



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 2008

Prepared by

Josef Ayoub
ExCo from Canada & Task 1 Representative

In collaboration with

Dr. Lisa Dignard-Bailey
CanmetENERGY
Innovation and Energy Technology Sector
Department of Natural Resources Canada
P.O. Box 4800, Varennes, Québec
CANADA J3X 1S6

May 2009

Table of Contents

| | |
|--|-----------|
| Definitions, symbols and abbreviations..... | 3 |
| Foreword | 6 |
| Introduction | 6 |
| 1 Executive summary | 7 |
| 2 The implementation of PV systems..... | 7 |
| 2.1 Applications for photovoltaics..... | 7 |
| 2.2 Total photovoltaic power installed | 8 |
| 2.3 PV implementation highlights, major projects, demonstration and field test programmes..... | 9 |
| 2.4 Highlights of R&D..... | 14 |
| 2.5 Public budgets for market stimulation, demonstration / field test programmes and R&D | 15 |
| 3 Industry and growth | 16 |
| 3.1 Production of feedstocks and wafers..... | 16 |
| 3.2 Production of photovoltaic cells and modules..... | 16 |
| 3.3 Manufacturers and suppliers of other components..... | 17 |
| 3.4 System prices | 18 |
| 3.5 Labour places | 19 |
| 3.6 Business value..... | 19 |
| 4 Framework for deployment (Non-technical factors)..... | 20 |
| 4.1 Indirect policy issues..... | 20 |
| 4.2 Standards and codes | 21 |
| 5 Highlights and prospects | 22 |
| | |
| Annex A Method and accuracy of data..... | 23 |
| Annex B Country Information..... | 24 |

Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS 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/m², cell junction temperature of 25°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 system in a remote area are excluded).

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

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

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

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.

Currency: The currency unit used throughout this report is CAD (Canadian dollar)

PV support measures:

| | |
|---------------------------------------|---|
| Enhanced feed-in tariff | an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer |
| Capital subsidies | direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost |
| Green electricity schemes | allows customers to purchase green electricity based on renewable energy from the electricity utility, usually at a premium price |
| PV-specific green electricity schemes | allows customers to purchase green electricity based on PV electricity from the electricity utility, usually at a premium price |
| Renewable portfolio standards (RPS) | a mandated requirement that the electricity utility (often the electricity retailer) source a portion of their electricity supplies from renewable energies (usually characterized by a broad, least-cost approach favouring hydro, wind and biomass) |
| PV requirement in RPS | a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside) |
| Investment funds for PV | share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends |
| Income tax credits | allows some or all expenses associated with PV installation to be deducted from taxable income streams |

| | |
|-----------------------------------|--|
| Net metering | in effect the system owner receives retail value for any excess electricity fed into the grid, as recorded by a bi-directional electricity meter and netted over the billing period |
| Net billing | the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price |
| Commercial bank activities | includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems |
| Electricity utility activities | includes 'green power' schemes allowing customers to purchase green electricity, large-scale utility PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models |
| Sustainable building requirements | includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy footprint or may be specifically mandated as an inclusion in the building development |

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

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is Canada's National Survey Report for the year 2008. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 EXECUTIVE SUMMARY

- **Installed PV power:** Canada's total PV power installed capacity increased 27% in 2008 to 32.72 MW compared to 25.80 MW at the end of 2007. The 2008 domestic PV module sales volume totalled 6.94 MW compared to 5.29 MW in 2007 – an increase of 31% in the one-year period. The 2008 PV module export sales totalled 21.32 MW compared to 7.33 MW in 2007 – about 190% increase from the previous year. Total PV sales in Canada (domestic and export) in 2008 were at 28.26 MW a 125% increase over the previous year. The growth of the PV market in Canada has been averaging 26% annually since 1993, and about 36% annually since 2000. In 2008, the largest module sales domestically occurred in the off-grid market (both residential and non-residential) with about 66% of market share while the grid-connected has seen its share of the market grow to 34% in 2008.
- **Costs & prices:** Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 3.91 in 2008. This represents an average annual price reduction of slightly over 10% over the 9-year period.
- **PV production:** There was a 53% increase in full-time, labour place equivalent employees engaged in PV activities in the public and private sectors (R&D, manufacturing, distributors, dealers, retailers, system installers, consultants and developers) in Canada in 2008. The largest increase reported has been in the manufacturing sector (modules, BOS and silicon feedstock) at 58% above 2007.
- **Public budget for PV:** Total public budgets in Canada showed a significant decrease of about 28% in 2008 over the previous year. This is due to large in the completion of the demonstration funding program TEAM that funded several high profile PV demonstrations over the last 10 years.

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 (84%) 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 30% of domestic PV sales in 2008. The domestic off-grid market remains at about 36% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. Sales in the grid-connected market accounted for 34% of total sales in Canada in 2008. This is a growing application sector spurred by the new Province of Ontario's feed in tariff launched in 2006, and currently undergoing a major revision that will facilitate 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 17 years. The cumulative installed off-grid power capacity was 27.48 MW in 2008 which represented 85% of the total installed in Canada. This is an unsubsidised market whereby 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 2008 grew by 166% over the previous year largely spurred by the Ontario Renewable Energy Standard Offer Program. This market sector has been averaging growth rates of 40% since 2000, with the strongest spurts in the last four years.

In 2008 the modules sales in Canada (excluding subsequent exports) grew by 31% 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 2008, total modules sales (domestic and export) reached 28.26 MW, an increase of 124% over the previous year of which 79% were for on-grid applications (distributed), and 21% for off-grid applications (residential and non-residential).

