# International Energy Agency

## CO-OPERATIVE PROGRAMME

## ON PHOTOVOLTAIC POWER SYSTEMS

## Task 1

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## Exchange and dissemination of information on PV power systems

## National Survey Report of PV Power Applications in Canada

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## 2011

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## Table of Contents

## 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/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 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 foot print 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 27 members are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Union, the European Photovoltaic Industry Association, the Solar Energy Industries Association and the US Solar Electric Power 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 2011. 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 nearly doubled to reach 558.74 MW in 2011 compared to 281.13 MW at the end of 2010. Most PV installations in Canada in 2011 were made within the grid-connected market segment. This is a significant growth sector that is spurred by the new Province of Ontario's Feed-in Tariff (FIT) launched in 2006 and expanded in 2009. The grid connected applications included 37% for residential and building integrated applications, and 62% for large ground-mounted utility scale systems equal to or less than 10 MW.

**Costs & prices:** Module prices (weighted average) have gradually declined from CAD 9.41 in 2001 to CAD 1.51 in 2011. This represents an average annual price reduction of slightly over 16% over the 10-year period. The installed price for systems ranged between CAD 3.41 to 6.78 per watt for grid-connected installations, and CAD 12.95 per watt for off-grid systems that include on-site battery storage.

**PV Production:** A number of new PV module manufacturers established presence in Ontario stimulated by the FIT and its associated minimal made-in-Ontario content. An estimated 158 MW of PV modules were manufactured in Canada in 2011.

**PV labour:** There are 5320 full-time, labour places equivalent engaged in PV activities in the public and private sectors (R&D, manufacturing, distributors, dealers, retailers, system installers, consultants and developers) in Canada in 2011 compared to 5440 in 2010.

**Public budget for PV:** Total public budgets in Canada increased significantly to $187 million CAD, an increase of more than 200% due to the FIT market incentive program in the province of Ontario that ranged between CAD 0.80 to 0.44 per kilowatt hour prior to 2012. The balance of this budget which funded R&D and demonstration budget was CAD $13 million in 2011.

## 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

The grid-connected market accounted for 34% of total sales in Canada in 2008 and reached close to 100% in 2011. This is a significant growth sector that is spurred by the Province of Ontario's FIT launched in 2006 and expanded in 2009. Of the grid connected applications, 37% of the installed MW was for residential and building integrated applications, and 62% for several large ground-mounted utility scale systems equal to or less than 10 MW.

The off-grid applications are not subsidized and represented less than 1% of PV systems installed in Canada in 2011. This consists 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 becomes more aware of opportunities. The "domestic" off-grid market consists primarily of remote homes and cottages, residential communication (radios), and recreational vehicles. The off-grid non-residential market consists of water pumping, road signals, navigational buoys, telecommunication repeaters, and industrial sensing, monitoring, and controlling.

### 2.2 Total photovoltaic power installed

As shown in Table 1, the installed off-grid power capacity in 2011 was 0.949 MW compared to 276.66 MW for the grid-connected market. This is a significant transition for the PV industry that historically served mainly the off-grid market.

The subsidies provided by the Ontario Power Authority for both rooftop and ground mounted photovoltaic installation led to a significant market increase of 49% in Canada in 2011 (Table 2a). Grid-connected applications installed on buildings in Canada in 2011 amounted to 131.58 MW.

Grid-connected centralized applications amounted to 366.11 MW in 2011. These installations were all made in Ontario were operators receive a rate of 0.42 or 0.44 CAD per kWh generated. It should be noted that the Ontario Power Authority reports the installed power in $MW_{AC}$. A derate factor of 0.85 was used to convert between DC and AC power.

**Table 1 - The PV power (MW) installed in 4 sub-markets in Canada in 2011.**

| Sub-market/ application | off-grid domestic | off-grid non-domestic | grid-connected distributed | grid-connected centralized | Total |
|---|---|---|---|---|---|
| **PV power installed** | 0.458 | 0.491 | 103.839 | 172.824 | **277.612** |
| **Market %** | 0.1 % | 0.2 % | 37.4 % | 62.3 % | **100 %** |

