



**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
2012**

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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/m², cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

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 Program: A program to test the performance of PV systems/components in real conditions.

Demonstration Program: A program 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, electricity utility businesses 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:

Feed-in tariff (FIT)	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that may be higher or lower 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 business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies
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	allows PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle
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
Activities of electricity utility businesses	includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) 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 23 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association and the US Solar Energy Industries Association are also members. Both Thailand and the International Copper Association are pending members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, 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 2012. 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

Canada's solar sector has experienced continued significant investment over the last 4 years. Direct employment in PV-related areas in Canada has grown with a 2012 labour force estimated at over 3 900 compared to 2 700 jobs in 2009. These jobs are supported by others in electric utilities, businesses and government engaged in projects, value chains and PV industry support structures. Along with this the reported revenues from commercial activities in the solar sector were estimated to be 1 026 million CAD in 2012.

In 2012, a Sector Profile for Solar Photovoltaics in Canada¹ was published as a comprehensive review of many aspects of the sector covered in this National Survey Report. It reported on the state of the PV market including various incentives in place, describing the PV supply chain, key manufacturers, economic impacts, workforce capability and the state of R&D initiatives in Canada.

1.1 Installed PV power

An additional 268.29 MW (87.52 MW distributed plus 181.18 MW centralized) of grid connected PV capacity was installed in 2012. This brings the cumulative installed capacity to 765.97 MW in Canada.

1.2 Costs & prices

In 2012 the weighted average module price reported was 1.15 CAD/Watt, this is a 24 % reduction compared to 2011. Turnkey average prices for grid connected systems range between 2.80 CAD/Watt to 5.00 CAD/Watt, compared to the off-grid systems which average 8.10 CAD/Watt. On average this represents a system price decrease ranging from 24 to 36 %, which largely reflects the decreasing module costs with increased efficiencies in the industry soft costs and supply chain development.

1.3 PV production

Canada PV production in 2012 includes approximately 460 MW_{DC} of standard and building integrated PV modules, and approximately 2 000 tonnes of silicon and 350 tonnes of cadmium telluride feedstock. This represents a 142 % growth in production from 2011, and just under half of the total production capacity in the country which amounted to 976 MW_{DC} in 2012. Most of the feedstock production is exported from Canada for manufacturing cells. Most of the module production serves the domestic market with the continued investment particularly from the Ontario domestic market under its feed-in tariff program. Canada also manufactures balance of system technologies and other components of PV systems.

1.4 Budgets for PV

Total market incentives and public budgets in Canada increased significantly to 333 million CAD in 2012, an increase of over 78 % compared to 2011 that was mainly due to the feed-in tariff program in the province of Ontario.

¹Sector Profile for Solar Photovoltaics in Canada <http://canmetenergy.nrcan.gc.ca/renewables/solar-photovoltaic/publications/3092>

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 PV capacity of 40 W or more. A PV system consists of modules, inverters, all installation and control components for modules, and any necessary batteries or other components related to solar generation.

For the purposes of this report, PV installations are included in the 2012 statistics if the PV modules were installed between 1 January and 31 December 2012, although commissioning may have taken place at a later date.

2.1 Applications for photovoltaics

The grid-connected market accounted for 34 % of total sales in Canada in 2008 and reached close to 100% in 2012. This is a significant growth sector, spurred by the Province of Ontario's Feed In Tariff (FIT) Program since October of 2009. Of the grid connected applications, 33 % of the installed MW capacity was for residential and building applications, and 67 % for several large groundmounted centralized utility scale systems.

The off-grid applications are generally not subsidized. They consist of stand-alone applications comprising a PV array as the sole generator or as a hybrid system combined with a small wind turbine or diesel generator. These systems are usually sited remotely with or without battery storage, but are increasingly installed in less remote areas as costs change and design professionals and the public become more aware of opportunities. The "domestic" off-grid market consists primarily of remote homes and cottages, residential communication (radios), and recreational vehicles. The off-grid non-residential market consists of water pumping, road signals, navigational buoys, telecommunication repeaters, and industrial sensing, monitoring, and controlling.

2.2 Total photovoltaic power installed

As shown in Table 3, the cumulative PV power capacity grew to 765.97 MW (± 3 %) in 2012. The off-grid capacities are not reported in 2012, but were estimated at about 1 % of the total installed capacity in 2011. That figure is anticipated to have decreased relatively in 2012 to the cumulative grid-connected capacity. This is a significant transition for the PV industry that historically served mainly the off-grid market prior to 2008.

Despite the year-long suspension of project approvals during to the Ontario FIT review process, the combined installed capacity of both rooftop and ground-mounted photovoltaic installations was almost the same as it was in 2011. Grid-connected applications installed on buildings in Canada in 2012 amounted to 87.52 MW of distributed generation, compared to 103.42 MW in 2011. There was a slight increase in centralized grid-connected projects with 181.18 MW installed in 2012, compared to 172.82 MW in 2011. This brings the total capacity installed in 2012 to 268.29 MW for grid-connected applications.

Table 1: PV power installed during calendar year 2012 in 4 sub-markets.