Table 1 - The PV power (kW) installed in 4 sub-markets in Canada during 2008.

| Sub-market/ application | off-grid domestic | off-grid non-domestic | grid-connected distributed | grid-connected centralized | Total |
|--|-------------------|--------------------------|-------------------------------|-------------------------------|--------------|
| PV power installed in 2008 (kW) | 2 515 | 2 103 | 2 326 | 0 | 6 944 |

Table 2. The cumulative installed PV power (kW) in 4 sub-markets in Canada in 2008.
(As of December 31 of each year)

| Sub-market / application | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|--|------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 | 10603 |
| 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 | 16 879 |
| Grid- Connected distributed | 167 | 194 | 195 | 212 | 241 | 254 | 257 | 287 | 305 | 342 | 368 | 405 | 476 | 1 059 | 1 443 | 2 846 | 5 172 |
| Grid- Connected centralized | 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0* | 0 | 36 | 65 | 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 | 32 719 |
| 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 | 27 482 |

* 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 | 2008 |
|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 958* | 280 | 272 | 350 | 700 | 820 | 1 090 | 1 356 | 1 328 | 1 682 | 1 161 | 1 833 | 2 054 | 2 862 | 3 738 | 5 291 | 6 944 |
| - | - | -3% | 29% | 100% | 17% | 33% | 24% | -2% | 27% | -31% | 58% | 12% | 39% | 31% | 42% | 31% |

* 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 2008.

The Government of Ontario's Renewable Energy Standard Offer Program – 2008 update

In 2008, the Province of Ontario's Renewable Energy Standard Offer Program (RESOP) has exceeded all expectations - achieving in excess of 1,000 megawatts of contracted projects - surpassing the 10-year target for renewable energy, in the first year. Because of its popularity, the OPA, in the first quarter of 2008, undertook a comprehensive review of the Program in order to implement several changes that it has learned since the RESOP's inception to ensure its continued success.

Summary of the province of Ontario RESOP Contracts in 2008 (January-December)

(rounded to the nearest kW)

| RE Source | # Contracts | Capacity (kW) |
|--------------|-------------|------------------|
| Solar PV | 290 | 525,581 |
| Wind | 93 | 745,516 |
| Water Power | 20 | 66,879 |
| Bio-Energy | 21 | 73,728 |
| TOTAL | 424 | 1,411,504 |

The planned improvements to the RESOP are intended to:

- "Make RESOP more efficient by requiring that projects make progress toward in service or else lose their contracts. This will provide opportunity to another project developer to participate in the standard offer program.
- Make RESOP open to more participants by restricting proponents to a single 10 MW project per feeder or transformer station. The OPA has opportunities for larger projects under its Renewable Energy Supply III competitive procurement process, where these larger projects belong.
- Encourage broader participation in the standard offer program by limiting any proponent to a maximum of 50 MW under development per technology at any one time. This means that once a developer brings their project into service, they are welcome to reapply for an additional RESOP contract.
- Simplify RESOP for micro-scale residential projects by removing the requirement for interval data for embedded generators.
- Implement a number of administrative revisions to the RESOP, in response to stakeholder concerns, in order to improve overall program efficiency and to further simplify the program."

ecoENERGY for Renewable Power

The ecoENERGY for Renewable Power (ecoENERGY RP) program which was announced in early 2007 by the Government of Canada as a component in a suite of initiatives to combat climate change and air pollution was revised in 2008 to address issues raised during the first year of operation. The ecoENERGY RP was designed to encourage the production of 14.3 terawatt-hours of clean electricity from low impact renewable energy sources, such as solar photovoltaic, wind, hydro, and biomass and ocean energy. In 2008, the program registered 227 projects for a total capacity of about 11,250 MW and signed 32 contribution agreements for about 1780 MW in capacity and expected payments of about 570 million CAD over 10 years. The objective of the program is to “position the low-impact renewable energy industries to make an increased contribution to Canada’s energy supply thereby contributing to a more sustainable and diversified energy future.”

Interconnection of Distributed Generation to the Electricity Grid

NRCan’s CanmetENERGY in partnership with key industry players and associations is undertaking 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.

In 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 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 Megawatt) 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. Tutorial material has been developed to promote and educate utility personnel that are tasked with conducting this interconnection “impact assessments” in Canada. In 2008, CanmetENERGY conducted targeted workshops designed under continuing education programs to support the training needs of the electricity industry in Canada.

Federal Programs in support of technology demonstration to market commercialization

Sustainable Development Technology Canada (SDTC) - an arms-length foundation that operates as a not-for-profit corporation, established by the Government of Canada in 2001 to support the development and demonstration of innovative technological solutions continued in 2008 to invest in clean energy technology solutions. SDTC works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian entrepreneurs, helping them to form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada. SDTC is the premier federally-funded body that leverages private sector resources to demonstrate market-ready technologies including solar photovoltaic.

Technology Early Action Measures (TEAM) - a federal interdepartmental technology investment Program that has supported late-stage development and first demonstrations of GHG-reducing technologies since its inception in 1998, has in 2008 began to wind-down its activities as its mandate came to an end. TEAM has invested nearly 130 million CAD in 150 projects with total investments of 1.16 billion CAD. It was instrumental in funding PV technology demonstrations in Canada with total investments of 12 million CAD in eight photovoltaic early market-entry ready projects – the most recent ones being the development and demonstration of combined solar PV and thermal power generation technologies in collaboration with the Canadian Solar Buildings Research Network, and the development and demonstration of solar powered stand alone next generation LED lighting with Carmanah Technologies Corporation and the City of Kelowna in the western Province of British Columbia.