**Table 2. The cumulative installed PV power (MW) in 4 sub-markets in Canada in 2011.**

**(As of December 31 of each year)**

| Sub-market / application | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Off-grid domestic | 0.19 | 0.31 | 0.45 | 0.61 | 0.86 | 1.38 | 2.15 | 2.54 | 3.32 | 3.85 | 4.54 | 5.29 | 5.90 | 6.68 | 8.09 | 10.60 | 15.19 | 22.85 | 23.31 |
| Off-grid non-domestic | 0.84 | 0.99 | 1.19 | 1.70 | 2.26 | 2.82 | 3.38 | 4.30 | 5.16 | 5.78 | 6.89 | 8.08 | 9.72 | 12.30 | 14.77 | 16.88 | 20.01 | 37.25 | 37.74 |
| Grid- Connected distributed | 0.19 | 0.20 | 0.21 | 0.24 | 0.25 | 0.26 | 0.29 | 0.30 | 0.34 | 0.37 | 0.40 | 0.47 | 1.07 | 1.44 | 2.85 | 5.17 | 12.25 | 27.74 | 131.58 |
| Grid- Connected centralized | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0* | 0 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 | 47.12 | 193.29 | 366.11 |
| **TOTAL** | **1.23** | **1.51** | **1.86** | **2.56** | **3.38** | **4.47** | **5.83** | **7.15** | **8.83** | **10.00** | **11.83** | **13.88** | **16.75** | **20.48** | **25.77** | **32.72** | **94.57** | **281.13** | **558.74** |
| **Total off-grid** | **1.03** | **1.30** | **1.64** | **2.31** | **3.12** | **4.20** | **5.53** | **6.84** | **8.48** | **9.63** | **11.43** | **13.37** | **15.62** | **18.98** | **22.86** | **27.48** | **35.20** | **60.10** | **61.05** |

**Table 2a. Trends in Annual Installed PV capacity in Canada (MW as of year end)**

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.27 | 0.28 | 0.35 | 0.70 | 0.82 | 1.09 | 1.36 | 1.32 | 1.68 | 1.17 | 1.83 | 2.05 | 2.87 | 3.74 | 5.29 | 6.95 | 61.85 | 186.56 | 277.61 |
| - | -3% | 29% | 100% | 17% | 33% | 24% | -2% | 27% | -31% | 58% | 12% | 39% | 31% | 42% | 31% | 791% | 202% | 49% |

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

***The Government of Ontario's Feed-In tariff program***

The Province of Ontario, Canada's second largest province, leads the country in photovoltaic (PV) investment. Ontario's Feed-In Tariff program [6], managed by the OPA, is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar PV, bioenergy, waterpower and wind. The incentive program is divided into two streams, one targets the small, medium and large renewable energy projects generating more that 10 kW of electricity (referred as the "FIT Program"), and the other targets very small renewable projects generating 10 kW of electricity or less, such as home or small business installations (referred to as the "microFIT Program") . Prices paid for renewable energy generation under FIT and microFIT programs vary by energy source and take into account the capital investment required to implement the project. Under the program, solar PV owners enter into a 20 year contract with the OPA to receive a fixed price of up to 0.802 CAD per kWh for the electricity they generate (Table 10a).

In October 2011, the province of Ontario began its scheduled 2-year FIT review. Supporting the emergence of a green energy economy in Ontario, the hallmarks of the program include a 20 year generation contract at a guaranteed rate per kW produced, and a 25%-60% (depending on the project type)

requirement of the content (goods and labour) to come from within the province. The effects of this program on the solar industry in Canada have been noted in previous reports, highlighting the benefits on the market competition and decreasing prices.

In response to the public call for feedback CanSIA, the national trade association for the solar energy industry, submitted a formal report of recommendations generated in consultation with its member companies. The CANSIA report recognized the significant impact that the FIT program has had on the industry, and identified thresholds for a sustainable solar industry in Ontario. If provided at least 500 MW of demand for new projects annually, CanSIA predicts the establishment of a competitive sector. It further predicts that this level of demand leading up to 2018 is achievable under the province's renewable generation and conservation targets as part of the Long-term Energy Plan, creating some 17,000 jobs in that time.