Sub-market/ application	off-grid domestic	off-grid non- domestic	grid- connected distributed	grid- connected centralized	Total
PV power installed in 2012 (MW)	NA	NA	87.52	181.18	268.69

To put this in context, across Canada almost 60 % of the generation capacity is from hydro, 14 % from nuclear, 14 % from coal and 9 % from natural gas, with the balance from oil, wind, biomass, solar and geothermal². The power supply mix varies significantly across the provinces and territories, reflecting the natural resources available.

In the province of Ontario where the largest installation of solar capacity is, solar generated power represents 1.4 % of the province's 35 858 MW capacity. In Canada solar represents less than 1 % of overall generation capacity, and production accounts for even less of the power consumed by the country (Table 2).

(Note: Refer to Annex A for a detailed description of the methodology for this survey report. Information was gathered from major provincial utilities that have grid-connected clients in Canada for 9 provinces and three territories. For Ontario, the data is publicly available on the Ontario Power Authority website³; however, it should be noted that the Ontario Power Authority reports the installed power in MWAC, therefore a derate factor of 0.85 was used to convert between DC and AC power for this survey report.)

Table 2: PV power and the broader national energy market.

Total national (or regional) PV <u>capacity</u> (from Table 2) as a % of total national (or regional) electricity generation capacity	<u>New</u> (2012) PV capacity (from Table 1) as a % of new electricity generation capacity	Total PV <u>electricity</u> production as a % of total electricity consumption
0.55 % (Less than 1 %)	10.6 %	0.18 % (Less than 1 %)

A summary of the cumulative installed PV Power, from 1992-2012, broken down into four sub-markets is shown in Table 3.

Table 3: The cumulative installed PV power in 4 sub-markets.

Sub-market	Cumulative installed capacity (MW) as at 31 December									
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Off-grid domestic	0.10	0.19	0.31	0.45	0.61	0.86	1.38	2.15	2.54	3.32
Off-grid non-domestic	0.69	0.84	0.99	1.19	1.70	2.26	2.82	3.38	4.30	5.16
Grid-connected distributed	0.17	0.19	0.20	0.21	0.24	0.25	0.26	0.29	0.30	0.34
Grid-connected centralized	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL (MW)	0.96	1.23	1.51	1.86	2.56	3.38	4.47	5.83	7.15	8.83

² National Energy Board – 2010 Reference Case <http://www.neb-one.gc.ca>

³ Ontario Power Authority <http://fit.powerauthority.on.ca/program-updates/past-updates/bi-weekly-fit-and-microfit-program-reports>

Sub-market	Cumulative installed capacity (MW) as at 31 December (cont'd)										
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Stand-alone domestic	3.85	4.54	5.29	5.90	6.68	8.09	10.60	15.19	22.85	23.31	NA
Stand-alone non-domestic	5.78	6.89	8.08	9.72	12.30	14.77	16.88	20.01	37.25	37.74	NA
Grid-connected distributed	0.37	0.40	0.47	1.07	1.44	2.85	5.17	12.25	27.74	131.16	218.68
Grid-connected centralized	0*	0	0.04	0.06	0.06	0.06	0.06	47.12	193.29	366.11	547.29
TOTAL (MW)	10.00	11.83	13.88	16.75	20.48	25.77	32.72	94.57	281.13	558.29	765.97

Note: *The single grid-connected centralised system was de-commissioned.

2.3 PV implementation highlights, major projects, demonstration and field test programs

2.3.1 The Government of Ontario's Feed-In Tariff program

Most investment in PV systems in Canada is in the Province of Ontario, the second largest province. Ontario's Feed-In Tariff (FIT) program, managed by the Ontario Power Authority (OPA), is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar PV, bioenergy, waterpower and wind. Projects eligible for the FIT must adhere to a 60 % domestic (Ontario) content policy. Prices paid for renewable energy generation under the FIT program vary by capacity and energy source and take into account the capital investment required to implement the project. Under the program, solar PV owners enter into a 20 year contract with the OPA to receive a fixed price for the electricity they generate.

In 2012 the FIT review⁴ resulted in an adjusted pricing schedule and a new point system for encouraging community and aboriginal participation in project development. In light of decreasing system costs, tariffs were decreased by 9.6 - 31.5 % for rooftop installations and 12.4 - 30.7 % for groundmount installations. Rooftop installations less than 10 kW now receive 54.9 ¢/kWh generated. Groundmount installations above 500 kW and less than 5 MW receive 35 ¢/kWh generated. Table 12 shows the adjustments to the pricing schedule. The current FIT program is in support of the province's target of 10.7 GW of non-hydro renewable generation by 2018 under its current Long Term Energy Plan.

After the FIT review, applications were taken for 50 MW of projects 10 kW or less, and 200 MW of projects between 10 and 500 kW. In December 2012 the World Trade Organization ruled against Ontario's domestic content policy for the FIT program, following complaints made by Japan and the EU. Canada is appealing that decision in 2013.

