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

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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 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 (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 Commission, the European Photovoltaic Industry 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 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 reached 94.57. MW in 2009 compared to 32.72 MW at the end of 2008. The grid-connected market now accounts for 87% of the market in 2009 compared to only 33% in 2008. This is a significant growth sector that is spurred by the new Province of Ontario's feed in tariff launched in 2006 and expanded in 2009. The grid connected applications included 11% for residential and building integrated applications, and 76% for three large ground-mounted utility scale systems.

Costs & prices: Module prices (weighted average) have gradually declined from CAD 11.09 in 1999 to CAD 3.31 in 2009. This represents an average annual price reduction of slightly over 10% over the 10-year period. The installed price for systems range between CAD 6 000 to 8 000 per kilowatt for grid-connected installations, and CAD 16 000 per kilowatt for off-grid systems that include storage.

PV Production: 42 MW of PV modules were manufactured by Day4 and Centennial Solar in Canada. In 2009, 5N Plus and Bécancour Silicon produced 125 metric tonnes of CdTe and 182 metric tonnes of silicon, respectively.

PV labour: There are 2700 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 2009. This is a 30% increase compared to 2008. The largest increase is in the public R&D sector where federal and provincial research funding agencies increased their investment in Canadian universities to augment the level of R&D activities in the field of materials and solar cells in 2009.

Public budget for PV: Total public budgets in Canada significantly increased to $31.2 million CAD which is an increase of over 315% due to the market incentive program in the province of Ontario. This is due to a large increase in the incentive program in Ontario that provides a feed-in tariff (FIT) for PV installations that range between CAD 0.80 to 0.44 per kilowatt hour. The balance of this budget which funded R&D and demonstration budget was CAD 5.2 million in 2009.

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 this grew to 87% in 2009. This is a significant growth sector that is spurred by the new Province of Ontario's feed in tariff launched in 2006 and expanded in 2009. The grid connected applications included 11% for residential and building integrated applications, and 76% for three large ground-mounted utility scale systems.

The off-grid applications are not subsidized and only represented 13% of PV systems installed in Canada in 2009. 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 become more aware of opportunities. The "domestic" off-grid market remains at about 7% of PV sales, primarily for remote homes and cottages, residential communication (radios), and recreational vehicles. The off-grid non-residential market for water pumping, road signals, navigational buoys, telecommunication repeaters, and industrial sensing, monitoring, and controlling represented 6% of PV sales in 2009.

2.2 Total photovoltaic power installed

As shown in Table 1, the installed off-grid power capacity in 2009 was 7.71MW compared to 54.14MW 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 huge market increase of 791% in Canada in 2009 (Table 2a).

Table 1 - The PV power (MW) installed in 4 sub-markets in Canada in 2009.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed	4.58	3.13	7.08	47.06*	**61.85**

* Includes installations in Ontario under FiT Program (total reported 40 MW in AC power, see *A Progress Report on Electricity Supply (Fourth Quarter 2009)*[1]) using 15% conversion to determine actual PV installed in Wp DC.

[1] http://www.powerauthority.on.ca/Storage.asp?StorageID=6668

Table 2. The cumulative installed PV power (MW) in 4 sub-markets in Canada in 2009.

(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	2009
Off-grid domestic	0.10	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
Off-grid non-domestic	0.69	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
Grid-Connected distributed	0.17	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
Grid-Connected centralized	0	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
TOTAL	**0.96**	**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**
Total off-grid	**0.79**	**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**

* Decommissioned.

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

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0.96*	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
-	-	-3%	29%	100%	17%	33%	24%	-2%	27%	-31%	58%	12%	39%	31%	42%	31%	791%

* 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.