***The changing face of PV financing - de-risking investment finance for PV projects through co-operatives.***

*SolarShare* is a non-profit co-operative that allows individual Ontario investors to buy $1000 bonds with a guaranteed 5% return over 5 years. For an economy still recovering from a recession and the future of pensions less certain, these bonds are considered attractive and especially low-risk because they are applied to already existing projects with 20 year contracts through the Ontario Power Authority FIT program. The initial capital funding of over $3.7 million was raised privately for the riskier phase of constructing 18 projects. That initial capital is recovered through the bonds and made available for future investment. Bond holders become members of the co-op with voting rights and thus are further engaged in issues surrounding the development of the local solar industry.[1]

AGRIS Solar[2] working with farmers in Ontario, and the Community Power Fund[3] are examples of two other co-op organizations enabling citizen investment in PV projects with predictable returns made possible through the FIT program. In addition, non-profit organizations like the Ontario Sustainable Energy Association and the Community Energy Partnership Program are facilitating community co-operative investments in solar with toolkits, workshops and user group forums and grant money for the initial start-up.

***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 2009 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.

***Alberta Solar Showcase Demonstration Project***

In provinces without Feed-In Tariff programs, such as Alberta, de-risking consumer investment in PV systems is being explored by local utilities such as Calgary's ENMAX. ENMAX obtained the initial $14.5M capital through the Climate Change and Emissions Management Corporation funded by the Alberta government. It offers installed systems with 15-year lease-to-own programs with a parts and labour warranty as well as ongoing service agreements. With net metering customers discount their monthly electricity bills

[1] http://solarbonds.ca
[2] http://www.agrissolar.coop
[3] http://cpfund.ca and http://www.ontario-sea.org/Storage.asp?StorageID=3571

according to the amount they generate.[4]

***Large Scale Demonstration Projects in British Columbia target net-zero energy consumption***

In 2011, Okanagan College[5] demonstrated its environmental leadership and innovative education programs by building the Jim Pattison "Centre of Excellence" in Sustainable Building Technologies and Renewable Energy Conservation on its Penticton campus in British Columbia. Okanagan College is a publicly-funded post-secondary institution that offers degree, diploma, certificate and Continuing Studies courses to more than 20,000 people annually. It is a leader in sustainability in Western Canada. Its Centre of Excellence has been built and will be operated to achieve the Living Building Challenge, which is among the world's most-demanding guidelines for sustainable construction.

SkyFire Energy was the project developer for the 260 kW solar energy system that used 1,106 Conergy solar modules on the rooftop of Okanagan College's newest building on its Penticton campus (Figure 1). The building was designed to meet the ambitious targets of the Living Building Challenge (illb.org), which requires net-zero energy and water consumption. The innovative features of the building itself are going to be used as a teaching tool to help train the next generation of students in green construction practices.

Figure 1. This large 260 kW rooftop solar Photovoltaic system was installed at the Okanogan College in British Columbia in 2011. (Photo: Skyfire Energy)

## 2.4 Highlights of R&D

***Canadian PV Innovation Network:***

[4] http://www.generatechoice.ca
[5] Naming of the Jim Pattison Center of Excellence - http://www.okanagan.bc.ca/page26539.aspx

The new PV Innovation Research Network[6], funded by the Natural Sciences and Engineering Research Council (NSERC), brings together a core group of 25 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners. The network will focus its efforts on organic, nanostructure and other innovative PV device approaches that have the potential to leapfrog existing and established technologies. In addition, there is new cross-agency collaboration with the Business Development Bank of Canada to support research partnerships with industry in the field of nanomaterials that includes 2.9 million CAD. Training, technology transfer and commercialization of R&D results are also part of the network's mandate. This new Canadian PV Innovation network is a major step in strengthening university R&D and support for PV technology development in Canada.

***Natural Resource Canada, CanmetENERGY R&D:***

CanmetENERGY is responsible for conducting R&D activities in Canada that facilitate the deployment of PV energy technologies throughout the country. The PV program coordinates national research projects, contributes to international committees on the establishment of PV standards, produces information that will support domestic capacity-building and organizes technical meetings and workshops to provide stakeholders with the necessary information to make informed decisions. Most research projects are carried out, on a cost-sharing basis, with industry, universities, research groups, quasi-public agencies, and other departments and governments. CanmetENERGY also leverages its expertise by participating in international committees on photovoltaic, participating in joint projects with industry, developing software to assist in feasibility studies, as well as developing information and training tools.

