovoltaic power installed

A sustainable Canadian PV market in off-grid applications has developed over the last 15 years. This market continued to show the strong annual growth that has averaged 24% for each the last 13years. The installed off-grid power capacity was 18.98 MW in 2006. 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 2006 the modules sales in Canada (excluding subsequent exports) grew by 31% over the previous year, and represented an average growth of 34% over the last four-year period. The market is responding (both positive and negative) 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 2006, the on-grid distributed market reported total sales (domestic and exported) resulting in a 60% reduction over the previous, compared to 49% increase for the off-grid (residential and non-residential) market. Although there has been a 2% increase of total sales over the previous year, most of

Table 1. The cumulative installed PV power in 4 sub-markets in Canada in 2006
(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
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
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
Grid-Connected distributed	167	194	195	212	241	254	257	287	305	342	368	405	476	1 059	1 443
Grid-Connected centralized	0	10	10	10	10	10	10	10	10	10	0*	0	36	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
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
Cumulative Annual trends	-	29%	22%	23%	38%	32%	32%	30%	23%	24%	13%	18%	17%	21%	22%

* 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	2006
na	280	272	350	700	820	1090	1356	1328	1682	1161	1671	2054	2862	3738
-	-	-3%	29%	100%	17%	33%	24%	-2%	27%	-31%	44%	23%	39%	31%

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 2006.

Largest solar photovoltaic pilot project in Canada installed at Exhibition Place in Toronto

In August 2006, the City of Toronto installed a 100 kilowatt PV rooftop system - the largest solar power system in Canada on the roof of the Horse Palace at Exhibition Place[i] (Figure 1). The system is comprised of four subsystem, each using a different combination of solar, inverter and mounting technologies, and are expected to generate a combined 120 megawatt-hours of electricity per year. The electrical performance of each of the subsystems is separately monitored and compared, allowing Exhibition Place to determine the best overall combination of technologies for use in future projects. This performance is available on a public website[ii]. Exhibition Place is mixed-use property on the Toronto shore of Lake Ontario located a few kilometres just west of central business district. The 197–acre area features expo, trade, and banquet centers, theatre and music buildings, parkland, sports facilities, and a number of civic, provincial, and national historic sites. It holds world-class events, including the Canadian National Exhibition, the Royal Agricultural Winter Fair, and World Youth Day. Each year about 5.2 million people visit the site. The solar system on the Horse Palace roof will join other renewable energy systems operating at Exhibition Place, which is the location of the first city-sited wind turbine in Canada. A fuel cell demonstration project was introduced in 2003. Exhibition Place's goal is to become energy self-sufficient by 2010, and ultimately to become a net exporter of clean electricity. Exhibition Place plans to expand the installation to 1.5 – 2 megawatts in the near future to enable it to reach its goal becoming energy self-sufficient by 2010. This project was funded by the federal government through the Federation of Canadian municipalities, the municipal government through the Toronto Atmospheric Fund and the private sector through the Better Buildings Partnership. This is an innovative public-private sector partnership that promotes and implements building renewal and energy- efficient retrofits of industrial, commercial, institutional and multi-residential buildings.

Fig. 1: 1100 kW PV roof-mounted installation at exhibition Place, Toronto, Ontario, Canada. (Photo credit Exhibition Place)

Fred Kaiser Building at the University of British Columbia

The University of British Columbia Office of Sustainability and Planning has a mandate to integrate "green buildings" and environmental practices for all new buildings on the UBC campus. In 2006, with some funding from the Federal Government leveraging fund from the private sector, UBC installed a 7 kW integrated grid-tie PV system into the skylight of the Fred Kaiser Building – home the UBC Department of Electrical and Computer Engineering (Figure 2).