The Government of Ontario's Renewable Energy Standard Offer Program

In 2009, the Province of Ontario, Canada's second largest province, through the passage into law of the *Green Energy Act*, adopted an aggressive green energy policy that includes a powerful Feed-In Tariff (FIT)[2] program as its centerpiece. The provincial government launched the program in September 2009, and delegated the responsibility for its implementation to the Ontario Power Authority (OPA). The FIT program replaced the province's highly popular Renewable Energy Standard Offer Program (RESOP)[3], which underwent review in 2008. As part of the FIT launch process, all renewable energy supply projects that have been approved under RESOP and are in commercial operation will continue according to their RESOP contracts. As of the third quarter of 2009, the OPA had 1,422 MW of renewable energy supply capacity of which 525.4 MW are from PV power generation projects under the RESOP Program. Of these, Canada's first three large-scale PV parks of 10 MW by enXco/ EdF-EN Canada[4], 20 MW by Enbridge[5] and First Solar and 9.1 MW (Figure 1) by Skypower Corporation[6] have achieved commercial operation in 2009 and became eligible for RESOP contract payments of 0.42 CAD/kWh for a 20-year power purchase agreements.

[2] http://www.fit.powerauthority.on.ca
[3] http://www.powerauthority.on.ca/sop/Page.asp?PageID=861&SiteNodeID=209
[4] Information from OPA, *"A Progress Report on Electricity Supply, Third Quarter 2009"*. 10 MW of solar PV capacity reached commercial operation in Q3 of 2009 and reported in the OPA report, and 30 MW achieved commercial operation in Q4 of 2009
[5] http://www.enbridge.com
[6] http://www.skypower.com

As of the fourth quarter of 2009, the RESOP Program was replaced by the Feed-in Tariff (FIT) Program. The RESOP contract holders whose projects were not in commercial operation were given an opportunity to rescind their RESOP contracts and apply for a FIT contract. This FIT program is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar PV, bioenergy waterpower and wind. The FIT 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 energy projects generating 10 kW of electricity or less, such as a home or small business installations (referred to as the "microFIT Program")[7]. 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 applicants are paid a fixed price of up to 0.802 CAD per kWh for the electricity they generate for a 20 years contract.

Figure 1: SunEdison's and SkyPower Corporation's 9.1-megawatt (MW) First Light Solar Energy Park in Stone Mills, Ontario, and the largest solar energy park built to date in Canada. (Photo credit: Dave Turcotte, CanmetENERGY)

Federal Programs in support of technology demonstration to market commercialization

Canada Mortgage and Housing Corporation's (CMHC's) EQuilibrium™ Sustainable Housing Demonstration Initiative[8] 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. As of 2009, six projects have been completed or at various stages of development. The PV production from all four projects will be monitored for a one-year period with a live feed from Fat Spaniel Technologies[9].

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

[7] http://www.microfit.powerauthority.on.ca.

[8] For further information on the EQuilibrium™ Initiative go to www.cmhc.ca and search 'EQuilibrium'

[9] www.fatspaniel.com/fat-spaniel-in-action/live-sites/. The EQuilibrium™ Projects are listed under CMHC EQuilibrium Homes as the installer.

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.

Demonstration Projects in Canada

Team North and Team Alberta 2009 Solar Decathlon Competition

Canada was represented by two university teams in U.S. Department of Energy 2009 Solar Decathlon competition: *Team North* (the "*North House"*, Figure 2a) bringing together students from University of Waterloo, Ryerson University and Simon Fraser University and *Team Alberta* (the "ENMAX SolAbode" Figure 2b) consisting of University of Calgary, SAIT Polytechnic, Alberta College of Art and Design and Mount Royal College students. Team North greatly impressed by finishing in fourth position of the general ranking. The team performed consistently throughout the whole competition by finishing in the top 5 of 7 of the 10 tests they had to compete in and by obtaining the second position in the communications test. Team Alberta also distinguished itself by achieving the 6th rank in the global competition and getting the 5th position in the home entertainment and comfort zone challenges. The U.S. Solar Decathlon is an excellent opportunity that provides architecture and engineering students with hands-on experience in innovative design that target net-zero energy solar optimized homes.