Canada Mortgage and Housing Corporation's (CMHC's) EQUilibrium™ Sustainable Housing Demonstration Initiative¹ brings together the private and public sectors with the goal of developing homes that are designed and constructed based on the principals of occupant health and comfort, energy efficiency, renewable energy production, resource conservation, reduced environmental impact, and affordability. In 2007 the Minister responsible for CMHC announced the 12 winners of the first EQUilibrium™ competition and later that year one house, ÉcoTerra, was opened to the public. In 2008, construction of three new projects and one retrofit project were completed and the homes opened for public and industry tours:

- Inspiration – The Minto ecohome², a single family home built by Minto Group Inc., was unveiled in Ottawa and was designed to generate as much energy as it consumes on a yearly basis. It uses a grid-tied 6.2 kW PV system.
- Avalon Discovery 3³, a single family home built by Avalon Master Builder, was unveiled in Red Deer and was designed to generate 360 kWh more energy than it consumes on a yearly basis. It uses a grid-tied 8.3 kW Solarsave PV system, which is a building-integrated PV roofing tile (Figure 1).



Figure 1: The Avalon Discovery EQUilibrium™ House, Red Deer, Alberta, Canada. (Photo credit: Avalon Master Builder)

¹ For further information on the EQUilibrium™ Initiative go to www.cmhc.ca and search 'EQUilibrium'

² See: http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/inmiec/upload/Inspiration-Minto_E-Oct30.pdf

³ See: http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/avdi/upload/Avalon_E.pdf

- The Riverdale NetZero Project⁴, a duplex built by Habitat Studio & Workshop Ltd., was unveiled in Edmonton and was designed such that both housing units would generate 350 kWh more energy than they consume on a yearly basis. Each unit has a dedicated grid-tied 5.6 kW PV system (Figure 2).



Figure 2: The Riverdale Net Zero Energy duplex, Edmonton, Alberta, Canada. (Photo credit: CMHC)

- Now House^{TM 5}, developed by The Now HouseTM Project Inc., is a retrofit 60-year-old post-war house, in an established area of Toronto. It has significantly reduced its energy consumption while introducing renewable energy production to achieve a predicted reduction in annual greenhouse gases by 55%. It uses a grid-tied 2 kW PV system with a favourable provincial feed-in tariff that should allow the house to achieve net-zero electricity cost.

The PV production from all four projects will be monitored for a one-year period with a live feed from Fat Spaniel Technologies⁶.

The John Molson School of Business Concordia University, Montreal, Quebec

In 2008, the federal government through NRCan's CanmetENERGY in collaboration with Concordia University of the Canadian Solar Buildings Research Network and the Canadian solar industry (Day4Energy Inc, suppliers of the PV panels; Conserval Engineering, suppliers of the Solarwall® and Sustainable Energy Technologies, suppliers of the inverters) have completed the design and installation of a combined solar power and heat generation system on a new building

⁴ See: http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/rinezepr/upload/Riverdale_E-Oct30.pdf

⁵ See: http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/rinezepr/upload/Riverdale_E-Oct30.pdf

⁶ www.fatspaniel.com/fat-spaniel-in-action/live-sites/. The EQUilibriumTM Projects are listed under CMHC EQUilibrium Homes as the installer.

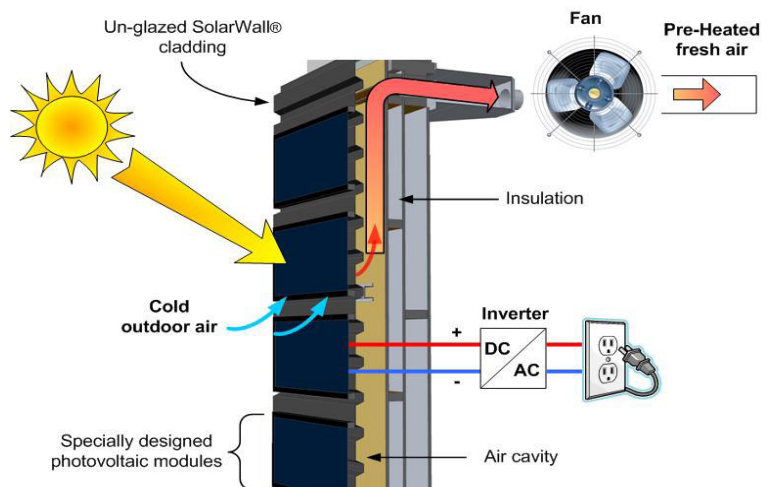
located at the university's headquarters in downtown Montreal (Figure 3). The integrated 24.5 kWp PV panels and the 75 kWp of heat by fresh-air solar heating with the SolarWall® cover approximately the top two floors of the building's south facing façade - approximately 300 sq. meters (Figure 4). This PV-T demonstration in a commercial building showcases innovative means by which buildings of the future could produce energy for their own use thereby reducing their demand on the electricity grid.