The system was designed by a partnership between architects and the PV industry as a result of an integrated design process that considered and prioritized all aspects of the building before establishing a design direction. "The building envelope controls the exterior environment with a 70% ceramic frit reducing solar gain and improving energy efficiency. The building is 35% more energy efficient than a standard building, saving 4,500 tonnes of greenhouse gas emissions each year. It also employs water saving features reducing water consumption by 40%. Photovoltaic panels mounted on the atrium skylight provide DC power for emergency lighting and DC experiments in the Power Lab"[iii].

Fig. 2: Skylight systems at the Fred Kaiser Building, UBC, British Columbia, featuring a grid-tie 7 kW BIPV. (Photo credit Carmanah)

The Alberta Solar Municipal Showcase

In 2006 the Province of Alberta's Climate Change Central, a "public-private partnership that promotes the development of innovative responses to global climate change and its impacts" in cooperation with several municipalities launched the Alberta Solar Municipal showcase[iv] - the first Province-wide demonstration project of its kind in Canada. This project involves 20 municipal organizations across the province showcasing grid-tied photovoltaic systems on highly-visible public buildings. All participating municipal organizations are contributing equal amounts of funding for these demonstrations to match Federal Government funding through its Green Municipal Fund. The project will explore the ways that participants use their showcase to educate and inform residents, building operators, inspectors, trades people and students about this technology and help to support the long-term viability of renewable energy in Alberta.

Demonstration of new solar Hybrid Power System for remote homes

The Government of Canada through a TEAM-funded technology demonstration project is assisting Xantrex Technology Inc. to develop advanced control systems 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 for remote and off-grid power applications. In August 2006, Xantrex installed its new solar Hybrid Power System in a demonstration project on the Xeni Gwet'in First Nation land near Chilko Lake, in a remote site located in central British Columbia (Figure 3). The Xantrex Hybrid Power Systemcan work efficiently with renewable energy sources such as solar power, micro-hydro power systems and small-scale wind generators to produce electricity for immediate use in the home or to be stored in batteries for later use – well suited to supply electricity to homes in remote areas.. The system integrates advanced power electronics, a battery bank and a generator into a single system that provides enough electricity to power an average household. The Xeni Gwet'in Enterprise, which provides technical and construction services to First Nation, plans to eventually install Hybrid Power Systems at 30 houses in the area.

Fig: 3 The Xantrex Hybrid Power System reduces First Nations generator fuel consumption and increases reliability at a remote site. (Photo credit Xantrex)

Net Zero Energy Housing Demonstration Pilot Projects

In 2006, the Federal Government through its Canada Mortgage and Housing Corporation announced the launch of the Equilibrium Housing initiative (formerly known as the Net Zero Energy Healthy Housing initiative)[v]. The new branding of the initiative coincided with the announcement of the twelve homebuilding teams that have been selected by CMHC to build pilot demonstration homes throughout Canada. EQuilibrium is a national housing initiative, led CMHC that brings the private and public sectors together to develop homes, and eventually communities, that address occupant health and comfort, energy efficiency, renewable energy production, resource conservation, reduced environmental impact and affordability. EQuilibrium housing integrates a wide range of technologies, strategies, products and techniques to reduce a home's environmental impact to an absolute minimum. At the same time, Equilibrium housing also features commercially available, on-site renewable energy systems to provide clean energy to help reduce annual consumption and costs. The ultimate goal is a highly energy efficient, low environmental impact house that provides healthy indoor living for its occupants, and produces as much energy as it consumes on a yearly basis. 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.

2.4 Highlights of R&D

The Canadian Photovoltaic Programme, managed by CETC–Varennes (Department of Natural Resources Canada), focuses on the scientific aspects of work on photovoltaic energy. It 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 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. The Programme's primary mandate is 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. CETC–Varennes promotes and facilitates the use of photovoltaic systems in buildings, by carrying out research and demonstration projects, serving on international standards committees and developing information and training tools. On-going activities undertaken by the PV Programme in 2006 include:

