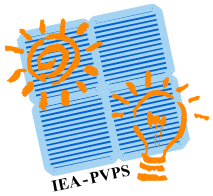
International Energy Agency



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

2010

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June 2011

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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 22 participating countries are Australia (AUS), Austria (AUT), 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 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 291.13 MW in 2010 compared to 94.57 MW at the end of 2009. The grid-connected market segment in Canada in 2010 remained at the same level as in 2009 at 87% of total installed capacity. 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 13% for residential and building integrated applications of equal to or less than 10 kW, and 74% 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 10.70 in 2000 to CAD 2.27 in 2010. This represents an average annual price reduction of slightly over 16% over the 10-year period. The installed price for systems range between CAD 4,00 to 8,00 per watt for grid-connected installations, and CAD 16,50 per watt for off-grid systems that include storage.

PV Production: A number of new PV module manufacturers established presence in Ontario stimulated by the Feed-in Tariff and its associated minimal Ontario content. An estimated 110 MW of PV modules were manufactured in Canada in 2010. In addition, 5N Plus and Timminco Solar produced an estimated 350 metric tonnes of CdTe and 8 metric tonnes of silicon, respectively.

PV labour: There are 5,440 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 2010. This is a 101% increase compared to 2009. The largest increase is in the manufacturing sector as new companies have set up manufacturing facilities in the province of Ontario.

Public budget for PV: Total public budgets in Canada significantly increased to $71.80 million CAD which is an increase of over 130% 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 21.80 million in 2010.

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 87% in 2010. 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 13% for residential and building integrated applications of equal to or less than 10 kW,, and 74% for several large ground-mounted utility scale systems equal to or less than 10 MW.

The off-grid applications are not subsidized and represented only 13% of PV systems installed in Canada in 2010. 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 4% 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 9% of PV sales in 2010.

2.2 Total photovoltaic power installed

As shown in Table 1, the installed off-grid power capacity in 2010 was 24.90 MW compared to 171.66 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 huge market increase of 218% in Canada in 2010 (Table 2a). Grid-connected applications installed on buildings in Ontario in 2010 amounted to 24.94 MW. In comparison, the grid-connected capacity installed on buildings in the rest of Canada in 2010 totalled 0.554 MW.

Grid-connected centralized applications amounted to 146.174 MW in 2010. These installations were all made in Ontario were operators receive a feed-in tariff rate of 0.42 or 0.44 CAD per kWh generated. Table 1a lists the centralized systems that were in operation or became operational in Ontario in 2010. 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 2010.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed	7.662	17.239	25.494	146.174	**196.569**
Market %	3.9 %	8.8 %	12.7 %	74.6 %	**100 %**

Table 1a - Large centralized PV power plants in operation in Canada in 2010.

Project developers or owners	Location (City in Ontario)	Project name (if any)	Rated power (MW_{DC})
SkyPower/SunEdison	Stone Mills	First Light	9.1
Enbridge and First Solar	Sarnia	Sarnia Solar Project	80
EDF EN	Arnprior		23.4
EDF EN	St Isidore	St Isidore A	12
SkyPower/SunEdison	Port Dover and Simcoe	Sun E Sky Norfolk I and II	18
Enbridge and First Solar	Tilbury		5

Table 2. The cumulative installed PV power (MW) in 4 sub-markets in Canada in 2010.

(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
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
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
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	37.74
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
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**	**291.13**
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**	**60.1**

* Decommissioned.

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
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	196.62
-	-3%	29%	100%	17%	33%	24%	-2%	27%	-31%	58%	12%	39%	31%	42%	31%	791%	218%

* 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 Feed-in tariff program

The Province of Ontario, Canada's second largest province, leads the country in photovoltaic (PV) investment. In 2010, the Ontario Ministry of Energy reaffirmed, in its Long Term Energy Plan [5], its commitment to "maintaining a clean, modern and reliable electricity system." Renewable energy sources, such as solar and wind, are slated to play a prominent role in new generation, assisted through continuation

of the successful Feed- in Tariff (FIT and micro- FIT) programs [6] administered by the Ontario Power Authority (OPA) [7]. In 2010, the OPA had 3,352 MW of in- service generation capacity from renewable energy, including 186 MW PV systems. Another 1,243 MW of PV capacity is under development [8].

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 enter into a 20 year contract to receive a fixed price of up to 0.802 CAD per kWh for the electricity they generate (Table 10a).