Figure 3: The combined solar PV – Thermal installation at the John Molson School of Business (JMSB), Concordia University, Montreal, Canada. (Photo credit: J. Ayoub, CanmetENERGY)



Figure 4: Schematic of the he combined solar PV – Thermal installation at the JMSB. (Credit: B. O'Neill, Canadian Solar Buildings Research Network)



2.4 Highlights of R&D

The federal photovoltaic activities are geared towards helping develop and deploy photovoltaic energy technologies in Canada. To this end two strategic approaches are being taken: to accelerate the deployment of this technology while supporting R&D activities. This mandate is funded by several federal sources including the Program of Energy Research and Development and the ecoENERGY Technology Initiative, and is implemented by NRCan's CanmetENERGY technology research centre located in Varennes, Quebec. The efforts undertaken provide stakeholders with the necessary information to make informed decisions. This includes the coordination of various research projects, participation in international committees on the establishment of standards, and producing information that will support domestic capacity-building. These efforts also actively seek innovative partnerships within the industry. Most research projects are carried out, on a cost-sharing basis, with industry, universities, research groups, quasi-public agencies, and other departments and governments. It also leverages its expertise by participating in international committees on photovoltaics, participating in joint projects with industry, developing software to assist in feasibility studies, as well as developing information and training tools. The aim of these activities is to generate knowledge and facilitate its communication to decision makers in Canada. On-going activities undertaken by the federal government in support of PV uptake in Canada in 2008 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;
- 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;
- 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 grid integration of decentralized energy resources and renewable energy into the main electrical grid is introducing a new paradigm of electric power generation and transmission: from where electrical power was generated in large power plants, sent to the consumption areas through transmission lines, and delivered to the consumers through a passive distribution infrastructure, to a distributed and dynamic power generation and smart grid infrastructure. CanmetENERGY is responsible for delivering on the R&D mandate of the Grid Integration of Renewable and Distributed Energy Resources (DER) – a Program that supports national science and technology efforts that will contribute to the modernization of the electricity grid network, enhance the benefits of renewable and clean distributed energy resources, increase the diversity and reliability of supply, and facilitate recovery after disruptions. While numerous benefits are associated with this change, such a transition also represents many challenges for all stakeholders (utilities, independent power producers, governments, regulators, manufacturers, housing industry). Through the Energy Science and Technology funding, NRCan addresses the technical, institutional and regulatory barriers, with the aim of promoting the grid integration of clean power including photovoltaic.

The Canadian Solar Buildings Research Network (SBRN)⁷ continues to be in the centre of Canada's R&D into solar buildings by innovating solar energy production and efficiency of its use in commercial, institutional and residential buildings in Canada. The SBRN pools the R&D resources of eleven universities and federal departments to develop the future generation of experts knowledgeable in solar buildings research. In 2008, the SBRN and NRCan collaborated on a high profile demonstration of a combined solar heat and power generating system that was installed on the façade of a new building at Concordia University in downtown Montreal. The RD and D efforts of the SBRN are providing in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions, and are supporting innovation in the construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

Spurred by sustained investments from federal and provincial research funding agencies such as NSERC⁸, CFI⁹, and the Ontario Centres of Excellence¹⁰, the level of research activities in the field of solar cell R&D has increased again in 2008. At least over 40 researchers (professors and post-docs) in Canadian universities had active research programs in or closely related to a broad range of photovoltaic technologies such as organic solar cells, dye sensitized solar cells, thin silicon devices, high efficiency III-V multijunctions and advanced crystalline silicon solar cells. Out of this number, a core group of 25 academic scientists are in the process of creating a Photovoltaic Research Innovation Network in collaboration with industrial, provincial and federal partners. A strategic network grant application has been submitted to NSERC and a funding decision should be reached during fall 2009.

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

Total public budgets in Canada showed a significant decrease of about 28% in 2008 over the previous year. This is due to large in the completion of the demonstration funding program TEAM that funded several high profile PV demonstrations over the last 10 years.

Table 3. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2008 (CAD x 1000)

| | R & D | Demo/Field test | Market Incentives | Total |
|-------------------|--------------|-----------------|-------------------|--------------|
| Federal | 2 630 | 3 025 | 0 | 5 655 |
| Provincial | 1125 | 150 | 580 | 1 855 |
| Total | 2 445 | 3 175 | 580 | 7 510 |

Table 3a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2008 (CAD x 1000)

| Year | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|------|------|------|------|------|------|------|-------|--------|-------|
| Total combined (Federal, provincial) | 890 | 1500 | 1950 | 5955 | 8540 | 9800 | 7700 | 8 150 | 10 400 | 7 510 |
| Annual trends | - | 68% | 30% | 205% | 43% | 15% | -21% | 6% | 28% | -28% |

⁷ www.solarbuildings.ca

⁸ National Science and Engineering Research Council of Canada at <http://www.nserc-crsng.gc.ca/>

⁹ Canada Foundation for Innovation at <http://www.innovation.ca/en>

¹⁰ <http://www.oce-ontario.org/Pages/Home.aspx>

3 INDUSTRY AND GROWTH

3.1 Production of feedstock, ingots and wafers

There is production of solar grade silicon feedstock in Canada for 2008.

Table 4: Production and production capacity information for 2008 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 | 1,200 metric tonnes | Continued expansion of annual solar grade silicon production capacity to 14,400 mt with the commissioning of 5 th and 6 th production lines in Oct 2008. | Export (Q-Cells, Germany, other) | 58/kg (average selling price) ¹¹ |
| 6N Silicon Inc. | Solar grade Si feedstock | NA | 2000 T/yr | NA | NA |

3.2 Production of photovoltaic cells and modules

Table 5: Production and production capacity information for 2008

| 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 | - | 0.97 | - | - | 3 | - |
| | a-Si | | 0.10 | | | | |
| | CIGS | | 0.30 | | | | |
| Day4 Energy Inc. | sc-Si | - | 25+ | - | - | 97 (47 in Phase I growth completed and 50 in Phase II on schedule by Q1 2009) | - |
| ICP Global Inc. | sc-Si | - | NA | - | - | NA | - |
| | a-Si | | | | | | |
| | CIGS | | | | | | |
| TOTALS | sc-Si | | 25.97+ | - | - | 100+ | - |
| | a-Sci | | 0.10+ | | | | |
| | CIGS | | 0.30+ | | | | |

¹¹ Timminco average selling price for Q1 2009 as reported in <http://www.timminco.com/docs/TIM%20Investor%20Presentation%20May%20-%20FINAL.pdf>

Module prices have gradually declined from CAD 11.09 in 1999 to CAD 3.91 in 2008 (weighted average of price range from CAD 3.70 to CAD 8.00). This represents an average annual price reduction of slightly above 10% over the 9-year period.

