IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in Canada
2014

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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COVER PICTURE

This 122 kilowatt building integrated PV system was designed by Gordon Howell for the Jeanne & Peter Lougheed Performing Arts Centre on the University of Alberta's Augustana campus in Camrose, central Alberta. The PV system is integrated into the cladding on all four sides. The Centre is a 550-seat theatre, built as a joint initiative between the City of Camrose, Camrose County, the Government of Alberta and the University of Alberta. (photo credit: Gordon Howell).

ACKNOWLEDGEMENT

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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 member countries

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 participating countries and organisations can be found on the www.iea-pvps.org website.

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 promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. 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 the country National Survey Report for the year 2014. 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 INSTALLATION DATA

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, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, **PV installations are included in the 2014 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2014, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

The grid-connected market accounted for 34 % of total sales in Canada in 2008 and reached close to 100% in 2014. 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, 21 % of the installed MW capacity was for residential and building applications, and 81 % for several large ground mounted centralized utility scale systems.

The off-grid applications are generally not incentivized. 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.

1.2 Total photovoltaic power installed

As shown in Table 1, the cumulative PV power capacity grew to 1 843 MW (±3 %) in 2014[1]. The combined installed capacity of both rooftop and ground-mounted photovoltaic installations grew by 52% compared to 2013. There was a significant increase in grid-connected applications installed on buildings in Canada in 2014 with 141,23 MW of distributed generation installed compared to 54,51 MW in 2013. Centralized grid-connected projects increased by 491,37 MW in 2014, compared to 390,00 MW in 2013. This brings the total capacity installed in 2014 to 632,60 MW for grid-connected applications.

[1] Please note that a factor of 0,85 was used to convert the AC power reported by Ontario into rated power used in this report.

Table 1: PV power installed during calendar year 2014

AC			MW installed in 2014 (mandatory)	MW installed in 2014 (optional)	AC or DC
Grid-connected	BAPV	Residential	141,23		DC
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential	NA		
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	491,37	491,37	DC
		CPV			
Off-grid		Residential	NA		
		Other			
		Hybrid systems			
		Total	632,60		DC

Table 2: Data collection process:

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	NA
Is the collection process done by an official body or a private company/Association?	Natural Resources Canada
Link to official statistics (if this exists)	NA
	Estimated accuracy of data: ±3 %

Table 3: PV power and the broader national energy market

MW-GW for capacities and GWh-TWh for energy	2014 numbers	2013 numbers
Total power generation capacities (all technologies)	NA	133,06 GW
Total power generation capacities (renewables including hydropower)	NA	86,3 GW
Total electricity demand (= consumption)	NA	514,4 TWh
New power generation capacities installed during the year (all technologies)	NA	-2 108 MW (Overall, negative growth due to coal plants closures (~4,000 MW), petroleum generation reductions (-343 MW) and other fossil fuels reduction (-981 MW); offset in part by growth in natural gas (+1,024 MW).
New power generation capacities installed during the year (renewables including hydropower)	NA	2 119 MW
Total PV electricity production in GWh-TWh	1,756 TWh	1,136 TWh
Total PV electricity production as a % of total electricity consumption	0.34 % (assuming same consumption level as 2013)	0.22 %

Table 4: Other informations

	2014 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	Centralized: 130 (est.) Decentralized: 24 000 (est.)
Capacity of decommissioned PV systems during the year in MW	NA
Total capacity connected to the low and medium voltage distribution grids in MW	1 796 MW
Total capacity connected to the medium voltage distribution grid in MW	NA
Total capacity connected to the high voltage transmission grid in MW	47 MW

Table 5: The cumulative installed PV power in 4 sub-markets.