As of December 2010, the OPA received, under the FIT program, 3,656 applications representing about 4,886 MW of PV generating capacity. Under the microFIT program, the OPA received 18,176 applications representing 166 MW of generating capacity (99% of which was for PV, Table 3) [13]. Given limited transmission capacity and an extremely large number of applications, a transmission planning process, known as the Economic Connection Test (ECT), was created to facilitate generator investment in new transmission "enabler" lines. A comprehensive regulatory evaluation of these new electricity network investment proposals would be conducted by the Ontario Energy Board (OEB) [14], the province's regulatory authority. A map tool showing the locations of PV projects that have been offered contracts by the OPA under the FIT Program, or are awaiting ECT, is also available from the OPA website [15].

Federal Programs in support of technology demonstration to market commercialization

Canada Mortgage and Housing Corporation's (CMHC's) EQuilibrium™ Sustainable Housing Demonstration Initiative[1] 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[2].

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

The Alberta Solar Showcase[3] demonstration project wraps up 20 successful new grid-connected solar PV installations on highly-visible municipal buildings around the Province of Alberta. Launched in 2006, with

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

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

[3] http://www.lassothesun.ca/index.htm

leveraged funding by the Government of Canada through the Federation of Canadian Municipalities Green Municipal Fund, the Project partnered Climate Change Central ('C3'), an Alberta-based, not-for-profit organization working to transform the way energy is used in that Province, with the City of Medicine Hat, as the project's municipal partner. The Alberta Urban Municipalities Association and the Alberta Association of Municipal Districts and Counties were also project funding supporters. The project has helped inform and educate municipal leaders, electrical inspectors, and utility providers and various other stakeholders on the benefits of solar PV. The 20 solar PV sites, presently being monitored for their performance, have the potential to generate an estimated 30,000 kWh of electricity and reduce 26 tonnes of GHG emissions annually.

Large Scale Demonstration Projects in Canada

In 2010, the world's largest solar PV facility, the 80 megawatt Sarnia Solar Project, was built by Enbridge and First Solar in Ontario (Fig. 1) [9]. It consists of 1.3 million First Solar PV modules and inverters from SatCon. The system, which occupies an area 0.943 km^2, will generate enough electricity to power more than 10,000 homes annually. Its construction required an investment of $400 million and created 800 jobs during assembly.

Figure 1: Enbridge and First Solar's 80 MW Sarnia Solar Project, the largest operating photovoltaic facility in the world in 2010 (Photo courtesy of Enbridge Inc.)

2.4 Highlights of R&D

Canadian PV Innovation Network:

The new PV Innovation Research Network [10], 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 responsible for delivering on the R&D mandate of the Grid Integration of Renewable and Distributed Energy Resources (DER) – a program that supports national science and technology efforts that will contribute to the modernization of the electricity grid network, enhance the benefits of renewable and clean distributed energy resources, increase the diversity and reliability of supply, and facilitate recovery after disruptions. While numerous benefits are associated with this change, such a transition also represents many challenges for all stakeholders (utilities, independent power producers, governments, regulators, manufacturers, housing industry). Through the Energy Science and Technology funding support, NRCan addresses the technical, institutional and regulatory barriers, to promote the grid integration of clean power including photovoltaics.

The Canadian Solar Buildings Research Network (SBRN)[4]:

In 2010, the Canadian Solar Buildings Research Network (SBRN) completed its five-year work program [11]. The network pooled the R&D resources of eleven universities and federal departments to develop the future generation of experts knowledgeable in solar buildings research. The goal of the research network was the development of solar-optimized buildings with integrated advanced technological systems that approached net-zero annual total energy consumption. CanmetENERGY also contributed to this research effort and is leveraging its activities through its leadership of 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, will document research results and promote practical demonstration projects that can be replicated worldwide.

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

Total public budgets in Canada significantly increased to $61.8 million CAD which is an increase of over 98% 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[5], CFI[6], and the Ontario Centers of

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

Excellence[7], increased their investment to augment the level of activities in the field of solar cell in 2010. 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 2010 (Million CAD)

	R & D	Demo/Field test	Market Incentives	Total
Federal	8.8	1	0	**9.8**
Provincial	6.0	6	40	**52**
Total	**14.8**	**7**	**40**	**61.8**

Table 3a. Trends in public budgets for R&D, demonstration/field test programmes and market incentives in Canada in 2010 (Million CAD)

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
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
Annual trends	68%	30%	205%	43%	15%	- 21%	6%	28%	- 28%	315%	98%