Table 6. Module prices (CAD/W) for 1999-2008

| Year | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|--|-------|-------|------|------|------|------|------|------|------|------|
| Standard module price (weighted average) | 11.09 | 10.70 | 9.41 | 7.14 | 6.18 | 5.53 | 4.31 | 5.36 | 4.47 | 3.91 |
| Annual trends | - | -3.5% | -12% | -24% | -13% | -10% | -22% | 24% | -17% | -13% |

3.3 Manufacturers and suppliers of other components

There are over 300 solar energy companies (sales companies, wholesalers, product manufacturers, project developers, private consultants, systems installers and industry associations) operating in Canada. The Canadian PV manufacturing sector has grown significantly in the last six years to serve both the domestic and export markets. In the last two years, there have been increased investments in silicon feedstock production. Canadian-based Timminco Limited¹², a leader in the production of silicon metal for the electronics, chemical and aluminum industries entered into the production of solar grade silicon through its wholly-owned subsidiary, Bécancour Silicon Inc. (BSI) in its new facility in Bécancour, Québec in late 2007. In 2008, the company registered total production of 1,214 metric tons (mt) of solar grade silicon. Also in 2008, Timminco commissioned its fifth and sixth production lines bringing their production capacity to about 7,200 metric tons annually. The company is a supplier to Q-Cells, one of the world's leading cell manufacturer. They have also reported signing long-term contracts with leading solar cell manufacturers - up to 16,000 mt under contract beginning in 2010¹³.

In 2008, the REC Silicon, a division of Norwegian multinational group Renewable Energy Corporation has announced its intention to invest more than 1.2 billion CAD to build a polysilicon manufacturing plant at the Bécancour industrial and harbour park in Bécancour, Quebec. Construction of the plant is scheduled in phases and is anticipated to begin in 2010 with production starting in 2012. The plant is expected to employ more than 300 people in the region.

In 2008 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, announced its sale to Schneider Electric S.A., a global specialist in energy management with operations in more than 100 countries with headquarters in Rueil-Malmaison, France. "With this acquisition, Schneider Electric reinforces its growing leadership position in solutions for renewable energies to better meet market demands and customers' needs in Energy Efficiency. Schneider Electric expects to realize significant synergies, leveraging both companies' strengths with Xantrex's leading technology, products, market knowledge and distribution channels combined with its own global sales, service, supply chain and solutions capabilities."¹⁵

In addition, Day4Energy Inc.¹⁶ a manufacturer of PV modules, also based in Burnaby in the Province of British Columbia, announced in 2008 that it is meeting its plans to expand its production capacity to 97 MW in 2009. At the end of the third quarter of 2008, the company was operating a production facility capable of producing 47MW of product based on a three shift, 5 day week basis. Day4Energy also announced in 2008 that it has entered into a multi-year

¹² Timminco Ltd. Website: <http://www.timminco.com>

¹³ <http://www.timminco.com/PressRelease.aspx?id=24&prId=936484>

¹⁴ Xantrex Technology Inc. website: <http://www.xantrex.com>

¹⁵ Schneider Electric S.A. website: <http://www.schneider-electric.com/sites/corporate/en/home.page>

¹⁶ Day4 Energy Technology Inc. website: <http://www.day4energy.com/>

manufacturing supply agreement with Jabil Circuit Inc., a leading global electronic solutions company. Under the terms of the multi-year agreement Jabil will purchase from Day4 Energy certain equipment required for the manufacture and supply of the modules and produce Day4 Energy's brand of modules for residential and commercial applications.

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 85% of Canada's PV market is off-grid, and so embraces a wide range of PV system sizes, complexities, and system configurations. The off-grid residential market has not shown any changes in the average turnkey price per application.

Table 7: Turnkey prices (CAD) of typical applications in 2008

| Category/Size | Typical applications in Canada | Current prices (CAD/W) |
|---------------------------------|--|------------------------|
| Off-Grid (≤1 kW) | Mainly remote cottage power supply | 15 |
| Off-Grid (≥1 kW) | | NA |
| Grid-Connected Specific case | | |
| Grid-Connected (≤10 kW) | 7.0 kW Montreal Net Zero Energy House (integrated) | 6 - 7 |
| Grid-Connected (≥10 kW) | 25 kW (PV) and up 75 kW (thermal) PV-T demo on John Molson School of Business, Concordia University, Montreal. | 6 - 8 |

Table 7a: National trends in turnkey prices (CAD) of typical applications from 1999-2008

| CAD/W | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---------------------------------|------|------|-------------------|-------------------|-------------------|-------|-------|------|------|------|
| Off-Grid (≤1 kW) | 17 | 17 | 20 | 18 | 21 | 18.5 | 15 | 17.3 | 15 | 15 |
| Off-Grid (≥1 kW) | | | | | | | | | 7.70 | NA |
| Grid-Connected Specific case | | | | | | 13.50 | 12.50 | NA | NA | NA |
| Grid-Connected (≤10 kW) | 21 | 20 | Insufficient data | Insufficient data | Insufficient data | 14.50 | 10 | 10 | 8.5 | 6.5 |
| Grid-Connected (≥10 kW) | | | | | | | 12.60 | 10 | 10 | 6-8 |

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by about 53% in 2008 to 2,090 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. The main sector of the increase was in the manufacturing sector as silicon feedstock manufacturers ramped up their production.