Sub-market	Stand-alone domestic (MW)	Stand-alone non-domestic (MW)	Grid-connected distributed (MW)	Grid-connected centralized (MW)	Total (MW)
1992	0,10	0,69	0,17	0	0,96
1993	0,19	0,84	0,19	0,01	1,23
1994	0,31	0,99	0,20	0,01	1,51
1995	0,45	1,19	0,21	0,01	1,86
1996	0,61	1,70	0,24	0,01	2,56
1997	0,86	2,26	0,25	0,01	3,38
1998	1,38	2,82	0,26	0,01	4,47
1999	2,15	3,38	0,29	0,01	5,83
2000	2,54	4,30	0,30	0,01	7,15
2001	3,32	5,16	0,34	0,01	8,83
2002	3,85	5,78	0,37	0,00	10,00
2003	4,54	6,89	0,40	0,00	11,83
2004	5,29	8,08	0,47	0,04	13,88
2005	5,90	9,72	1,07	0,06	16,75
2006	6,68	12,30	1,44	0,06	20,48
2007	8,09	14,77	2,85	0,06	25,77
2008	10,60	16,88	5,17	0,06	32,72
2009	15,19	20,01	12,25	47,12	94,57
2010	22,85	37,25	27,74	193,29	281,13
2011	23,31	37,74	131,16	366,11	558,29
2012	NA	NA	218,68	547,29	765,97
2013	NA	NA	273,19	937,29	1 210,48
2014	NA	NA	540,85	1 302,23	1 843,08

The growth in installed PV capacity across Canada reflects provincial and territorial support measures. Figure 1 shows the installed capacity across the country, with the bulk of that capacity in Ontario.