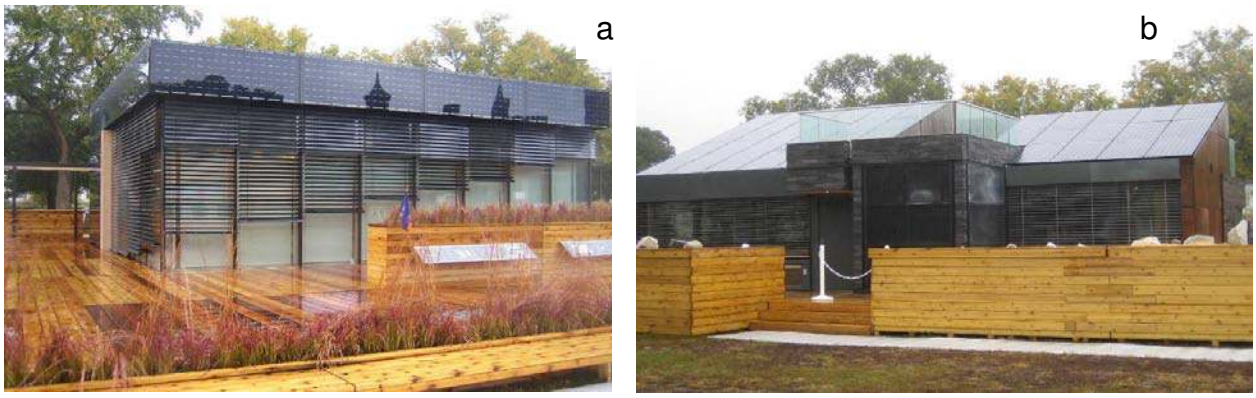


Figure 2: Canada's two entries in the 2009 US DOE Solar Decathlon Competition, the North House (a), and ENMAX SolAbode (b) - marketable solar powered home that makes use of the latest in high-performance architecture energy management technology while building Canada's next generation of leaders in sustainable engineering, business and design. (Photos credits: Team North and Team Alberta)

The T'Sou-ke First Nation Solar Power Project, Sooke, British Columbia

In 2009, the T'Sou-ke First Nation, a native community in Sooke on the southern end of Vancouver Island became the largest solar energy producing community in the Province of British Columbia (Fig. 3). The T'Sou-ke solar project is a suite of solar options for producing hot water and electricity. The PV component consists of three models: 62 kW grid-connected array atop the band's canoe shed providing the electricity needs of the community or for sale to BC Hydro, the provincial utility; a 7 kW grid-connected system on the band hall for emergency battery back-up in case of a power outage; and a 6 kW system on the bands' fisheries office that will require some form of backup such as diesel, propane or another renewable technology. The T'Sou-ke First Nation solar project is being held up as an energy autonomy model for other aboriginal communities across the province, particularly those that are off grid and reliant upon diesel generators for electricity.

Figure 3: The T'Sou-ke First Nation Solar PV Project, BC's largest solar system. (Photo credit. Sia Voidani)

2.4 Highlights of R&D

Canadian PV Innovation Network - A core group of 29 academic scientists from 13 universities established a Photovoltaic Research Innovation Network in collaboration with industrial, provincial and federal partners in 2009. The PV Innovation Network[10], for which funding of $5 million for 2010-2015 was approved by NSERC, to support research in four main categories: inorganic photovoltaic devices; organic photovoltaic devices; hybrid organic-inorganic photovoltaic devices; and nano-structured photovoltaic devices. 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 Program - This Program supports the development and deployment of Solar Photovoltaic energy technologies throughout the country[11]. Efforts undertaken by CanmetENERGY, such as the coordination of various research projects, participation in international committees on the establishment of standards, and development of knowledge that will support domestic capacity-building, 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 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.