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

| Year | 2008 |
|---|--------------|
| R&D (public) ¹ | 70 |
| Manufacturing ² | 1570 |
| Other³ | 450 |
| Total | 2 090 |
| 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 1996-2008

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Total labour | 169 | 201 | 220 | 250 | 260 | 275 | 535 | 615 | 765 | 975 | 1 080 | 1 370 | 2080 |
| Annual growth | - | 19% | 10% | 14% | 4% | 6% | 94% | 15% | 24% | 27% | 11% | 21% | 53% |

3.6 Business value

Reported overall revenues from commercial activities of 11 manufacturing operations and 20 other Canadian PV companies was estimated to be CAD 437 M in 2008 up from CAD 290 M in 2007. An additional CAD 9 M of revenue from sales inside and outside Canada of PV systems in the category of 40 Wp or less were reported by several companies. Also about CAD 70 M of revenues was generated by solar grade silicon manufacturer Timminco Ltd. (through its subsidiary Bécancour Silicon Inc.) in 2008¹⁷ bringing the total revenue from solar PV operations in Canada to a little over CAD 500 Million. 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 99% in 2008. Revenues from export sales rose by 609% from 2007, whereas domestic sales fell by 13% from last year.

¹⁷ From Timminco 2008 Annual report <http://www.timminco.com/report/>.

Table 8: Trends in PV business in Canada from 1992-2008

| Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 208 |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|
| 10 ⁶ CAD | 18 | 17 | 17 | 25 | 28 | 33 | 38 | 40 | 42 | 45 | 95 | 100 | 125 | 150 | 201 | 290 | 510 |
| Change | - | -6% | 0 | 47% | 12% | 18% | 14% | 5% | 5% | 7% | 111% | 5% | 25% | 17% | 34% | 44% | 76% |

4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

Table 9: PV support measures (Canada 2008)

No changes from reported in 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 Indirect policy issues

There have been no new federal initiatives supporting PV development that have been announced in 2008. However, the Province of Ontario’s Renewable Energy Standard Offer Program which exceeded all expectations underwent a comprehensive review of the Program in 2008 with a planned release of a new incentive program in 2009.

Regarding the net-metering landscape in Canada, electric power generation in Canada is a provincial jurisdiction. Canadian electricity customers who want to install renewable energy technology generating systems at their sites and interconnect them to their local utility grid may do according to their 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 (e.g. 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.

Net Billing/Net Metering Policies in Canada – December 2008

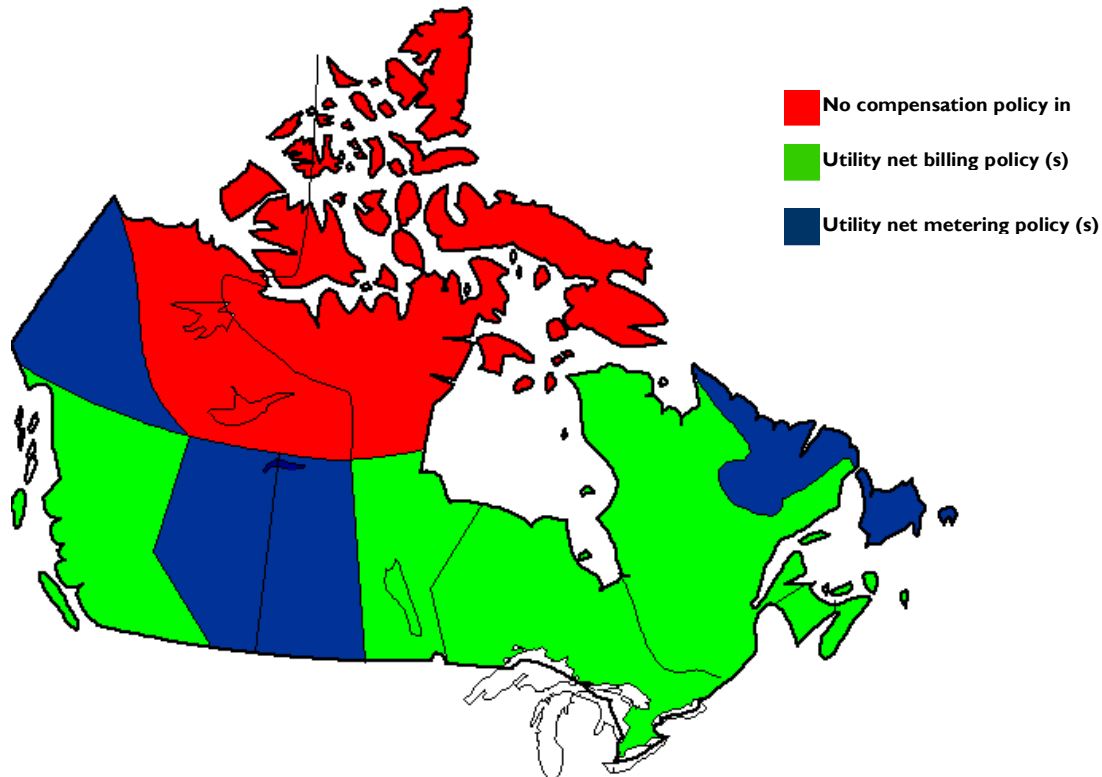


Figure 5: Net-metering landscape in Canada – 2008.