CanmetENERGY is leading a large international collaboration for the IEA-SHC/ECBS Task 40/Annex 52, entitled "Towards Net Zero Energy Solar Buildings". Its objective is to study current net zero, near net zero and very low energy buildings and to develop a common understanding of a harmonized international definitions framework, tools, innovative solutions and industry guidelines. To achieve this objective, Task/Annex experts from 18 countries, including Canada, are documenting research results and promoting practical demonstration projects that can be replicated worldwide.[7]

***The Smart Net-zero Energy Buildings strategic Research Network (SNEBRN)***

The Smart Net-zero Energy Buildings strategic Research Network (SNEBRN) has been funded for five years (2011-2016) under the strategic research networks program of NSERC.[8] This is a continuation of the research conducted under the previous network, known as the Solar Buildings Research Network (SBRN), which completed its program at the end of 2010. Joining 18 researchers from SBRN will be 11 new researchers in the new Network's university team, making a total of 29 researchers from 15 Canadian universities taking part in the effort. In addition there are partners from government and industry. The vision of SNEBRN is to perform the research that will facilitate widespread adoption in key regions of Canada, by 2030, of optimized NZEB energy design and operation concepts suited to Canadian climatic conditions and construction practices. We aim to influence long-term national policy on the design of net-zero energy buildings and communities in association with our partners.

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

Total public budgets in Canada increased significantly to $61.8 million CAD, an increase of over 98% due to the market incentive program in the province of Ontario (Table 3). Other field-testing and demonstration projects focused on the assessment of solar photovoltaic technologies applied to residential and commercial building, as well as small remote community-scale applications.

[6] NSERC PV innovation network - www.pvinnovation.ca
[7] http://www.iea-shc.org/task40/

Federal and provincial research funding agencies such as NSERC[9], CFI[10], and the Ontario Centers of Excellence[11], increased their investment to augment the level of activities in the field of solar cell research in 2011. A survey of leading universities in Canada found that about 50 research laboratories employing an estimated 200-250 full-time equivalent researchers 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 multi-junctions and advanced crystalline silicon solar cells.

The 80 MW Sarnia Solar Power plant was awarded a contract under the ecoENERGY for Renewable Power, a federal market incentive program. The largest market incentive for PV however comes from the Ontario RESOP and FIT programs.

### Table 3. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2011 (Million CAD)

| | R & D | Demo/Field test | Market Incentives | Total |
|---|---|---|---|---|
| **Federal** | 9 | 1 | 1 | **11** |
| **Provincial** | 1 | 2 | 173 | **176** |
| **Total** | **10** | **3** | **174** | **187** |

### Table 3a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2011 (Million CAD)

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total combined (Federal, provincial)** | 1.5 | 1.95 | 5.96 | 8.54 | 9.80 | 7.70 | 8.15 | 10.4 | 7.51 | 31.2 | 61.8 | 172.7 |
| **Annual trends** | 68% | 30% | 205% | 43% | 15% | - 21% | 6% | 28% | - 28% | 315% | 98% | 179% |

[9] National Science and Engineering Research Council of Canada at http://www.nserc-crsng.gc.ca/
[10] Canada Foundation for Innovation at http://www.innovation.ca/en
[11] Ontario Centre of Excellence at http://www.oce-ontario.org/Pages/Home.aspx

# 3 *INDUSTRY AND GROWTH*

## 3.1 Production of feedstock, ingots and wafers

Timminco solar suspended production of its solar grade silicon in 2011. Two suppliers of feedstock materials are now active in Canada (Table 4).

**Table 4: Production and production capacity information for 2010 (2011 not available) 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 | 2011 Price (CAD) |
|---|---|---|---|---|---|
| Calisolar. (renamed Silicor Materials in 2012) | Solar grade Si feedstock | NA | 2,000 T/yr (2009) | NA | $29-80/kg (average polysilicon selling price in 2011 |
| 5N Plus | CdTe high purity compounds | 350 metric Tonnes (2010 est.) | NA | First Solar, Calyxo, Abound Solar | $170/kg Te<br>$2.82/kg Cd |