The Canadian Solar Buildings Research Network (SBRN)[12] - This network conducts R&D on 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. The R,D&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

[10] PV Innovation Network at www.pvinnovation.ca

[11] http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/standalone_pv.html

[12] Solar Buildings Research Network at www.solarbuilings.ca

innovation in the construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

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

Total public budgets in Canada significantly increased to $31.2 million CAD which is an increase of over 315% due to the market incentive program in the province of Ontario (Table 3). The 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.

Federal and provincial research funding agencies such as NSERC[13], CFI[14], and the Ontario Centers of Excellence[15], increased their investment to augment the level of activities in the field of solar cell in 2009. 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.

Table 3. Public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2009 (Million CAD)

	R & D	Demo/Field test	Market Incentives	Total
Federal	2.6	1.0	0	**3.6**
Provincial	1.0	0.6	26	**27.6**
Total	**3.6**	**1.6**	**26**	**31.2**

Table 3a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2009 (Million CAD)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total combined (Federal, provincial)	0.89	1.5	1.95	5.96	8.54	9.80	7.70	8.15	10.4	7.51	31.2
Annual trends	-	68%	30%	205%	43%	15%	- 21%	6%	28%	- 28%	315%

[13] National Science and Engineering Research Council of Canada at http://www.nserc-crsng.gc.ca/
[14] Canada Foundation for Innovation at http://www.innovation.ca/en
[15] 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

There are three suppliers of feedstock materials located in Canada (Table 4). 5N Plus had a significant increase in Cadmium Telluride production that is exported for the fabrication of thin-film CdTe modules. The production of silicon from Bécancour Québec was approximately 182 metric tonnes. 6N Silicon was acquired by Calisolar recently.

Table 4: Production and production capacity information for 2009 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	182 metric tonnes	48 000 T/yr	Export (Q-Cells, Germany, other)	36/kg (average selling price)[16]
6N Silicon Inc. (acquired by Calisolar in 2010)	Solar grade Si feedstock	NA	2000 T/yr	NA	NA
5N Plus[17]	CdTe high purity compounds	125 metric Tonnes	NA	First Solar, Calyxo, Abound Solar	NA

3.2 Production of photovoltaic cells and modules

Table 5: Production and production capacity information for 2009

Cell/Module manufacturer	**Technology** (sc-Si, mc-Si, a-Si, CdTe)	**Total Production (MW)** Cell	Module	Con.	**Maximum Production Capacity (MW)** Cell	Module	Con.
Centennial Solar	sc-Si a-Si CIGS	-	2.00 0.20 0.10	-	-	6	-
Day4 Energy Inc.	sc-Si	-	~ 40	-	-	100+	-
TOTALS	**sc-Si** **a-Sci** **CIGS**		**~ 42** **0.20** **0.10**	**-**	**-**	**106+**	**-**

[16] Timminco Annual Report 2009; Timminco average selling price for Q1 2009 as reported in http://www.timminco.com/docs/TIM%20Investor%20Presentation%20May%20-%20FINAL.pdf

[17] 5N Plus Annual report 2009

As shown in Table 6, module prices have gradually declined from CAD 11.09 in 1999 to CAD 3.31 in 2009 (weighted average of price range from CAD 2.67 to CAD 9.00). This represents an average annual price reduction of slightly above 10% over the 10-year period.

Table 6. Module prices (CAD/W) for 1999-2009

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Standard module price (wgt avg)	11.09	10.70	9.41	7.14	6.18	5.53	4.31	5.36	4.47	3.91	3.31
Annual trends	-	-3.5%	- 12%	- 24%	- 13%	- 10%	- 22%	+24%	- 17%	- 13%	-15%

3.3 Manufacturers and suppliers of other components

There are nearly 350 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[i] and Énergie Solaire Québec[ii]. The majority of these companies are also participating in the Province of Ontario's new 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 2009. 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 40 percent 'Ontario' content for projects less than 10 kW in size. Above that threshold the required local content is 50%.