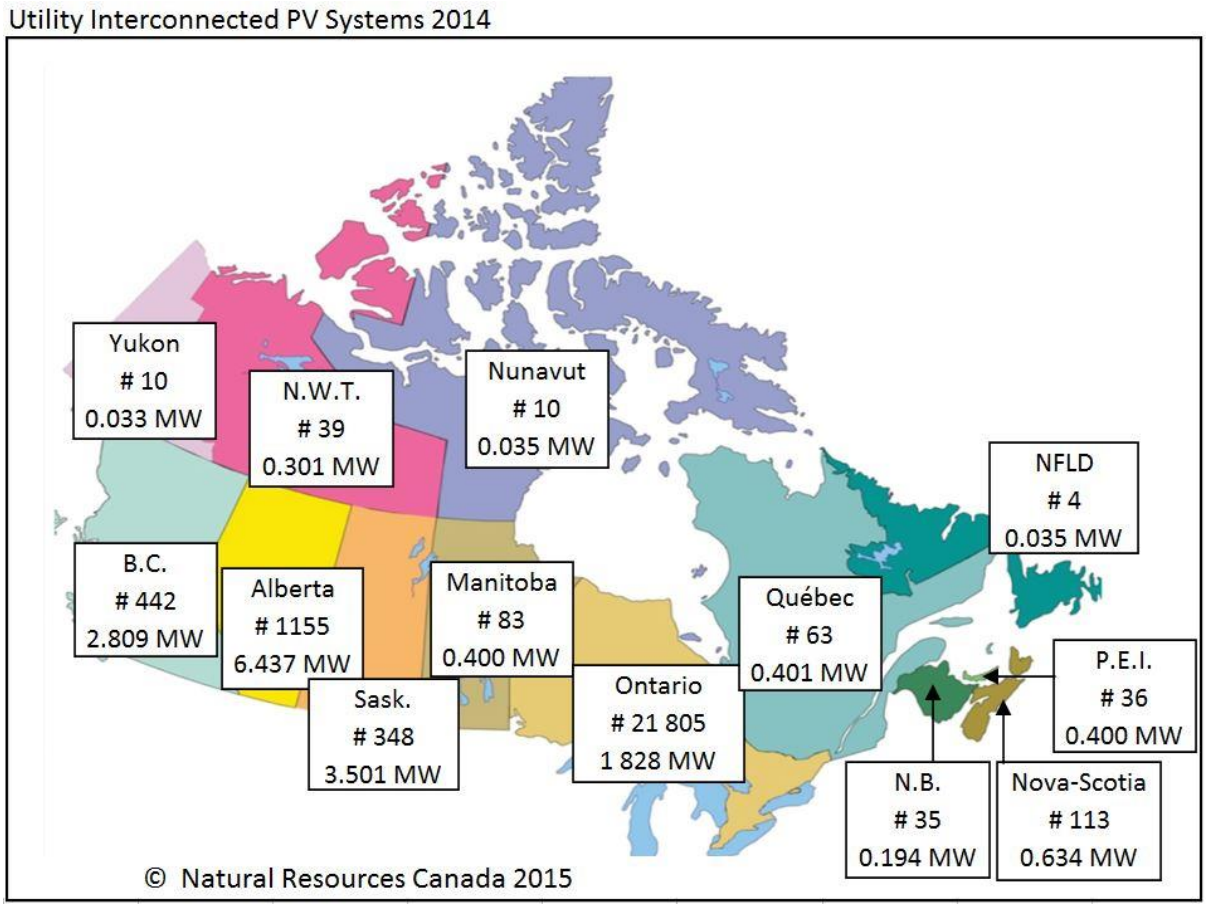

Figure 1: Grid-connected PV Systems in Canada 2014

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

As shown in table 6, module prices have gradually declined from 10,70 CAD/Watt in 2000 to 0,85 CAD/Watt in 2014. This represents an 11 % decrease from 2013 module prices.

Table 6: Typical module prices for a number of years

Year	2000	2001	2002	2003	2004	2005	2006	2007
Standard module price(s): Typical	10,70	9,41	7,14	6,18	5,53	4,31	5,36	4,47
Best price								

Year	2008	2009	2010	2011	2012	2013	2014	2015
Standard module price(s): Typical	3,91	3,31	2,27	1,52	1,15	0,95	0,85	
Best price					0,85	0,80	0,82	

2.2 System prices

The industry reported system prices for grid-connected systems. The average installed turnkey price for grid connected applications was 2,00 – 4,00 CAD, but this price varies regionally and according to system size. A summary of typical system prices is provided in the following tables (table 7 & 8). From 2013 to 2014 the range of system prices for applications decreased between 10 to 14 %.

Table 7: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W (CAD/W)
OFF-GRID Up to 1 kW		NA
OFF-GRID >1 kW		NA
Grid-connected Rooftop up to 10 kW (residential)	Building applied PV system on a house	3,00 – 4,00
Grid-connected Rooftop from 10 to 250 kW (commercial)	Building applied PV system on a commercial rooftop	2,90
Grid-connected Rooftop above 250kW (industrial)	Large building applied PV system on a commercial rooftop	2,20
Grid-connected Ground-mounted above 1 MW	Ground-mounted utility scale PV system (1-10 MW)	2,00 – 2,60
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)		NA

Table 8: National trends in system prices (current) for different applications (in Canadian dollars)

Price/Wp	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residential PV systems < 10 KW	20,00	NA	NA	NA	14,50	10,00	10,00	8,50	6,50	8,50
Commercial and industrial	NA	NA	NA	NA	NA	12,60	10,00	10,00	NA	6,00-8,00
Ground-mounted utility	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Price/Wp	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Residential PV systems < 10 KW	6,50 - 8,00	6,79	3,00-5,00	3,44	3,00 – 4,00					
Commercial and industrial	6,00	5,27	4,00	3,27	2,20 - 2,90					
Ground-mounted utility	4,00	3,50	2,80	2,88	2,00 - 2,60					

2.3 Cost breakdown of PV installations

2.3.1 Residential PV System < 10 kW

Table 9 lists the cost breakdown for a typical residential PV system under ten kilowatts in 2014.