4.3 Standards and codes

In 2008, Canadian Standards Association (CSA) has published the Canadian interconnection standard CAN/CSA-C22.3 No.9-08 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".

The second edition of the Canadian Standards Association CSA-C61215 standard (Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval) was published by CSA in August 2008. Furthermore, Canadian experts participated in the

development of international standards within the International Electrotechnical Commission (IEC). The second edition of the IEC 61646 on design qualification and type approval for thin film PV modules was published by the IEC in May 2008. Also in 2008, a teleconference information session was organized to provide an update to the Canadian PV industry and CanmetENERGY provided an update on PV module standards during the annual meeting of the CSA Technical Committee on Solar Energy (C420) regarding the status of PV module standards and their adoption in Canada. This information session also allowed getting feedback from the Canadian industry on a number of issues related to PV module performance, manufacturing and standards.

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 2008, the RESOP had exceeded its 10-year target in its first year of operation with about 1411 MW of contracts signed, but project implementation delays have led to only 1.2 MW being connected to date.

Delays in connection queues in strategic areas of the province are being reviewed with intent to address the backlog of applications for connection to secondary distribution feeders. The Ontario Smart Grid Forum, managed by the Independent System Operator of Ontario, has made public its recommendations on the benefits of a Smart Grid, including improved system reliability, increased customer participation and environmental benefits such as improving the integration of smaller generators embedded in the distribution system.

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. 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. In addition the SBRN partners are contributing to two Canadian teams from universities in the provinces of Alberta and Ontario that will compete in the US Department of Energy sponsored Solar Decathlon competition that will take place in Washington, DC, in the fall of 2009.

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 2008 in developing the foundation for significant changes in policies 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 62 PV industry players of which 36 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 2008 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 2008.

The estimated PV module capacity installed in Canada in 2008 is estimated to be 6.944 MW ($\pm 10\%$). An additional 21.32 MW ($\pm 15\%$) were exported.

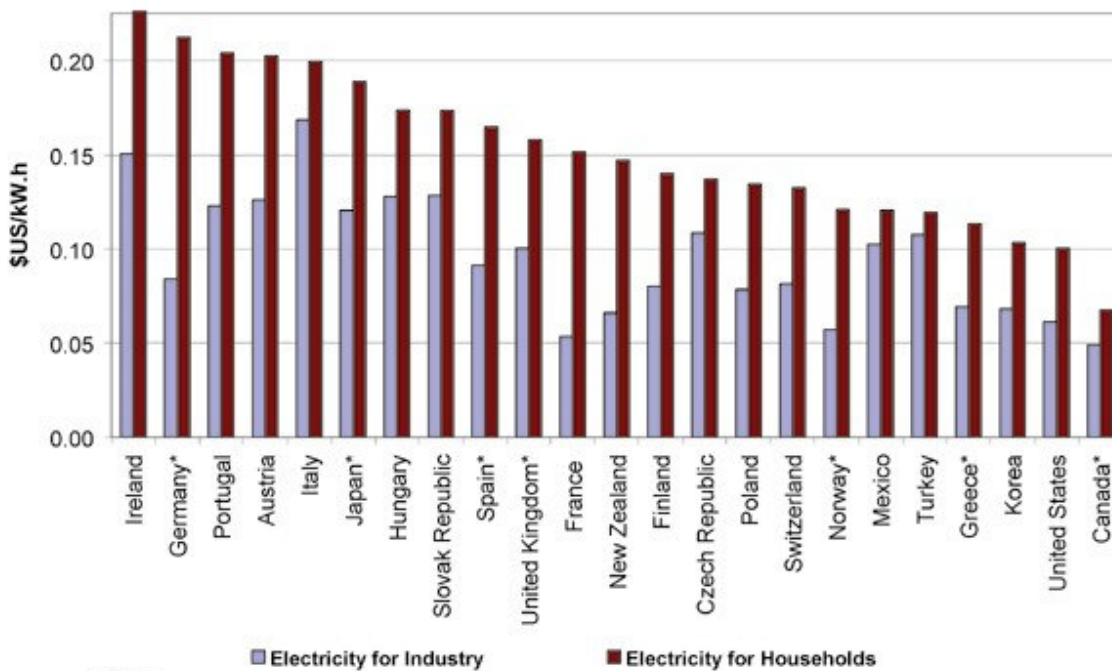
Annex B: Country information

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

Please provide the following, including a short reference as to the source of the information (for example, author's estimate, electricity supply association etc etc):

1. Retail electricity prices - household, commercial, public institution

Industry and Household Electricity Prices in Select Countries - 1st Quarter 2007



Notes:

* Earliest available data

Source: Government of Canada

<http://www.neb.gc.ca/clf-nsi/rnrgynfntn/prcng/lctrct/frqntlskdqstn-eng.html>

2. Typical household electricity consumption (kWh)

Extremely variable throughout the country. Check Environment Canada website:

<http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=1801BDDDB-1>

3. Typical metering arrangements and tariff structures for electricity customers (for example, interval metering? time-of-use tariff?)