- R&D for the integration of PV-thermal systems in buildings;
- Solar optimisation on Net-Zero Energy Homes;
- Participating in the Canadian Solar Buildings Research Network (Figure 1);
- Developing photovoltaic resource maps for Canada[vi];
- 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[vii];
- Collaboration with Measurement Canada on net-metering to address the regulatory issues[viii];
- Simulation studies on the impact of utility interconnected PV systems and micro-grids;
- Representing Canada in the International Energy Agency Photovoltaic Power Systems Programme;
- Disseminating information to the Canadian PV industry, the Royal Architectural Institute of Canada and other PV stakeholders; 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 Network[1] (SBRN) – 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 SBRN is headquartered at Concordia University in Montreal (Figure 4). This collaborative R&D effort provides in-depth analyses to Canadian stakeholders on the

Fig. 4: The Solar Buildings Research Network headquarters, Concordia, University, Montreal, Canada.

[1] Solar Buildings Research Network: http://www.solarbuildings.ca/

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.

In 2006, solar cell R&D was carried out within at least six universities and other Canadian research institutes. Research topics ranged from early fundamental research on organic polymers, quantum dots and electrochemical cells to applied R&D on advanced crystalline silicon and heterojunction solar cells. Some of these results were presented at the annual Solar Energy Society of Canada Inc. annual conference which was held in Montreal in August 2006.

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

Total public budgets in Canada showed a slight increase of CAD 450,000 (6%) in 2006 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.

Table 2. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2006 (CAD x 1000)

	R & D	Demo/ Field test	Market Incentives	Total
Federal	3 300	3050	0	**6 350**
Provincial	1 200	600	100	**1 800**
Total	**4 500**	**3 650**	**100**	**8 150**

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	2006
Total combined (Federal, provincial)	890	1500	1950	5955	8540	9800	7700	8 150
Annual trends	-	68%	30%	205%	43%	15%	- 21%	6%

3 *INDUSTRY AND GROWTH*

3.1 Production of feedstock, ingots and wafers

There is no production of feedstock and wafers to report in Canada for 2006.

Table 3: Production and production capacity information for 2006 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)**
NA	NA	NA			

3.2 Production of photovoltaic cells and modules

Table 4: Production and production capacity information for 2006

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 mc-Si	-	0.5	-	-	2	-
Day4Energy Inc.	sc-Si	-	0.5	-	-	10	-
Centennial Solar	sc-Si a-Si CIGS	-	1.10 0.10 0.15	-	-	3 MW / shift Included above	-
TOTALS	Sc-Si and mc-Si a-Sci CIGS		**2.10** **0.10** **0.15**			**15**	

Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 5.36 in 2006. This represents an average annual price reduction of 9% over the 7-year period.

Table 4a. Module prices (CAD/W) for 1999-2006

Year	1999	2000	2001	2002	2003	2004	2005	2006
Weighted Average prices	11.09	10.70	9.41	7.14	6.18	5.53	4.31	5.36
Trend in Price reduction	-	3.5%	12%	24%	13%	10%	22%	-24%

3.3 Manufacturers and suppliers of other components

There are over 150 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 Industry Association and Energie Solaire Quebec. The Canadian PV manufacturing sector has grown significantly in the last five years to serve both the domestic and export market. There was a small increase in manufacturing employment in Canada from 627 in 2005 to 645 in 2006. The largest manufacturers continue to be Xantrex, Carmanah, Automation Tooling Systems and ICP Global. Other Canadian companies that have recently expanded their operations include:

Day4Energy Inc. formed in 2001 in Burnaby, British Columbia, a manufacturer of PV modules and sun concentrator receivers for a variety of applications ranging from one-sun flat panel modules to specialized photovoltaic receivers designed to operate under sun concentration ratios of up to 7-times above normal levels has moved to a new and larger facility in 2006 that is serving as a launching pad for the company's first commercial production line. This move was an important millstone for the company as it marked its official transition from pure research and development to the commercialisation phase along the technology innovation chain. Also, in 2006, the Company received certification from the Underwriters Laboratory of its first product, the DAY4 48MC solar module – a product line is based on the company's patented Day4™ electrode technology. The company continues to push forward with its sun concentrator program that holds the promise of dramatic cost reduction of PV power generation in the near future[ix] .