⁴ <http://www.energy.gov.on.ca/en/fit-and-microfit-program/2-year-fit-review/>

2.3.2 Northwest Territory Showcase Demonstration Project

In the Northwest Territories a large 60.6 kW PV system was installed (Figure 1) to assess the cost and benefits of solar PV/diesel hybrid systems in remote community microgrids. The system is economical and reduces the environmental risk of transporting diesel. In light of the project's success the decision was made to expand it to a total of 104 kW in 2013. These grid-connected systems can make up 20 % of a community's average power load without requiring battery storage or complex controls.

The Northwest Territories developed a "Solar Energy Strategy 2012-2017"⁵ that aims to displace 20 % of diesel-powered generation with solar PV in 25 diesel powered communities. The strategy includes development of a monitoring program that can be used to model PV production in northern climates.



Figure 1: Fort Simpson is Northwest Territories Power Corporation's largest diesel-powered community. This 61 kW system (the largest north of 60° in Canada) will help displace 15 000 L of fuel annually and provide up to 8.5 % of the village's minimum power requirements during the summer. (Photo: Skyfire Energy)

2.3.3 Kortright Photovoltaic Performance Verification (PVPV) Program

The Kortright Centre serves as a renewable energy demonstration and training facility for Ontario and Canada. The Sustainable Technology Evaluation Program⁶ monitors the performance of modules under its standardized field test conditions. Results from this test site serve as a baseline for Ontario yield expectations. PVPV uses module level maximum power point tracking (MPPT) and independent module level performance analyzers to monitor power and energy yields. The modules are also independently flash tested under Standard Test Conditions (STC). The field test also measures on-site total global horizontal insolation and plane of the array insolation, ambient and module temperatures, and ambient wind speed. Kortright's PVPV program issued monthly reports in 2012 on the average performance of 3 modules from each of 5 Ontario manufacturers.

⁵ Northwest Territories Solar Energy Strategy:
http://www.enr.gov.nt.ca/live/documents/content/Solar_Energy_Strategy_2012-2017.pdf

⁶ Photovoltaic Performance Verification Program (www.pvpv.ca)

2.4 Highlights of R&D

2.4.1 Canadian PV Innovation Network:

The PV Innovation Research Network, funded by the Natural Sciences and Engineering Research Council (NSERC), brings together a core group of 32 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners. The network submitted its midterm report and held its third national scientific conference and first Canadian PV graduate school event. The network focuses its efforts on organic, nanostructure and other innovative PV device approaches that have the potential to leapfrog existing and established technologies.

2.4.2 Smart Net-zero Energy Buildings strategic Research Network (SNEBRN):

The NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBSN) performs research that will facilitate widespread adoption in key regions of Canada of optimized net zero energy buildings design and operation concepts by 2030. CanmetENERGY is contributing 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". 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.

2.4.3 Natural Resource Canada, CanmetENERGY

NRCan's CanmetENERGY is responsible for conducting PV 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.

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

Total market incentives and public budgets in Canada increased significantly to 333 million CAD, an increase of over 78 % compared to 2011 due to the market incentive program in the province of Ontario (Table 4). The R&D and demonstration/field test investments remained about the same, from 2011 to 2012, increasing by 2 million CAD in federal R&D. Demonstration and field test projects focused on the assessment of solar photovoltaic technologies applied to residential and commercial buildings, as well as small remote community-scale applications.

Federal and provincial research funding agencies such as NSERC⁷, CFI⁸, and the Ontario Centers of Excellence⁹, increased their investment to augment the level of activities in the field of solar cell research in 2012. A survey of leading universities in Canada found that about 40 research groups from 20 universities employing an estimated 400-450 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.

Sustainable Development Technology Canada (SDTC), an arms-length foundation that operates as a not-for-profit corporation, established by the Government of Canada supports the development and demonstration of innovative clean technological solutions. During the 2008-2011 time period, SDTC co-funded 5 private projects worth 7.6 M CAD on solar cells, concentrated PV systems, building integrated applications and micro inverters. SDTC works closely with a 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.

The Natural Resources Canada ecoENERGY Innovation Initiative (ecoEII) funds research and development to reduce barriers to the deployment of renewables¹⁰. The Toronto and Region Conservation Authority (TRCA) received 1 million CAD in ecoEII funding for the Kortright Energy Yield Test Standard¹¹. By developing a solar energy yield test standard for Canada, this project is designed to increase the reliability and optimized performance of PV systems in Canada. The project will provide environmentally specific energy ratings through the validation of the International Electrotechnical Commission (IEC) standard (61853) for PV module performance testing and energy ratings under outdoor conditions. The results will help form one of the best available data sources in Canada on the performance of PV in cold climates. Verification and eventual use of the standard in Canada will instill greater consumer confidence in PV technologies and provide a more stable environment for business investment in the solar sector.