Check the National Energy Board website for information;

<http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/lctrcty/lctrctymrks20052006-eng.pdf>

4. Typical household income.

Chart 2

Median after-tax income, families of two persons or more, Canada and Provinces, 2005 to 2006

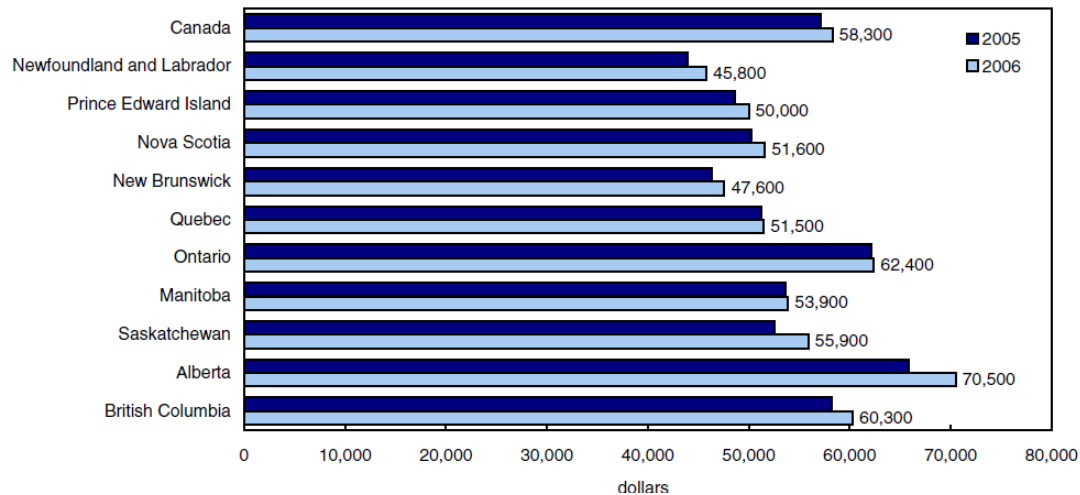
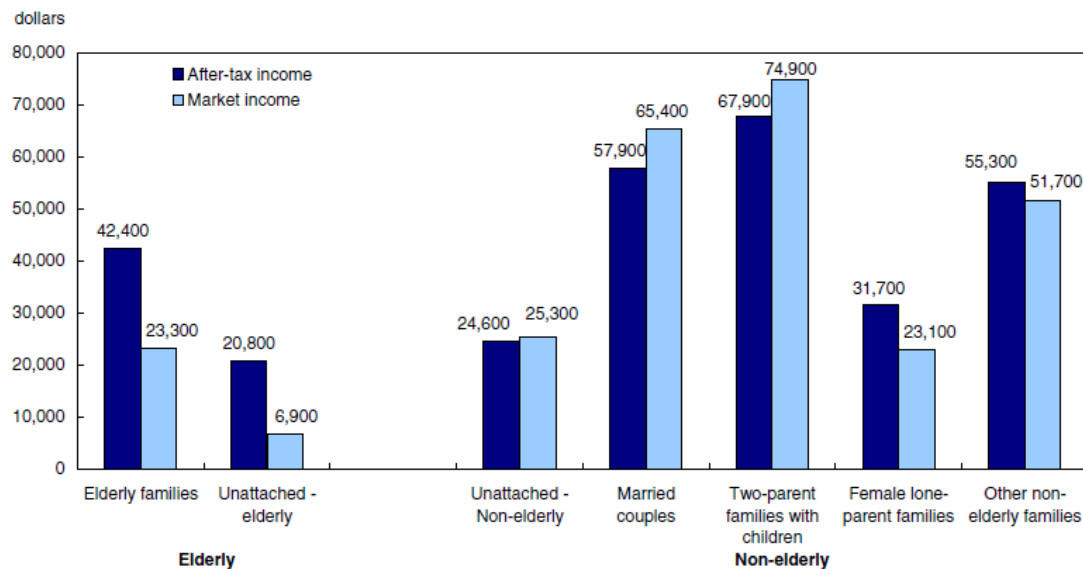


Chart 4

Median market and after-tax income by family types, Canada, 2006



Source: Government of Canada

<http://www.statcan.gc.ca/cgi-bin/af-fdr.cgi?!=eng&loc=http://www.statcan.gc.ca/pub/75-202-x/75-202-x2006000-eng.pdf&t=Income%20in%20Canada>

5. **Typical mortgage interest rate**
Varies at prime plus 0.60-2.5%. See
<http://www.nationalmortgage.ca/services/first.cfm?CFID=2770445&CFTOKEN=17419975>

6. **Voltage (household, typical electricity distribution network)**

AND

7. **Electricity industry structure and ownership (eg vertically integrated or separate generation, transmission, distribution?; retailers and network businesses – integrated or separate?; state owned or municipal or private etc?; electricity industry regulator?)**

See Canadian Electricity Association website at

http://www.canelect.ca/en/electricityincanada/electricity_in_canada_glossary.html

8. **Price of diesel fuel**
CAD 0.80-0.85 /litre

9. **Typical values of kWh / kW for PV systems in parts of your country.**
Interactive maps of the photovoltaic (PV) potential and solar resource of Canada have been developed by the Canadian Forest Service (Great Lakes Forestry Centre) in collaboration with the CANMET Energy Technology Centre (CETC-Varenes) Photovoltaic systems group. Insolation data was provided by the Data Analysis and Archive Division, Meteorological Service of Canada, Environment Canada. The maps give estimates of the electricity that can be generated by grid-connected photovoltaic arrays without batteries (in kWh/kW) and of the mean daily global insolation (in MJ/m² and in kWh/m²) for any location in Canada on a 300 arc seconds ~10 km grid. They are presented for each month and for the entire year, for six different PV array orientations: a sun-tracking orientation and five fixed South-facing orientations with latitude, vertical (90°), horizontal (0°) and latitude ± 15° tilts (see figure). Data can be obtained at any grid location by "querying" the maps.

<https://glfc.cfsnet.nfis.org/mapserver/pv/index.php?lang=e>