Table 9: Cost breakdown for a residential PV system – local currency

Cost category	Average (CAD/W)	Low (CAD/W)	High (CAD/W)
Hardware			
Module	0,85	0,82	1,01
Inverter	0,45	0,31	0,90
Other (racking, wiring…)	0,23	0,22	0,25
Soft costs			
Installation	0,97	0,26	2,81
Customer Acquisition	0,28	0,11	0,45
Profit	0,73	1,07	0,28
Other (permitting, contracting, financing…)	0,14	0,01	0,30
Subtotal Hardware	1,53	1,35	2,16
Subtotal Soft costs	2,12	1,45	3,84
Total	3,65	2,80	6,00

2.4 Financial Parameters and programs (leasing…)

PV projects, based on 20-year power purchase agreements with entities of solid creditworthiness, are generally able to attract project debt financing starting at $5– 10 million, representing up to 80% of total capital. These arrangements are typically available through banks as well as life insurance companies and pension funds. Banks generally provide financings of up to 8 years with an amortization of up to 16 years. Pension funds and life insurance companies tend to provide longer term financing, typically close to the term of the power purchase agreement; up to 18 years.

Currently, the borrower's cost of capital is typically between 6-6.5 % for long term financing. This rate can be less for shorter terms. Since projects under $5 million are generally subject to the same due diligence and financing costs as larger projects, usually rendering the project uneconomical, there are much fewer options from institutional lenders. Considering that project financings originated as a means to finance large infrastructure projects over $100 million allowing lenders to be easily remunerated for their efforts, projects below $5-10 million tend to lack the required economies of scale. Some opportunities, however, are developing from a small number of other parties willing to invest in the equity of a project while providing the required project debt financing. Yield-co's have emerged as a prominent vehicle for financing assets post-COD. Crowdfunding is another emerging opportunity outside of institutional lenders for projects under $5 million.

While some lenders are prepared to provide term financing (as of commercial operation date) and construction financing (from shovel readiness to commercial operation date), many lenders prefer to focus on term financing only and leave the intricacies of construction financing to others. Construction financing can be structured in various ways. Its interest rate tends to be in the 5% range but it varies according to the structure chosen.

Options for financings with small residential systems include mortgage backed options providing up to 100% of purchase price depending on collateral used and up to 20 year amortization of the loan. Such financings allow recourse to collateral over and above the project itself which permit a higher degree of leverage.

Table 10: PV financing scheme

Average Cost of capital per market segment	5-6 percent
Description of a specific PV financing scheme (leasing, renting…)	Many companies install and own systems on residential and commercial/industrial rooftops that are leased by a third party whereby the building owner receives monthly payments for the space on the roof with little or no initial investment.

2.5 Additional Country information

Canada's electricity sector is regulated provincially and is comprised primarily of a mixture of wholesale open markets and vertically integrated crown corporations. Electricity generation in Canada was 614,5 TWh[2] in 2013 with the largest producers of electricity being the provinces of Quebec

[2] Canadian Electricity Association, 2015

(206,8), Ontario (149,8), BC (64,1) and Alberta (63,6) respectively. The population of Canada was estimated to be 35 678 834 inhabitants[3] at the end of 2014.

Table 11: Country information

Retail Electricity Prices for an household (range)	70,6 – 160,3 CAD / MWh[4]
Retail Electricity Prices for a commercial company (range)	55,9 – 111,84 CAD / MWh
Retail Electricity Prices for an industrial company (range)	45,5 – 133,3 CAD / MWh
Population at the end of 2014 (or latest known)	35 678 834
Country size (km^2)	9 985 000
Average PV yield (according to the current PV development in the country) in kWh/kWp	1 150
Name and market share of major electric utilities.	Hydro-Québec, Ontario Power Generation, BC Hydro and Power

[3] Statistics Canada, 2015

[4] Hydro-Québec, 2015 http://www.hydroquebec.com/publications/en/corporate-documents/comparaison-electricity-prices.html

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

3.1 Direct support policies

A number of direct support policy measures have been put in place in Canada. Table 12 summarizes the different PV support measures. The most significant PV-specific support measures are in Ontario through a feed-in tariff policy.