Table 4: Public budgets for R&D, demonstration/field test programmes and market incentives (M CAD)

	R & D	Demo/Field test	Market incentives
National/federal	11	1	1
State/regional	1	2	318
Total	333		

⁷ National Science and Engineering Research Council of Canada at <http://www.nserc-crsng.gc.ca/>

⁸ Canada Foundation for Innovation at <http://www.innovation.ca/en>

⁹ Ontario Centre of Excellence at <http://www.occ-ontario.org/Pages/Home.aspx>

¹⁰ ecoENERGY Innovation Initiative at <http://www.nrcan.gc.ca/energy/science/2003>

¹¹ Kortright Energy Yield Test Standard project at <https://www.thelivingcitycampus.com/demonstration/living-city-campus-solar-test-facility-verify-international-solar-photovoltaics-yield->

3 INDUSTRY AND GROWTH

3.1 Production of feedstocks, ingots and wafers

Canada continues to produce feedstock for the global solar industry through two companies, Silicor Materials and 5N Plus (Table 5).

In 2012 Calisolar was renamed to Silicor Materials. Silicor Materials is an American company with major operations in Canada. It has a R&D office in Germany, and is building a manufacturing facility in the US. Their primary client is Suntech (China).

5N Plus is a Canadian company, with 14 manufacturing facilities in Canada, US, Malaysia, England, China, Belgium and Laos. They have 18 sales offices in Asia, Europe, North America and South America. First Solar (US) is their primary customer and is one of the top five module producers worldwide.

Table 5: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers (or total national production)	Process & technology	Total Production	Product destination (if known)	Price (if known)
Silicor Materials	Silicon feedstock	2 000 tonnes (2009 est.)		
5N Plus	CdTe high purity compounds	350 tonnes (2010 est.)		

3.2 Production of photovoltaic cells and modules

Table 6 presents data from 11 companies in Canada producing PV modules, all of which have their facilities located in the province of Ontario. Many of these companies are contract manufacturing modules for other multi-national companies. Together these 11 companies produced an estimated 460 MW_{DC}, largely for the domestic market in Canada. This represents a 142 % growth in production from 2011, and just under half of the total production capacity in the country which amounted to 976 MW_{DC} in 2012.

Of these 11 manufacturers, 7 are Canadian companies. Canadian Solar is the largest of the Canadian companies. Of its 1.8 billion CAD in revenues (2011), 50 % came from Europe, 25 % from Asia, and 25 % from the Americas. The company has 10 000 employees globally, with 400 working in Canada. It also has a 50:50 joint venture with SkyPower (a Canadian developer) to develop utility scale projects in the Middle East, Africa and Latin America.

Table 6: Canadian PV Module Production and Capacity 2012

Company	Technology	2012 Production (MW _p)	Maximum Production Capacity by year end 2012 (MW _p)
Celestica	mc-Si, sc-Si	460	220
Canadian Solar	mc-Si, sc-Si		220
MEMC/Flextronics*	mc-Si		120
Photowatt / ATS*	mc-Si		100
Silfab	mc-si, sc-Si		90
Eclipsall	sc-si		70
Heliene	mc-Si		54
OSM Solarform*	mc-Si, sc-Si		50
Solgate*	mc-Si, sc-Si		22
Lumin	mc-Si, sc-Si		20
Centennial	mc-Si, sc-Si, CIGS, Amorphous, Spherical (flexible)		10
Total			460

* 2012 Production was estimated and 2012 production capacity based on 2011 PVPS submission.

3.3 Module prices

As shown in Table 7, module prices have gradually declined from 10.70 CAD/Watt in 2000 to 1.15 CAD/Watt in 2012. This represents a 24 % decrease from 2011 module prices. The minimum module price that was achieved in 2012 was 0.85 CAD/Watt for imported modules.

Table 7: Module prices (CAD/W) for 2000-2012

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Standard module price (wgt avg)	10.70	9.41	7.14	6.18	5.53	4.31	5.36	4.47	3.91	3.31	2.27	1.52	1.15
Annual trends	-3.5%	-12%	-24%	-13%	-10%	-22%	+24%	-17%	-13%	-15%	-31%	-33%	-24%

3.4 Manufacturers and suppliers of other components

A comprehensive sector profile report was published in March 2012 which explores the whole PV supply chain in Canada, including balance of system technologies. The *Sector Profile for Solar Photovoltaics in Canada* can be found online¹² from the CanmetENERGY website.

¹² Sector Profile for Solar Photovoltaics in Canada <http://canmetenergy.nrcan.gc.ca/renewables/solar-photovoltaic/publications/3092>

The balance of system technology market in Canada is mainly served by foreign companies with operations in Canada, or production through contract manufacturing. The companies that have development and manufacturing facilities in Canada include Schneider-Electric (Xantrex), Eaton and Sungrow Canada. Other major brands manufacture through contracts with companies such as Celestica, SAE Power and Sanmina.

3.5 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 distributors, are not involved in the installations and are not in a position to provide information on turnkey system prices. The average installed turnkey price for small grid connected applications was 2.80 – 5.00 CAD, but this price may vary regionally. A summary of typical system prices is provided in the following tables. From 2011 to 2012 the range of system prices for applications decreased between 24 to 37 % (Table 8).