ARISE Technologies Corporation[x], based in Kitchener, Ontario, is a Canadian-based public solar technology company, whose goal is to help solar energy become a cost-effective, mainstream energy solution. The company has two divisions: the ARISE PV Technology Division is developing a, high-efficiency solar cell based on proprietary patented technology, with plans to be in production in 2007; and, the ARISE Systems Division provides a complete range of renewable energy solutions. In 2006 the Company received funding from the Saechsische Aufbaubank GmbH in Germany towards the building of an 80 MW PV production facility in Bischofswerda, near Dresden. It is expected that the facility will be in operation in the second quarter of 2008.

Based in Calgary, Alberta, Sustainable Energy Technologies Ltd. is develops and markets advanced power electronics products for the emerging alternative and renewable energy markets. Sustainable Energy's main product line is the SUNERGY series of inverters for solar PV applications. The first product is a 5 kW inverter for European grid-connected markets. In 2006, it

entered into agreements with Barcelona based companies Gabriel Benmayor SA and Free Power SL to jointly manufacture and distribute SUNERGY 5 inverters in Spain. The Company's corporate vision is to "play a key role in the advancement of all clean energy technologies by developing and marketing of the most technologically advanced power electronics in the industry, by strategically partnering with the largest and most established players in the market.''

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 2006

Category/Size	Typical applications in Canada	Current prices (CAD/W)
Off-Grid (≤ 1 kW)	Mainly remote cottage power supply	17.3
Off-Grid (>1 kW)		NA
Grid-Connected Specific case		NA
Grid-Connected (≤ 10 kW)	Commercial, institutional roof-mounted	10
Grid-Connected (>10 kW)	100 kW installation at Exhibition Place, Toronto	10

Table 5a: National trends in turnkey prices (CAD) of typical applications from 1999-2006

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

Grid-Connected (>10 kW)							12.60	10

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by about 11% in 2006 to 1080 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	**2006**
R&D (public) [1]	50
Manufacturing [2]	650
Other[3]	380
Total	**1080**

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 1996-2006

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total labour	169	201	220	250	260	275	535	615	765	975	1080
Annual growth	-	19%	10%	14%	4%	6%	94%	15%	24%	27%	11%

3.6 Business value

The total commercial activity from Canadian PV companies was estimated to be CAD 201M in 2006 up from CAD 150M in 2005. 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 34% growth is mainly due to manufacturing revenues reported by 13 manufacturers that increased by 30% to CAD 137M of which about CAD 111M 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 1992-2006

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Million CAD	18	17	17	25	28	33	38	40	42	45	95	100	125	150	201
Annual growth	-	-6%	0	47%	12%	18%	14%	5%	5%	7%	111%	5%	25%	20%	34%

4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

Table 7: PV support measures (Canada 2006)

	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. It will encourage the production of 14.3 terrawatt hours of new electricity from renewable energy sources. It will provide an incentive of one cent per kilowatt-hour for up to 10 years to eligible low-impact, renewable electricity projects constructed over the next four years, April 1, 2007 to March 31, 2011. http://www.ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/index-eng.cfm
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