The Province's Green Energy Act is creating the appropriate business conditions to attract investments to grow the solar industry in Ontario. In 2009, Canadian Solar Inc.[iii] (a vertically integrated provider of ingots, wafers solar cell and modules and specialized solar products) announced its intentions to establish a manufacturing facility in Ontario that will create 500 jobs to take advantage of the province's FIT Program that mandates local content. Also, ATS Automation Tooling Systems Inc.[iv], the parent company of Photowatt International[v] announced in 2009 that it has established Photowatt Ontario Inc. at its site in Cambridge, Ontario as part of its plan to lead the Ontario solar energy market. Photowatt Ontario offers turnkey solar project development, installation and solar products. Another development in 2009 is the Government of Ontario[vi] and Korea-based Samsung C&T Corporation[vii] - led consortium announcement of a 7 billion CAD green energy investment for 2,500 MW of solar (500 MW) and wind (2000 MW) energy generation in the Province. This investment is expected to triple Ontario's renewable solar and wind energy generation and lead to manufacturing facilities being constructed in Ontario.

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 fluctuation in installed turnkey prices for small grid connected applications ranged between 6 to 10 CAD due to regional market demand.

Table 7: Turnkey prices (CAD) of typical applications in 2009

Category/Size	Typical applications in Canada	Current prices (CAD/W)
Off-Grid (≤ 1 kW)	Residential	16
Off-Grid (≥1 kW)		
Grid-Connected (≤ 10 kW)	Distributed	8.5
Grid-Connected (≥10 kW)	Centralized	NA

Table 7a: National trends in turnkey prices (CAD) of typical applications from 1999-2009

CAD/W	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Off-Grid (≤ 1 kW)	17	17	20	18	21	18.5	15	17.3	15	15	16
Off-Grid (≥1 kW)									7.70	NA	NA
Grid-Connected Specific case						13.50	12.50	NA	NA	NA	NA
Grid-Connected (≤ 10 kW)	21	20	ID	ID	ID	14.50	10	10	8.5	6.5	8.5
Grid-Connected (≥10 kW)							12.60	10	10		6-8

ID=Insufficient data

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by about 30% in 2009 to 2700 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	2009
R&D (public) [1]	100
Manufacturing [2]	1975
Other[3]	625
Total	**2 700**

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.

Table 8a: Trends in total PV labour places in Canada for 1996-2009

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total labour	169	201	220	250	260	275	535	615	765	975	1 080	1 370	2080	2 700
Annual growth	-	19%	10%	14%	4%	6%	94%	15%	24%	27%	11%	21%	53%	30%

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 the following table. 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 11 manufacturing operations and 20 other Canadian PV companies were estimated to be CAD 659 M in 2009 up from CAD 437 M in 2008. An additional CAD 11 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. Approximately CAD 50 M of revenues was generated by feedstock manufacturers in 2009. The overall total revenue increased by 42% to CAD 720 million in 2009 compared to 510 million in 2008 (Table 9).

Table 9: Trends in PV business in Canada from 1992-2009

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MCAD	18	17	17	25	28	33	38	40	42	45	95	100	125	150	201	290	510	720
Change	-	-6%	0	47%	12%	18%	14%	5%	5%	7%	111%	5%	25%	17%	34%	44%	76%	42%

4 FRAMEWORK FOR DEPLOYMENT (Non-technical factors)

Table 10: PV support measures (Canada 2009)

No changes from what was reported in 2008.

	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)

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

Ontario Power Authority Feed-In Tariff Price Schedule for Solar PV (CAD)[18]

Application type	**Size Tranches**	**Contract Price (¢/kWh)**	
Any type	≤ 10 kW	80.2	**micro FIT**
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	

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

Net-Metering in Canada

Net metering regulations have been put in place in most provinces and territories in Canada. An electricity review in the Northwest Territories of Canada is expected to allow net-metering in 2010. Some utilities have developed and implemented programs that streamline the application process specify net metering requirements and set out approved tariffs (for example BC Hydro and Hydro Quebec Distribution).