[5] National Science and Engineering Research Council of Canada at http://www.nserc-crsng.gc.ca/
[6] Canada Foundation for Innovation at http://www.innovation.ca/en
[7] 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 2010 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	8 metric tonnes	48 000 T/yr	Export (Q-Cells, Germany, other)	36/kg (average selling price)[8]
6N Silicon Inc. (acquired by Calisolar in 2010)	Solar grade Si feedstock	NA	2000 T/yr	NA	NA
5N Plus[9]	CdTe high purity compounds	350 metric Tonnes (est.)	NA	First Solar, Calyxo, Abound Solar	200$/kg Te 10$/kg Cd

3.2 Production of photovoltaic cells and modules

Table 5: Production and production capacity information for 2010

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		~ 80			100+	
Heliene	sc-Si mc-Si		~ 10 0			50+	
Photowatt Canada	mc-Si		~ 5			100+	
Opsun	sc-Si		~ 10			50	
Canadian Solar Inc.	sc-Si,	-	~ 2.5	-	-	200+	-

[8] 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

[9] 5N Plus Annual report 2010

	mc-Si		~ 2.5				
TOTALS	**sc-Si** **mc-Si** **a-Si** **CIGS**		~ **102.5** ~ **7.5** ~ **0.2** ~ 0.10	**-**	**-**	**306+** **200+**	**-**

As shown in Table 6, module prices have gradually declined from CAD 10.70 in 2000 to CAD 2.27 in 2010 (weighted average of price range from CAD 2.67 to CAD 9.00). This represents an average annual price reduction of slightly above 16% over the 10-year period.

Table 6. Module prices (CAD/W) for 1999-2010

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
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
Annual trends	-3.5%	- 12%	- 24%	- 13%	- 10%	- 22%	+24%	- 17%	- 13%	-15%	-31%

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 2010. 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 2010, 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 2010 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.

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 6.5 to 8 CAD due to regional market demand.

Table 7: Turnkey prices (CAD) of typical applications in 2010

Category/Size	Typical applications in Canada	Current prices (CAD/W)
Off-Grid (≤ 1 kW)	Residential	16.50
Off-Grid (≥1 kW)		
Grid-Connected (≤ 10 kW)	Distributed	6.5 - 8.0
Grid-Connected (≥10 kW)	Centralized	4.0

Table 7a: National trends in turnkey prices (CAD) of typical applications from 2000-2010

CAD/W	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Off-Grid (≤ 1 kW)	17	20	18	21	18.5	15	17.3	15	15	16	16.5
Off-Grid (≥1 kW)								7.70	NA	NA	NA
Grid-Connected Specific case					13.50	12.50	NA	NA	NA	NA	NA
Grid-Connected (≤ 10 kW)	20	ID	ID	ID	14.50	10	10	8.5	6.5	8.5	6.5 - 8.0
Grid-Connected (≥10 kW)						12.60	10	10		6-8	4-6

ID=Insufficient data

3.5 Labour places

The number of labour places in PV-related activities in Canada grew by about 30% in 2010 to 5440 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
R&D (public) [1]	150
Manufacturing [2]	3510
Other[3]	1780
Total	**5440**

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 1997-2010

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total labour	201	220	250	260	275	535	615	765	975	1 080	1 370	2080	2 700	5 440
Annual growth	19%	10%	14%	4%	6%	94%	15%	24%	27%	11%	21%	53%	30%	101%

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 20 manufacturing operations and 32 other Canadian PV companies were estimated to be CAD 1,068.5 M in 2010 up from CAD 659 M in 2009. An additional CAD 11.5 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 70 M of revenues was generated by feedstock manufacturers in 2010. The overall total revenue increased by 60% to CAD 1.150 billion in 2010 compared to 720 million in 2009 (Table 9).

Table 9: Trends in PV business in Canada from 1993-2010

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MCAD	17	17	25	28	33	38	40	42	45	95	100	125	150	201	290	510	720	1,150
Change	-6%	0	47%	12%	18%	14%	5%	5%	7%	111%	5%	25%	17%	34%	44%	76%	42%	60%

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)[10]

Application type	Size Tranches	Contract Price (¢/kWh)	
Rooftop Ground-mounted	≤ 10 kW	80.2 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	

[10] 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).