Table 8: Turnkey Prices (CAD/W) of typical applications in 2012

Category Size	Typical Applications in Canada	Current Prices (CAD/W)	
		2011	2012
Off-Grid (≤ 1 kW)	Residential		
Off-Grid (≥ 1 kW)	Residential	12.95	8.10
Grid-Connected (≤ 10 kW)	Distributed	6.79	3.00 - 5.00
Grid-Connected (≥ 10 kW)	Centralized & Distributed	3.50-5.27	2.80 – 4.00

Table 8 a: National trends in system prices (CAD/W) from 2000 - 2012

CAD/W	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Off-Grid (≤ 1 kW)	17.00	20.00	18.00	21.00	18.50	15.00	17.30	15.00	15.00	16.00	16.50	NA	NA
Off-Grid (≥ 1 kW)									NA	NA	NA	12.95	8.10
Grid-Connected (≤ 10 kW)	20.00	NA	NA	NA	14.50	10.00	10.00	8.50	6.50	8.50	6.50 - 8.00	6.79	3.00-5.00
Grid-Connected (≥ 10 kW)						12.60	10.00	10.00		6.00-8.00	4.00 - 6.00	3.50 - 5.27	2.80-4.00

3.6 Labour places

Currently, the number of labour places in PV-related activities in Canada is highly dependent on the FIT program in Ontario. Labour places, shown in Table 9, dropped significantly, from 5 320 jobs in 2011 to 3900 in 2012. These positions span the PV value chain, including those in manufacturing, sales and installation, company R&D, and utility PV dedicated labour. The main decrease was from within the distributor and installation companies that have been undergoing a process of industry consolidation. This trend was most visible during the one year suspension of new contracts associated with the Ontario FIT program review. In 2012, CanSIA identified 650 Canadian organizations and companies that are providing their services in Canada to the PV industry.

Table 9: Estimated PV-related labour places in 2012

Research and development (not including companies)	180
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	3 720
Distributors of PV products	
System and installation companies	
Electricity utility businesses and government	NA
Other	NA
Total	3 900

3.7 Business value

The Canadian PV industry revenue is the sum of the PV related turnover of all the businesses working in the PV sector, that is presented in Table 10. 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 estimated revenue was 1 026 M CAD in 2012. This includes approximately 70 M CAD of revenues was generated by feedstock manufacturers. The export market accounted for 8 % of total revenues in 2012 (Table 10a) which is an increase from 3 % reported in 2011.

Canada has companies which span the PV value chain. About 3/4 of manufacturers are multinational companies operating through contract manufacturing in Canada. Other multinationals have bought smaller Canadian manufacturing facilities in Canada such as Silicor buying 6N, Eaton buying IE Power, and Schneider buying Xantrex. Most of these companies are concentrated in Ontario, with BC and Quebec hosting the balance of other manufacturing companies. Distribution and installation companies are similarly concentrated in Ontario, however many have capacity in other provinces across Canada.

Table 10: Value of PV business, Trends in PV business in Canada from 2000-2012 (M CAD)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
M CAD	42	45	95	100	125	150	201	290	510	720	1 310	1 175	1 026
Change	5%	7%	111%	5%	25%	17%	34%	44%	76%	42%	82%	-11%	-13%

Table 10a: Revenue distribution within the PV business in Canada in 2012 (M CAD)

	Manufacturing	System Installation	Other	Total	%
Export	14	3	70	87	8
Domestic	589	350	NA	939	92
Total	603	353	70	1 026	100

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 11 lists the main support measures (definitions are included at the beginning of this report) for PV during 2012. The most significant PV-specific support measures are in Ontario with a feed-in tariff and local content policy, as discussed throughout this report. Net metering programs exist in almost all provinces, some limiting the generation by capacity or a customer's annual consumption. The province of Alberta's Micro-Generation Regulation stipulates that customers generating less than 1 MW have no connection fees, and customers can sell back to the grid through a net metering arrangement.

Table 11: PV support measures

	National / Regional (State) / Local
Enhanced feed-in tariffs	Yes (province of Ontario)
Direct capital subsidies	No
Green electricity schemes	No
PV-specific green electricity schemes	No
Renewable portfolio standards (RPS)	Yes (province of PEI)
PV requirement in RPS	No
Investment funds for PV	Yes (private sector, co-operatives)
Tax credits	Yes (federal, province-specific)
Net metering	Yes (province-specific)
Net billing	Yes (province-specific)
Commercial bank activities	Yes
Electricity utility activities	Yes
Sustainable building requirements	Yes (through voluntary action to attain LEED-level certification for commercial and institutional buildings)

The growth in installed PV capacity across Canada reflects provincial and territorial support measures. Figure 2 shows the installed capacity across the country, with the bulk of that capacity in Ontario. Looking at other provincial and territorial support measures, PV capacity can be expected to increase in the Northwest Territories under their new solar strategy, and continued growth can be expected throughout the country where net metering programs exist and as system prices decrease.