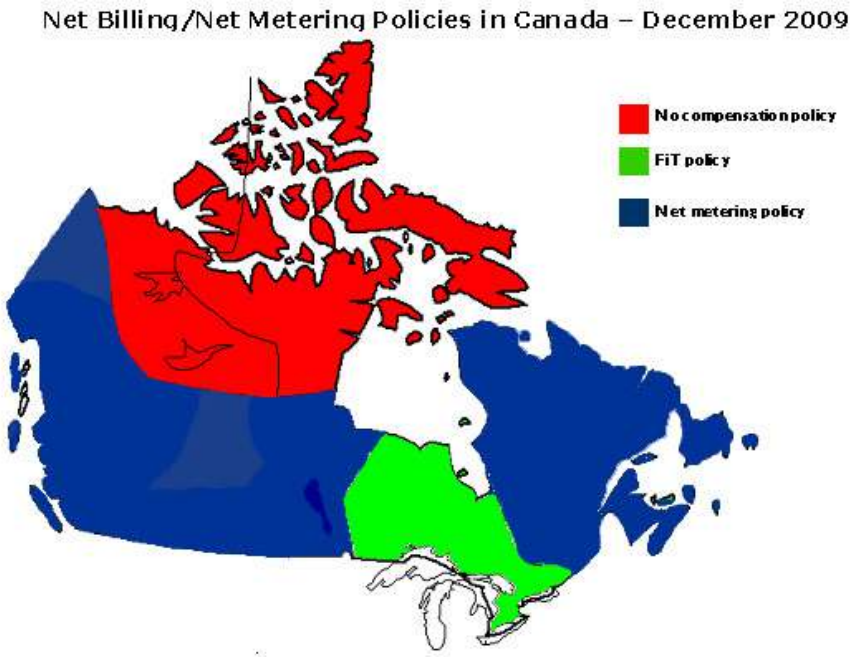


Figure 4: Net-metering landscape in Canada – 2009.

Standards and codes

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 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[viii]. 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[19] for low voltage installations at load centers such as residences and commercial buildings, with 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.

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 is a key issue to ensure that systems are inter-operable with utility networks. This effort was completed in 2009 with the final approval and publication of the IEC 61850-7-420 Ed.1 standard for basic communication structure, including photovoltaic device and system logical nodes.

[19] www.csa.ca

5 HIGHLIGHTS AND PROSPECTS

The Feed-In Tariff Program (and RESOP) is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. By the end of 2009, the RESOP had exceeded its 5-year target with 525 MW of solar PV contracts signed of which 47.1 MW being in commercial operation to date. The FIT program addressed many of the concerns regarding the delays and interconnection obstacles identified by CanSIA and other renewable energy industry associations during the review process of the RESOP, and have made it less complicated for applicants. The tremendous initial response to the microFIT program signals a strong support for residential solar rooftop applications in Ontario.

The federal government is investing in research activities to develop and test photovoltaic electricity generation forecasts, with emphasis on physical parameters and timescales relevant to electric utilities, PV system developers, owners and operators. As solar electricity in Ontario continues to grow its share of the province's electricity mix, the federal government is also leading the R&D investments into activities to better understand the technical challenges of high penetration levels of PV in electricity grids. This work will be undertaken in collaboration with an international group of stakeholders to better address the emerging field of PV integration in smart grids in Canada.