Overview of the Government of Ontario's Renewable Energy Standard Offer Program

In the fall of 2006, the Province of Ontario, through the Ontario Power Authority (OPA) and the Ontario Energy Board (OEB), launched its feed-in tariff, the Standard Offer Program (SOP)[xi] for the Province. The SOP is designed to encourage and promote the greater use of solar photovoltaic, as well as other renewable energy sources including wind, waterpower and biomass that would be connected to the electricity distribution system of Ontario. To qualify under the SOP, the applicants must be willing to make the necessary investments in their facilities and in the costs of connection to the distribution system and metering, bear certain ongoing costs of operation and maintenance, and enter into a contract with the OPA pursuant to which the OPA will pay the Generator for electricity delivered for a 20 year payment period. The SOP guarantees payment of CAD $0.42/kWh for grid-tied PV projects less than 10 MW for a contract term of 20 years. For all other Generators, they will be paid an initial base price of CAD$0.11/kWh (after May 1, 2007 the price will increase annually with inflation), plus a performance incentive of an additional CAD $0.352/kWh for Generators who can control their output to meet peak demand requirements reliably over time. The SOP, will help Ontario meets its renewable energy supply target of having 2,700 megawatt of electrical power generated by new renewable energy sources by 2010, by providing a standard pricing regime and simplified eligibility, contracting and other rules[xii] for small renewable energy electricity generating projects.

4.2 Indirect policy issues

No significant policy issues are being found with stand-alone PV systems, which comprise 95% 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[xiii] 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. There are three project areas 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 federal government is continuing work in 2006 on the Net-Metering Project to identify and eliminate barriers to the introduction of net metering in the electricity sector. 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 5). 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.