## 3.2 Production of photovoltaic cells and modules

**Table 5: Canadian PV Module Production and Capacity 2011**

| Company | Technology | 2011 Production (MW) | 2011 Year End Capacity (MW) |
|---|---|---|---|
| **Manufacturers that provided production data** | | | |
| Canadian Solar | mc-Si, sc-Si | 45 | 220 |
| MEMC / Flextronics | mc-Si | 20 | 120 |
| Heliene | mc-Si | 20 | 65 |
| Siliken | mc-Si | 10 | 25 |
| Eclipsall | sc-Si | 10 | 65 |
| Centennial | see below* | 7 | 30 |
| OSM Solar Form | mc-Si | 6 | 50 |
| Lumin | mc-Si, sc-Si | 2 | 10 |
| **Subtotal** | | **120** | **585** |
| | | | |
| **Other manufacturers** | | | |
| Celestica | mc-Si, sc-Si | Undisclosed | 100 |
| Photowatt / ATS | mc-Si | | 100 |
| Silfab | mc-Si, sc-Si | | 90 |
| Solgate | mc-Si, sc-Si | | 22 |
| Unconquered Sun | mc-Si | | 18 |
| **Subtotal** | | **70** | **330** |
| **Total** | | **190** | **915** |

Note: some plants were not operating for the full 12 months of 2011. * mc-Si, sc-Si, CIGS, Amorphous, Spherical (flexible). sc-Si - single crystal silicon; mc-Si - multi crystal silicon

As shown in Table 6, module prices have gradually declined from CAD 10.70 in 2000 to CAD 1.52 in 2011 (weighted average of price ranged from CAD 1.10 to CAD 7.00). This represents an average annual price reduction of slightly above 16% over the 11-year period.

**Table 6. Module prices (CAD/W) for 2000-2011**

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Standard module price (wgt avg)** | 10.70 | 9.41 | 7.14 | 6.18 | 5.53 | 4.31 | 5.36 | 4.47 | 3.91 | 3.31 | 2.27 | 1.52 |
| **Annual trends** | -3.5% | - 12% | - 24% | - 13% | - 10% | - 22% | +24% | - 17% | - 13% | -15% | -31% | -33% |

### 3.3 Manufacturers and suppliers of other components

There are nearly 650 solar photovoltaic companies (sales companies, wholesalers, product manufacturers, project developers, private consultants, systems installers and industry associations) operating in Canada many of which are members of the Canadian Solar Industries Association and Énergie Solaire Québec. The majority of these companies are also participating in the Province of Ontario's current Feed-In Tariff Program (and its precursor the Renewable Energy Standard Offer Program). The FIT Program continued to attract to renewable energy project developers and product manufactures to the Province in 2011. Under the 'new content rules', any developer wishing to participate in the FIT Program must show that the equipment and labor used to install the system consist of 60% Ontario-based content.

### 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 the respondents to the survey who are mainly distributers are not involved in the installations and are not in a position to provide information on turnkey system prices. The average installed turnkey price for small grid connected applications was 6.79 CAD, but this price may vary regionally.

**Table 7: Turnkey prices (CAD) of typical applications in 2011**

| Category/Size | Typical applications in Canada | Current prices (CAD/W) 2010 | 2011 |
|---|---|---|---|
| **Off-Grid ( ≤ 1 kW)** | Residential | 16.50 | |
| **Off-Grid ( ≥1 kW)** | | | 12.95 |
| **Grid-Connected ( ≤ 10 kW)** | Distributed | 6.50 - 8.00 | 6.79 |
| **Grid-Connected ( ≥10 kW)** | Centralized & Distributed | 4.00 - 6.00 | 3.50-5.27 |

**Table 7a: National trends in turnkey prices (CAD) of typical applications from 2000-2011**

| CAD/W | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Off-Grid (≤ 1 kW)** | 17.00 | 20.00 | 18.00 | 21.00 | 18.50 | 15.00 | 17.30 | 15.00 | 15.00 | 16.00 | 16.50 | NA |
| **Off-Grid (≥1 kW)** | | | | | | | | 7.70 | NA | NA | NA | 12.95 |
| **Grid-Connected Specific case** | | | | | 13.50 | 12.50 | NA | NA | NA | NA | NA | NA |
| **Grid-Connected ( ≤ 10 kW)** | 20.00 | ID | ID | ID | 14.50 | 10.00 | 10.00 | 8.50 | 6.50 | 8.50 | 6.50 - 8.00 | 6.79 |
| **Grid-Connected (≥10 kW)** | | | | | | 12.60 | 10.00 | 10.00 | | 6.00-8.00 | 4.00 - 6.00 | 3.50 - 5.27 |

ID=Insufficient data

## 3.5 Labour places

The number of labour places in PV-related activities in Canada stayed relatively constant in 2011 compared to 2010 to 5320 jobs. These positions include those in manufacturing, sales and installation, R&D, and other positions in the PV-value chain including company R&D, as well as utility PV dedicated labour. The main increase was in the manufacturing sector as new companies have set up manufacturing bases in the Province of Ontario to enable them to satisfy the FiT Program Ontario content requirements. In addition approximately 200 jobs are for feedstock suppliers (Silicon and Cadmium Telluride).