Table 12: PV support measures (summary table)

	On-going measures	Measures that commenced during 2014
Feed-in tariffs (gross / net?)	Yes (Province of Ontario)	50 MW microFIT (≤ 10 kW), 123.5 MW and 100 MW of FIT 3 and FIT 3 extension (>10 ≤ 500kW), RFQ for 140 MW Large Renewable Procurement program (>500kW) (competitive; non FIT).
Capital subsidies for equipment or total cost	Yes (Provinces including Saskatchewan and municipalities including Medicine Hat, Alberta and territories including Northwest Territories).	-
Green electricity schemes	Yes (voluntary)	-
PV-specific green electricity schemes	No	-
Renewable portfolio standards (RPS)	No	-
PV requirement in RPS	No	-
Investment funds for PV	No	-
Income tax credits	No	-
Prosumers' incentives (self-consumption, net-metering, net-billing…)	Net metering and net-billing common	-
Commercial bank activities e.g. green mortgages promoting PV	No	-
Activities of electricity utility businesses	Many utilities are active in several ways including residential lease-to-own programs	-
Sustainable building requirements	Yes (voluntary)	-

3.2 Direct Support measures

3.2.1 Support measures exiting in 2014

3.2.1.1 Description of support measures excluding prosumers, BIPV, and rural electrification

Ontario – The province of Ontario continued its procurements at the residential-, commercial and utility-scales. Residential-scale solar (≤ 10 kW) was procured through the microFIT program which has an annual procurement target of 50 MW. Commercial-scale solar (>10 ≤ 500kW) was procured through the FIT program. For the first time since 2011, the province also re-launched utility-scale procurement by running an RFQ for the Large Renewable Procurement (LRP) program which will competitively contract 140 MW in 2015.

Saskatchewan **–** The province of Saskatchewan continued its net-metering rebate program which offers offering a one-time rebate, equivalent to 20 per cent of eligible costs to a maximum payment of $20,000, for an approved and grid interconnected net metering project. This program is offered through the province's largest utility SaskPower but is available to all electricity customers in the province.

Alberta - ENMAX Energy Corporation, an electricity retailer in Alberta that offers electricity and natural gas products and services to customers also offers a lease-to-own solar option.

Medicine Hat – The City of Medicine Hat's Hat Smart capital rebate program offers up to $4,700 for eligible systems that enter into an ENMAX Energy Home Solar Lease to Own Agreement.

Yukon – The Energy Branch of the Yukon Government offers a Micro-Generation program that facilitates and incentivises utility-tied renewable energy systems for Yukoners and businesses. For surplus generation, the program offers an incentive of $0.21/kWh for export to the territorial grid (metered with dual-register meter) or $0.30/kWh in diesel generation communities. The Territory also offers a capital rebate of 20% of the cost of renewable energy systems components for both on-territorial grid and off-grid systems.

Northwest Territories - The Alternatives Energy Technology Program (AETP) assists Northwest Territories residents and businesses is intended to reduce fuel use, and lower the cost of operations through the adoption of solar. Under the AETP there is the Residential Renewable Energy Fund (RREF) which provides funding of up to one-third of the cost (maximum to any recipient is $5,000 per year) and the Business Renewable Energy Fund (BREF) is available to assist NWT commercial businesses including off-grid lodges and camps in remote locations where fuel prices and carbon footprints are high.

3.2.1.2 Prosumers' development measures

Most provinces and territories have some form of net-metering or net-billing policy that provides micro-generators with compensation for excess generation. Ontario is the only province with a feed-in tariff. Program design including generator size limits and compensation for excess generation varies from jurisdiction to jurisdiction. Compensation for excess generation is provided in several ways including credits and payment at retail rates or at higher than market rates.

3.2.1.3 BIPV development measures

In Ontario, BIPV projects are eligible to participate in the Feed-in Tariff program. At present, there are no targeted BIPV development requirements across Canada however several voluntary green building programs have given rise to demonstration projects.