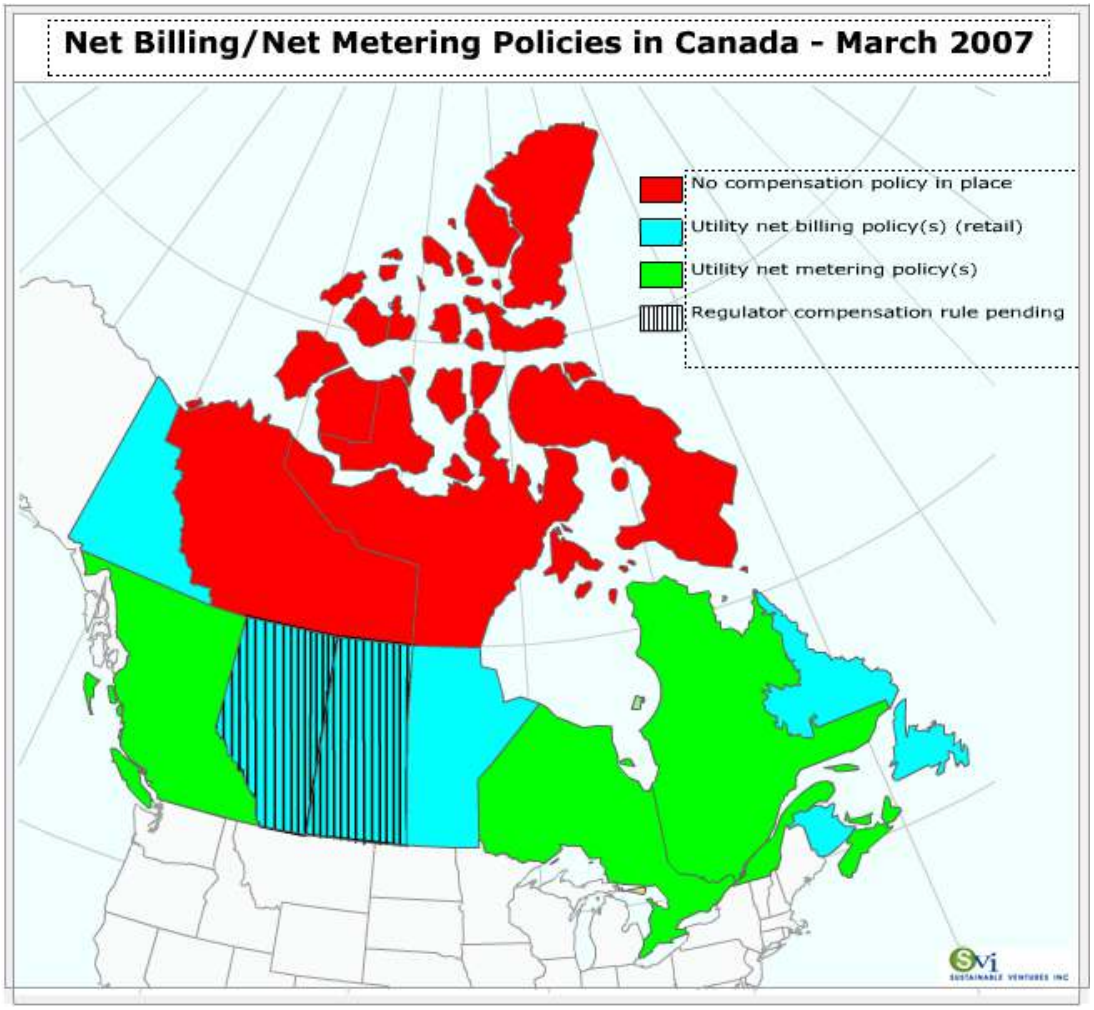

Figure 5: Net-metering landscape in Canada in 2006-2007.

4.3 Standards and codes

In 2006, the Micropower-Connect Technical Committee announced that Canadian Standards Association (CSA) has released the first Canadian interconnection standard. This standard entitled "Interconnecting inverter-based micro-distributed resources to distribution systems" is the result of the adoption and revision of the MicroPower Connect Guideline that was first published in July 2003. This new National Standard of Canada (CAN/CSA-C22.2 No. 257-06), one of a

series of Standards issued by the CSA under Part II of the Canadian Electrical Code, specifies the electrical requirements for safe interconnection of inverter-based micro-distributed resource (micro-DR) systems connected to 600 V (nominal) or less distribution systems (single or three phase).

Canadian experts participated in the development of international standards within the International Electrotechnical Commission'. 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. In 2006 Canada was continuing to work on adopting them.

5 HIGHLIGHTS AND PROSPECTS

The Province of Ontario's Renewable Energy Standard Offer Program (RESOP) launched on November 22, 2006 is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. The SOP in its initials stage will most likely stimulate the market leaders or "early adopters" to purchase PV systems, and hopes to attract investment into 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 (SBRN), which began its R&D mandate in 2006, 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. 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. The Canadian Solar Industries Association[xiv] and Énergie Solaire Québec[xv] have continued their promotional and marketing activities. CanSIA in particular has been very active in 2006 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 47 PV industry players of which 36 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 2006 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 2006.

The estimated PV module capacity installed in Canada in 2006 is estimated to be 3.74 MW (±10%). An additional 990 kW (±15%) were exported.

ENDNOTES

[i] Exhibition Place, Toronto: http://www.explace.on.ca/
[ii] Monitored Performance of 100 kW PV system at Horseshoe Palace: http://view2.fatspaniel.net/FST/Portal/TorontoHorsePalace/
[iii] Fred Kaiser Building: http://www.sustainablebuildingcentre.com/learn/fred_kaiser_building_at_ubc
[iv] Alberta Solar website: http://www.lassothesun.ca/index.htm.
[v] Canada Mortgage and Housing Corporation website: http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/index.cfm
[vi] Photovoltaic (PV) potential and insolation web-based maps: https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php
[vii] Micropower Connect Website: http://www.powerconnect.ca/mpc/index.htm
[viii] Net Metering update in Canada website: http://www.powerconnect.ca/net/index.htm
[ix] Day4Energy website: http://www.day4energy.com/press_day4energy.htm.
[x] ARISE website: http://www.arisetech.com/component/option,com_frontpage/Itemid,1/.
[xi] Renewable Energy Standard Offer Program website: http://www.powerauthority.on.ca/sop/
[xii] The Program Rules for the Renewable Energy Standard Offer Program, as prepared by the OPA, are available for download at http://www.powerauthority.on.ca/sop/Page.asp?PageID=122&ContentID=4107&SiteNodeID=162&BL_ExpandID=161
[xiii] Micro-power Connect website: http://www.power-connect.ca/english/index.htm
[xiv] Canadian Solar Industries Association: http://www.cansia.ca/
[xv] Énergie Solaire Québec: http://www.esq.qc.ca/