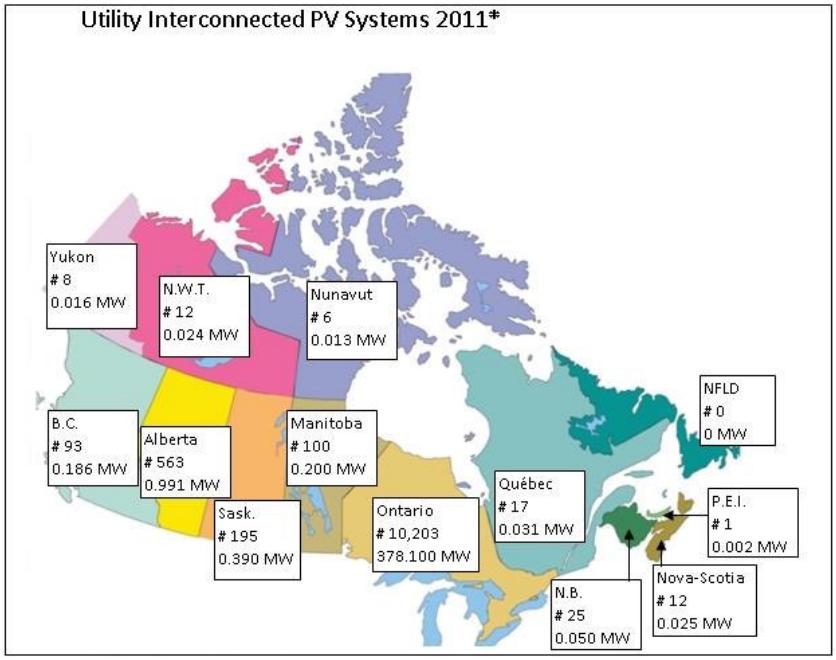


Figure 2: Map showing the Canadian provinces and the number of utility interconnected PV Systems reported to date (* survey conducted in March 2011, with updated data reported for Ontario and Alberta for December 2011).

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 IEC61215 and IEC61646 standards that define the test and qualification requirements for crystalline and thin-film solar PV modules. It has initiated a process for the joint adoption of the IEC 61730 for PV module safety, in collaboration with Underwriter's Laboratory and the Canadian Standard Association, that would replace the current 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, 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. The tremendous initial response to the microFIT program signals a strong support for residential solar rooftop applications in Ontario.

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.

Annex A. Method and accuracy of data

The estimated PV module capacity installed in Canada in 2010 is estimated to be 291 MW (±5%). 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, 2010. 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 70 PV industry players of which 47 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.