Annex A. Method and accuracy of data

The estimated PV module capacity installed in Canada in 2009 is estimated to be 94.57 MW (±10%). Information on feedstock suppliers were obtained from publicly available company reports. Information was gathered from the Ontario Power Authority quarterly progress reports regarding PV solar utility scale parks that were operational on December 31st, 2009. Products imported over the internet and through direct orders were not included in this market study. In addition, a telephone survey was conducted to obtain information from 62 PV industry players of which 31 provided responses. 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.
- 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 2009 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 40 Wp or less category.
- Typical module prices.
- Turnkey prices of typical applications.

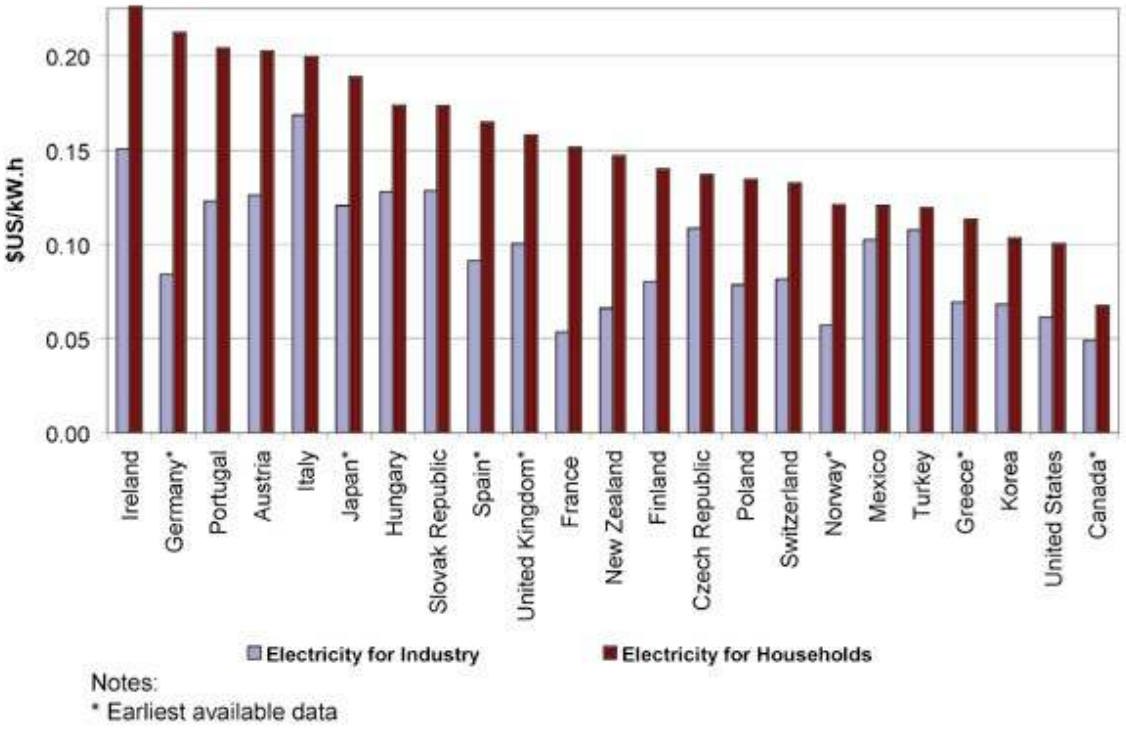
Annex B: Country information

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 Select Countries - 1st Quarter 2007



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.

Chart 2
Median after-tax income, families of two persons or more, Canada and Provinces, 2005 to 2006