**Table 8: Labour places** (source: Canada's National PV Market Survey)

| Year | 2010 | 2011 |
|---|---|---|
| **R&D (public)** [1] | 150 | 180 |
| **Manufacturing** [2] | 3510 | 2930 |
| **Other**[3] | 1780 | 2210 |
| **Total** | **5440** | **5320** |

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.

Natural Resources Canada commissioned Navigant to complete a "Sector Profile for Solar Photovoltaics in Canada"[12] that includes a workforce assessment to 2014. This analysis concluded that the labour needs will peak in 2013. The largest areas of need are manufacturing and construction trades combining for approximately 5800 jobs in 2013. However, needs fall by 2014 as new PV construction project falls off.

[12] Sector Profile for Solar PV in Canada
http://canmetenergy.nrcan.gc.ca/renewables/solar-photovoltaic/publications/3092

**Table 8a: Trends in total PV labour places in Canada for 1997-2011**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total labour** | 201 | 220 | 250 | 260 | 275 | 535 | 615 | 765 | 975 | 1080 | 1370 | 2080 | 2700 | 5440 | 5320 |
| **Annual growth** | 19% | 10% | 14% | 4% | 6% | 94% | 15% | 24% | 27% | 11% | 21% | 53% | 30% | 101% | -2% |

## 3.6 Business value

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 table 9. This includes the revenues of consultants, installers and manufacturers of both modules and balance of system components, as well as Silicon and Cadmium Telluride feedstock producers. The reported revenues from commercial activities of 27 manufacturing operations and 87 other Canadian PV companies were estimated to be CAD 1,175 M[13] in 2011. Approximately CAD 70 M of revenues was generated by feedstock manufacturers in 2011. The domestic PV market in Canada in 2011 accounted for 97% of total revenues (Table 9a).

**Table 9: Trends in PV business in Canada from 1993-2011 ($M)**

| Year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCAD | 17 | 17 | 25 | 28 | 33 | 38 | 40 | 42 | 45 | 95 | 100 | 125 | 150 | 201 | 290 | 510 | 720 | 1310 | 1175 |
| Change | -6% | 0 | 47% | 12% | 18% | 14% | 5% | 5% | 7% | 111% | 5% | 25% | 17% | 34% | 44% | 76% | 42% | 82% | -11% |

**Table 9a: Revenue distribution within the PV business in Canada in 2011 ($M)**

| | Manufacturing | System Installation | Other | Total | % |
|---|---|---|---|---|---|
| **Export** | 61 | 11 | 70 | 142 | 12 |
| **Domestic** | 377 | 656 | NA | 1033 | 88 |
| **Total** | **438** | **667** | **70** | **1175** | **100** |

[13] The estimated CAD 1,175 M PV business value is based on manufacturer sales (n=27) at 438 M; installer and distributor sales (n=87) at 656 M, exports at 11 M; and feedstock 70 M (2010 estimate).

# 4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

**Table 10: PV support measures (Canada 2011)**

| | National / Regional (State) / Local |
|---|---|
| Enhanced feed-in tariffs | Yes (Province of Ontario) |
| Direct capital subsidies | No |
| Green electricity schemes | No |
| 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) |

**Table 10a: Feed-In Tariff support measure in Ontario**

***Ontario Power Authority Feed-In Tariff Price Schedule for Solar PV (CAD)[14]***

| Application type | Size Tranches | Contract Price (¢/kWh) | |
|---|---|---|---|
| Rooftop<br>Ground-mounted | ≤ 10 kW | 80.2<br>64.2 | microFIT |
| Rooftop | > 10 ≤ 250 kW | 71.3 | FIT |
| Rooftop | > 250 ≤ 500 kW | 63.5 | |
| Rooftop | > 500 kW | 53.9 | |
| Ground-mounted | > 10 kW ≤ 10 MW | 44.3 | |

***Net-Metering in Canada***

Net metering regulations have been put in place in most provinces and territories in Canada. A survey of grid-connected PV systems was conducted at the beginning of 2012. As shown on figure 2, the top two

provinces in terms of installed grid-connected capacity at the end of December 2011 were Ontario (11,955 systems, 493.883 MW) and BC (308 systems, 1.647 MW).