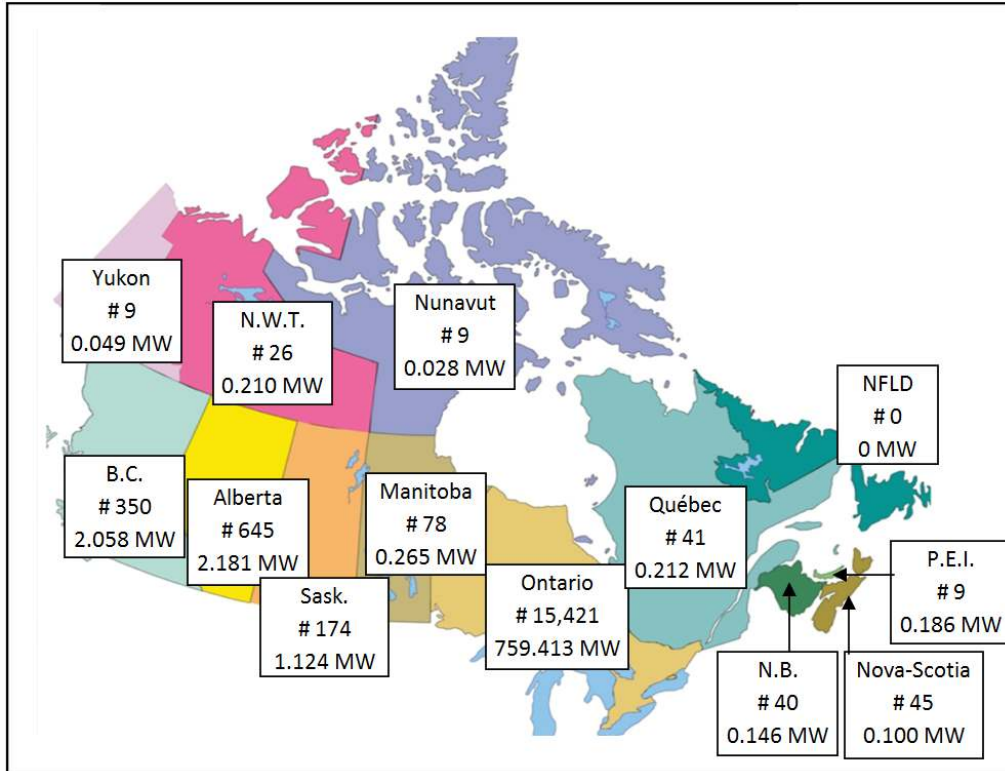


Figure 2: Grid-connected PV Systems in Canada 2012

4.1 Direct policy issues

The province of Ontario's installed capacity will continue to grow under the current Long Term Energy Plan targets for renewable generation, supported by the FIT program. The incentive program is divided into microFIT for projects 10 kW and less; small FIT for projects up to 500 kW and large FIT for projects greater than 500 kW. Table 12 reflects the new pricing schedule for PV systems following the 2012 review of the Ontario FIT program. The Ontario Power Authority cited the decreasing cost of modules and other system components as justification for decreasing the feed-in tariff price. These prices apply to eligible projects in support of the province's 10.7 GW by 2018 target for non-hydro renewable energy under its current Long Term Energy Plan. Other changes to the program include a priority point system for the ranking of small and large FIT projects to encourage engagement with municipalities, community co-ops and aboriginal groups in projects.

The Saskatchewan Net Metering Program¹³ provides a 20 % rebate on installed system costs for up to 100 kW projects to a maximum of 20 000 CAD.

¹³ Saskatchewan Net Metering Rebate: <http://www.saskpower.com/efficiency-programs-and-tips/generate-and-move-your-power/net-metering-program/net-metering-rebate/>

Table 12: Feed-In Tariff support measure in the province of Ontario (CAD)

Application type	Project Size Tranche	Original FIT Price (¢/kWh)	New FIT Price (¢/kWh)	% Change from Original FIT Price
Solar Rooftop	≤ 10 kW	80.2	54.9	-31.5%
	>10 ≤ 100 kW*	71.3	54.8	-23.1%
		<250 kW		
	>100 ≤ 500kW*	63.5	53.9	-15.1%
		>250 ≤ 500kW		
>500 kW	53.9	48.7	-9.6%	
Solar Groundmount	≤ 10 kW	64.2	44.5	-30.7%
	>10 kW ≤ 500 kW*	44.3	38.8	-12.4%
	>500 kW ≤ 5 MW*	44.3	35.0	-21.0%
	> 5 MW*		34.7	-21.7%

In Quebec the Programme d'aide à l'installation d'équipements solaires opérationnels¹⁴ (PAIESO) covered up to 50 % of installed cost for Solar Thermal and 75 % for PV for commercial, industrial, institutional, municipal and agricultural installations that offset fossil fuel use (stand alone, mini-grid) through the end of 2012.

Nova Scotia's community Feed-in Tariff¹⁵ (COMFIT) program began a review in 2012 for the feasibility of implementing photovoltaics into the program, developed to help facilitate the Province's 2015 and 2020 goals of renewable electricity generation at 25 % and 40 % respectively.

The Northwest Territories Alternative Energy Technologies Program¹⁶ supports the governments Energy Plan and Greenhouse Gas Strategy. The program offers funding for up to 1/3 or 1/2 of the cost of energy projects depending on the applicant and the size of the project. This can equal up to 50 000 CAD per year for community projects, up to 15 000 CAD per year for commercial projects and up to 5 000 per year for residential projects.