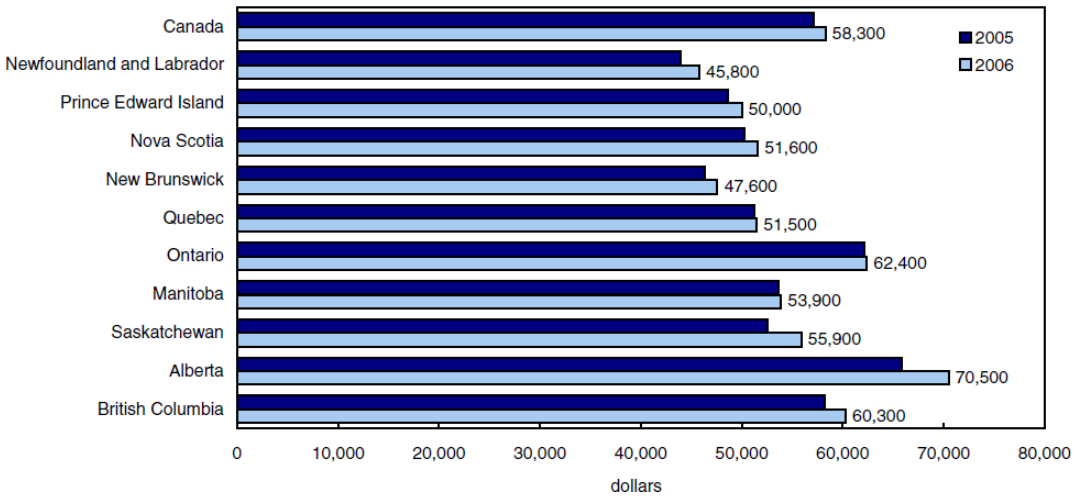
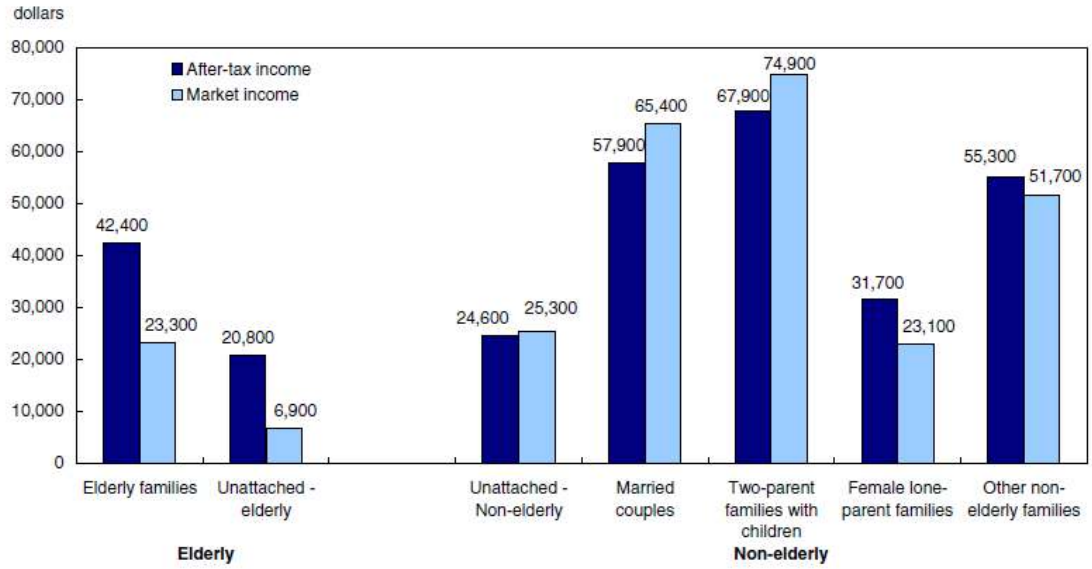


Chart 4
Median market and after-tax income by family types, Canada, 2006



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

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 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 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

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[i] http://www.cansia.ca
[ii] http://www.esq.gc.ca
[iii] http://www.canadian-solar.com
[iv] http://www.atsautomation.com/
[v] http://www.photowatt.com/en/
[vi] http://www.news.ontario.ca/opo/en/2010/01/korean-companies-anchor-ontarios-green-economy.html (announced on Jan. 21, 2010)
[vii] http://www.samsungcnt.com/pr/board_view.asp?fnum=131&fidx=1805&fpart=eng
[viii] http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2007-172/2007-172e.pdf