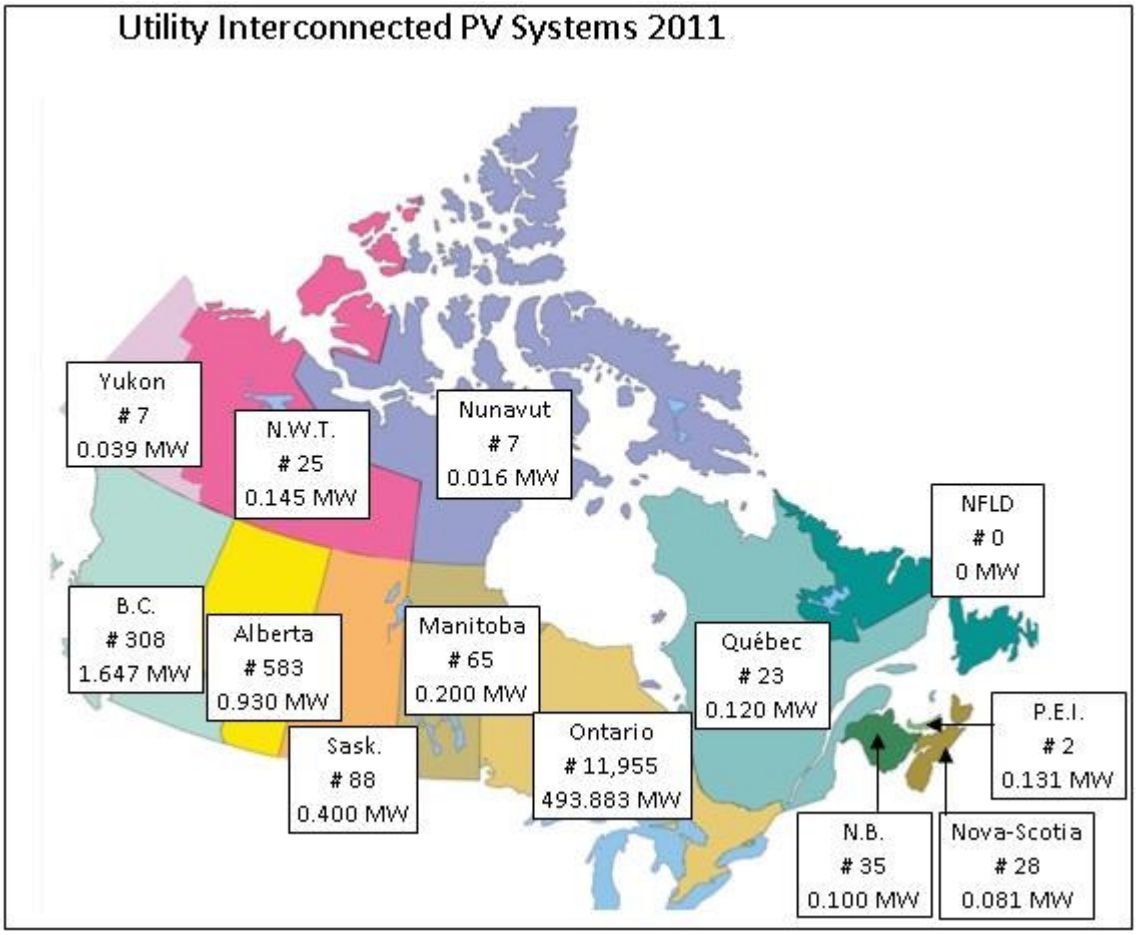


Figure 2: Map showing the Canadian provinces and the total number of utility interconnected PV Systems reported in 2011.