¹⁴ Programme d'aide à l'installation d'équipements solaires opérationnels:
<http://www.efficaciteenergetique.mrnf.gouv.qc.ca/en/business-clients/municipalities/programme-daide-a-l-installation-dequipements-solaires-operationnels/#sthash.V0IGOUQ0.dpuf>

¹⁵ Nova Scotia Community Feed-in Tariff Program: <http://nsrenewables.ca/feed-tariffs>

¹⁶ Northwest Territories Alternative Energy Technologies Program
<http://www.enr.gov.nt.ca/live/pages/wpPages/aetp.aspx>

4.2 Indirect policy issues

There are a number of indirect policies which influence the market for solar in the provinces and territories of Canada. These programs are identified and linked through the CanSIA website¹⁷. These are in addition to targets for reducing carbon emissions, carbon taxes and caps that exist in various provinces.

Among other targeted benefits, smart grid development in Canada aims to support greater integration of distributed and intermittent generation, such as PV. Most notably Ontario and Alberta are exploring market mechanisms for ancillary services which can support greater grid penetration of wind and PV generation.

The development of remote microgrids in Canada can often support PV deployment, as many of these remote off-grid systems favour low-maintenance PV generation in hybrid systems with diesel and other forms of generation. Remote microgrids with PV are being explored more actively in BC, Yukon, Northwest Territories and Nunavut. The Northwest Territories also published its Solar Energy Strategy 2012-2017, described in Section 2.3.

4.3 Interest from electricity utility businesses

In Alberta ENMAX, the Calgary utility, developed its Generate Choice program¹⁸ where it offers customers a selection of pricing programs for 1.3 kW or more with a 15 year limited maintenance warranty. Many of the province's Boutique Retailers participate in the Light up Alberta - Micro-Generation Premium Credit Program,¹⁹ which offers 0.15 CAD/kWh for electricity generated from solar energy and exported to the grid.

In Ontario certain utilities are offering solar installation and maintenance programs for customers. For example, PowerStream Solar²⁰ leases rooftops from commercial customers to install PV systems eligible for the province's FIT program. Other utilities have unregulated affiliate companies that offer these services. For example, Horizon Energy Solutions Inc. is held by the Hamilton and St. Catherine's utilities and owned by these two cities. Through their Solar Solutions²¹ program they lease Industrial Commercial and Institutional (ICI) rooftop space to host solar systems, and also offer turnkey solutions for building owners that prefer to own and operate their systems.

Utility involvement in these types of ventures offers them more standardization and control over PV grid-connected systems on their electricity distribution system, and more opportunities to serve their customers.

4.4 Interest from municipalities and local governments

Numerous cities such as Dawson Creek in BC have municipal sustainability plans into which PV contributes toward the city's goals. Edmonton, Alberta conducted a residential and commercial solar electricity pilot program which offered up to 9 000 CAD of the cost to install a PV system on residences, and up to 18 000 CAD for installations on businesses. Edmonton is now in the process of producing a plan for the city based on greenhouse gas

¹⁷ Review of provincial and territorial supports: <http://www.cansia.ca/government-regulatory-issues/consumer-incentives/provincial>

¹⁸ Enmax Generate Choice: <http://www.generatechoice.ca/>

¹⁹ Light Up Alberta: http://www.albertacanada.com/AIS-BP_Light_Up_Alberta_-_premium_credit_programme_for_micro-generators.pdf

²⁰ PowerStream Solar: <http://www.powerstreamsolar.ca/solar/>

²¹ Horizon Energy Solutions Inc. Solar Solutions: <http://www.horizonenergysolutionsinc.com/SolarSolutions/Pages/default.aspx>

reductions and economic growth which will include incentive programs for PV and other forms of renewable generation. Toronto in Ontario has a Building Integrated PV (BIPV) working group which meets monthly, convened by municipal staff and participated in by local building developers, researchers and BIPV companies. Many cities, such as the City of Toronto, also exercise renewable generation procurement policies for their municipal properties, and others in Ontario are developing their own generation portfolios.

4.5 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. The Standards Council of Canada is Canada's representative at the International Electrotechnical Commission (IEC), a global organization that works towards the harmonization of safety and quality standards for a broad range of electrical products.

The Canadian national committee for the development of international solar photovoltaic standards, has several expert groups that are reviewing the standards and codes to streamline interconnection to the electricity grid in Canada. In 2012, Canada adopted the amendments to the IEC standards on solar photovoltaic module safety (IEC 61730). In addition, Canada hosted an international working group that is studying improvements to solar power converter equipment.

5 HIGHLIGHTS AND PROSPECTS

In 2012, a Sector Profile for Solar Photovoltaics in Canada was published. It reported on the state of the PV market including various incentives in place, describing the PV supply chain, key manufacturers, economic impacts, workforce capability and the state of R&D initiatives in Canada.