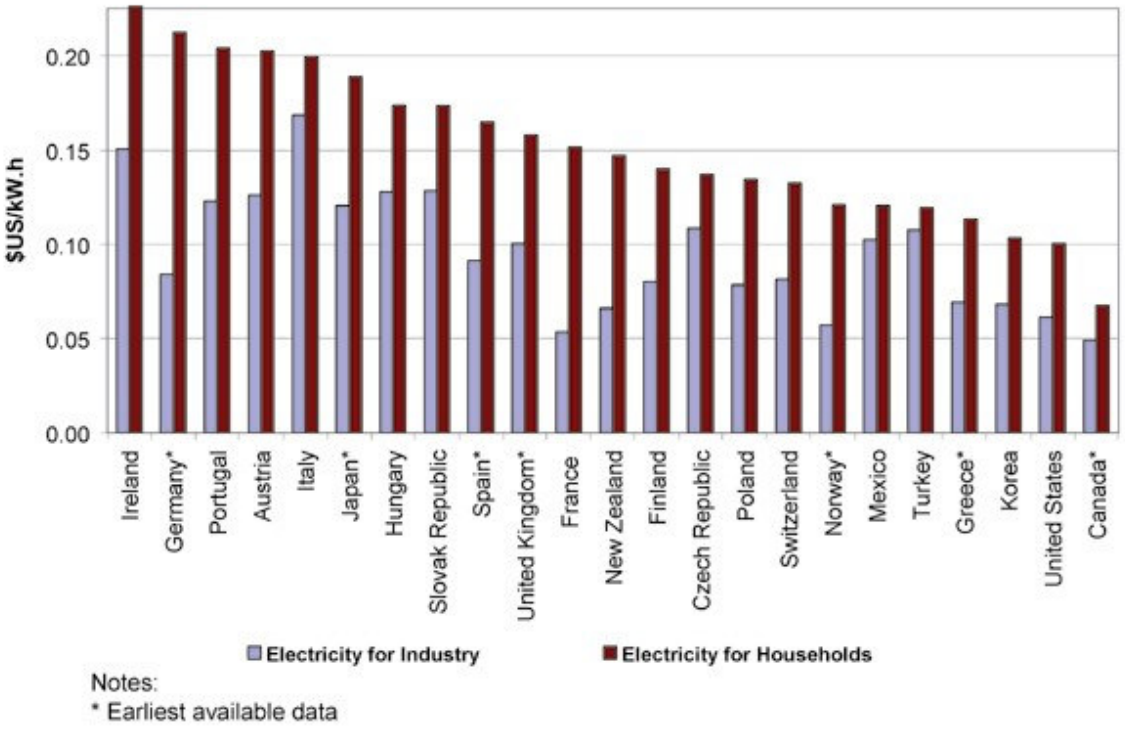
Annex B: Country information

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

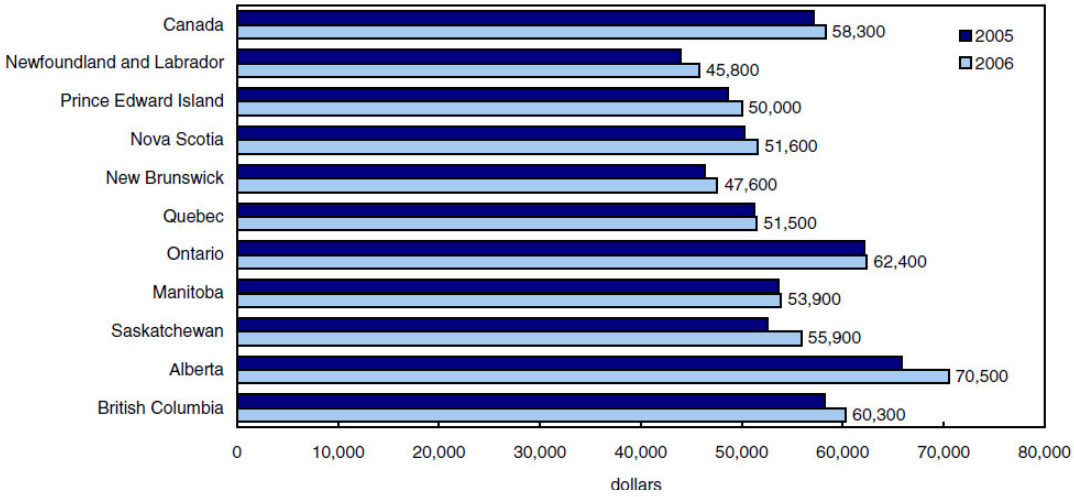
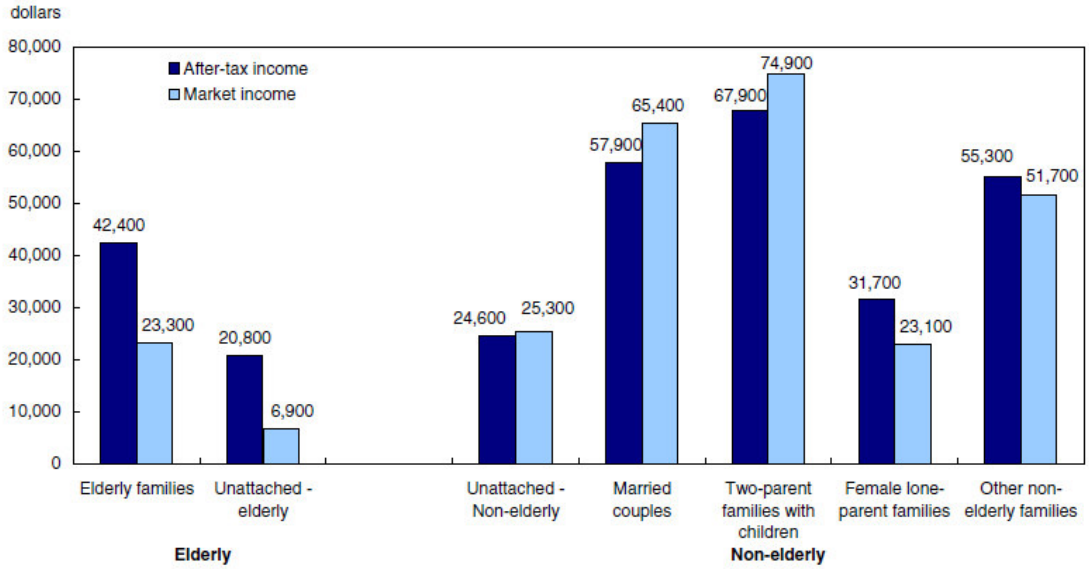


Chart 4
Median market and after-tax income by family types, Canada, 2006



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

[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/