**Standards and codes**

The Standards Council of Canada, an agency of the Federal department Industry Canada, is responsible for the National Standards System. It is responsible for standards accreditation of organizations and test laboratories. Standards Council of Canada is Canada's representative at the International Electrotechnical Commission (IEC), a global organization that works towards the harmonization of standards in a broad range of electrical product safety and quality. The Canadian sub-committee to the IEC TC 82 actively participates in the development of PV standards. It collaborates with the Canadian Standards Association to make recommendations on international standards adoption. To date Canada has adopted the international IEC 61215 and IEC 61646 standards that define the test and qualification requirements for crystalline and thin-film solar PV modules. In 2011 it has completed the adoption of the IEC 61730 for PV module safety, in collaboration with the Canadian Standard Association, that now replaces the former ULC-1703 PV module safety standard.

NRCan's CanmetENERGY, in partnership with key industry players and associations, has championed a national effort to address the delays and avoid multiplication of regional grid interconnection requirements across the country. This included the development of two harmonized national interconnection standards,

[14] http://www.fit.powerauthority.on.ca

CSAC22.2 no.257 and the CSA C22.3 no.9. CanmetENERGY conducts research and field-testing addressing concerns raised by electricity distributors to update and improve the electrical code. Distributed generation installations of PV systems must be installed in accordance with all applicable general rules of the Canadian Electrical Code: Part I and II for low voltage installations at load centers such as residences and commercial buildings and Part III for medium to high voltage of the electricity distribution and transmission systems.

This national effort has been expanded to address future Smart Grid applications. The Standard Council of Canada and NRCan's CanmetENERGY have established a Canadian Smart Grid Technology and Standards Task Force in support of a global effort to harmonize requirements. As an example of its commitment to the International Electrotechnical Commission, Canada provided support for the development of an international standard for electricity network communication and distributed energy resources. This was a key issue to ensure that systems were interoperable with utility networks, and was reflected in the first edition of the IEC 61850-7-420 Ed.1 standard for basic communication structure, including photovoltaic device and system logical nodes.

## 5 HIGHLIGHTS AND PROSPECTS

The Feed-In Tariff Program in the province of Ontario is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. The FIT program addressed many of the concerns regarding the delays and interconnection obstacles identified by the industry during the review process. An updated FIT scheme will be implemented in Ontario in 2012.

The federal government is also leading the efforts of a technical study group to better understand the technical interconnection issues for high penetration levels of PV systems in electricity grids. This work will be undertaken in collaboration with the International Energy Agency PVPS Task 14 and Canadian stakeholders to better address the emerging field of PV integration enabled through smart grid infrastructure in Canada.

Natural Resources Canada commissioned Navigant to develop a Sector Profile for Solar Photovoltaics in Canada[11] which looks at the state of the market market throughout Canada, including various incentives in place, provides an update on installations in 2011, describes the PV supply chain, key manufacturers, economic impacts, workforce capability and the state of R&D initiatives in Canada. The report can be accessed through this link: http://canmetenergy.nrcan.gc.ca/renewables/solar-photovoltaic/publications/3092

# Annex A. Method and accuracy of data

The estimated PV module capacity installed in Canada in 2011 is estimated to be 558.74 MW (±5%). Products imported over the internet and through direct orders were not included in this market study. Information was gathered from a survey of major provincial utilities that have grid-connected clients in Canada and the Ontario Power Authority quarterly progress reports regarding PV solar utility scale parks. A PV sector profile was completed to obtain the number of labour places. A survey of 27 PV manufacturers was completed to obtain R&D expenditures and the domestic and export revenues. A survey of 87 PV installer/retailers/distributors was conducted to obtain the weighted average PV module and system cost in CAD/Watt. Additional information on larger Canadian PV companies was collected from their annual reports to shareholders. The survey 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.
- 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 2011 as well as the positive and negative effects of the Internet on PV business.
- Typical module prices.
- Turnkey prices of typical applications.

## 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):

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

**Industry and Household Electricity Prices in Canada**

6.82 – 17.47 cents/kWh

**Source:** Government of Canada

http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/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=1801BDDB-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/lctrctymrkts20052006-eng.pdf

### 4. Typical household income.

**Source:** Government of Canada
(http://www.statcan.gc.ca/cgi-bin/af-fdr.cgi?l=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)

120 V

### 7. Electricity industry structure and ownership

See Canadian Electricity Association
website :http://www.canelect.ca/en/electricityincanada/electricity_in_canada_glossary.html

### 8. Price of diesel fuel

CAD $1.00 /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 CanmetENERGY. 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 $MJ/m^2$ and in $kWh/m^2$) 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