The Canadian Solar Industry Association (CanSIA) in their strategic planning process has identified innovation in the solar electricity sector as a key strategic opportunity for Canada. In December 2012 CanSIA published a Whitepaper on Solar Electricity Innovation in Canada.²² A committee will support an in-depth analysis of opportunities for innovation in solar electricity generation and prepare a Solar Electricity Innovation Roadmap for Canada in 2013.

The Feed-In Tariff (FIT) 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.

Other existing and past programs in the provinces and territories such as the Saskatchewan Net metering program, the PAIESO program in Quebec, and the Nova Scotia COMFIT program demonstrate formative and growing PV market opportunities in a number of regions across Canada. Future growth is anticipated through a number of provincial initiatives that have been announced. The review of PV potential in Nova Scotia as part of the provincial community Feed-In Tariff program (COMFIT) could provide additional opportunity for the development of PV markets in Atlantic Canada. It is expected that Alberta will release its Renewable Energy Framework in 2013 and provide further opportunities for growth in the PV sector. The five-year strategic program by the government of the Northwest Territories will see 20 % of their community average load met by PV power in 25 of its remote microgrid communities. Other Canadian provincial and territorial governments continue to evaluate the potential for accelerating the deployment of solar PV in their energy supply mix.

²² CanSIA Innovation Whitepaper:
http://www.cansia.ca/sites/default/files/20121202_cansia_seisc_whitepaper_v1.0_final_1.pdf

ANNEX A. METHOD AND ACCURACY OF DATA

The PV module capacity installed in Canada in 2012 is estimated to be 765.97 MW ($\pm 3\%$). Products imported over the internet and through direct orders were not included in this market study. Information was gathered from a survey of major provincial utilities that have grid-connected clients in Canada and the Ontario Power Authority quarterly progress reports regarding PV solar utility scale parks. The number of labour places was estimated based on a previous solar PV sector profile published in March 2012, the PV module manufactured capacity and the installed PV capacity in 2012. A survey of 13 PV manufacturers was completed to obtain R&D expenditures and the domestic and export revenues in 2012. A survey of 43 PV installer/retailers/distributors was conducted to obtain the weighted average PV module and system cost in CAD/Watt in 2012. Additional information on larger Canadian PV companies was collected from their annual reports to shareholders and publicly available information. 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 (CAD), average capacity (Wp), and turnkey price per application (CAD/Wp) for off-grid residential and on-grid distributed applications.
- Total revenues (and the percentage related to export activities) from manufacturers of modules, inverters/power conditioners, storage batteries, controllers, equipment for PV systems, manufacturing and test equipment, and consumer products.
- Total investments in R&D, increased manufacturing capacity and acquisitions in PV-related business over the last two years from manufacturers of modules, inverters/power conditioners, storage batteries, controllers, equipment for PV systems, manufacturing and test equipment, and consumer products.
- Average PV power (kWp) of solar products from solar product manufacturers.
- Factors that had a significant impact on businesses in 2011 as well as the positive and negative effects of the Internet on PV business.
- Typical module prices.
- Turnkey prices of typical applications.

ANNEX B: COUNTRY INFORMATION

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

1. **Retail electricity prices - household, commercial, public institution Industry and Household Electricity Prices in major cities in Canada**

5.32 - 18.46 cents/kWh

Source: Hydro Quebec; Rates in effect Apr. 1, 2012

http://www.hydroquebec.com/publications/en/comparison_prices/

2. **Typical household electricity consumption (kWh)**

The national average was 40 GJ or 11 100 kWh/year in 2007. Note that there is a high degree of variability throughout the country due to differences in energy sources (ex: electricity made up 61 % of overall household energy use in the province of Quebec, but only 20 % in Alberta).

Source: Government of Canada

<http://www.statcan.gc.ca/pub/11-526-s/2010001/part-partie1-eng.htm>

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

Refer to the National Energy Board website for information; <http://www.neb.gc.ca/clf-nsi/rnrgynfmrtn/nrgyrprt/lctrcty/lctrctymrkts20052006-eng.pdf>

4. **Typical household income.**

69 860 CAD median

Source: Government of Canada

<http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil108a-eng.htm>

5. **Typical mortgage interest rate**

A one year closed term mortgage varies at prime (3 %) plus 0.65; minus 0.81

Source: Canada mortgage.com

<http://www.canadamortgage.com/RatesShow/ShowRates.cfm?CFID=5620113&CFTOKEN=57063720>

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

120 V

7. **Electricity industry structure and ownership**

See Canadian Electricity Association website:

<http://www.electricity.ca/glossary.php>

8. **Price of diesel fuel**

Average retail price for diesel in Canada: 1.25 CAD/litre (Dec. 25, 2012)

Source: Government of Canada

http://www2.nrcan.gc.ca/eneene/sources/pripri/prices_byyear_e.cfm?ProductID=5

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/m² and in kWh/m²) for any location in Canada on a 300 arc seconds ~10 km grid. They are presented for each month and for the entire year, for six different PV array orientations: a sun-tracking orientation and five fixed South-facing orientations with latitude, vertical (90°), horizontal (0°) and latitude ± 15° tilts (see figure). Data can be obtained at any grid location by "querying" the maps.

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