3.2.1.4 Rural electrification measures

In Canada, there are nearly 300 off-grid communities with a total population of approximately 200,000 people. These communities include Aboriginal and non-Aboriginal settlements, villages or cities as well as long-term commercial outposts and camps for mining, fishing and forestry activities. Of these sites, approximately 175 are indigenous communities (First Nations, Innu, Inuit or Métis)

with approximately 130,000 residents. There are several initiatives in partnership across all levels of Government to assist with the transition of these communities from diesel fuel to cleaner sources of energy including solar.

3.2.1.5 Other measures including decentralized storage and demand response measures

Decentralized storage remains at the pilot stage with a small number of projects having been developed in partnership between utilities and energy storage providers.

3.2.2 Support measures phased out in 2014

N/A

3.2.3 New support measures implemented in 2014

N/A

3.2.4 Measures currently discussed but not implemented yet

A dialogue has begun in Ontario as to how the province can effectively transition from its Feed-In Tariff program to a model more closely tied to net-metering or self-consumption. It is expected that program design will occur throughout 2015.

3.2.5 Financing and cost of support measures

The ways in which incentives are paid in Canada varies from region to region. Ontario's feed-in tariff is funded by electricity consumers. Means by which other programs are funded include provincial and municipal taxes.

3.3 Indirect policy issues

3.3.1 International policies affecting the use of PV Power Systems

In December 2014, Canada's federal bodies responsible for international trade began the investigation of complaints of anti-dumping and subsidization of certain modules originating in the People's Republic of China.

3.3.2 The introduction of any favourable environmental regulations

N/A

3.3.3 Policies relating to externalities of conventional energy

N/A

3.3.4 Taxes on pollution (e.g. carbon tax)

Several Canadian provinces have emission policies in place including Alberta, British Columbia and Quebec. In 2014, Ontario took steps toward introducing its emissions regulation program.

3.3.5 National policies and programmes to promote the use of PV in foreign non-IEA countries

Export Development Canada, Canada's Export Credit Agency supports and develops Canada's export trade and international business efforts and provides Financing and insurance solutions for Canadian exporters and investors including Accounts Receivable Insurance, Financing (Lending), Export Guarantee Program, Bonding Services and Political Risk Insurance. EDC's services are applicable to eligible solar projects that use Canadian equipment going into solar projects or for Canadian investment going into solar projects.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

4.1.1 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, which held its fifth national scientific conference in Montreal in May 2014, focuses on innovative PV devices that have the potential to leapfrog existing and established technologies.

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

The NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBRN) 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 has been leveraging its activities through its leadership of the recently completed Task 40/Annex 52, entitled "Towards Net Zero Energy Solar Buildings" - a large international collaboration jointly managed by the IEA SHC and EBC programs. To achieve this objective, some 75 T40A52 experts from 19 countries, including Canada, have documented research results and promoted practical case studies that can be replicated worldwide[5].

4.1.3 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.

4.1.4 Refined Manufacturing Acceleration Process (REMAP)

A new Network of Centre of Excellence of Canada on *Refined Manufacturing Acceleration Process (ReMAP)* was created in 2014. The network aims to enable and accelerate commercialization of electronics innovations, ensuring that Canada's investment in electronics technology translates into economic growth and job creation. This network has received $19 million over 4 years and brings together 6 large industry partners, 6 academic and government partners, and 8 startups and SMEs. Projects themes deal with Materials, Optics and Photonics and Solar Photovoltaics (smart lamination materials, enhanced encapsulants, smart electronics for PV power conversion equipment and solar windows).

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

Total public budgets in Canada for R&D, demonstration/field test programmes decreased slightly to 14 M CAD (Table 13). The demonstration/field test investments remained about the same, from 2014 to 2015. Demonstration and field test projects focused on the assessment of solar photovoltaic

[5] International Energy Agency Solar Heating and Cooling – Task 40: http://task40.iea-shc.org/

technologies applied to residential and commercial buildings, as well as small remote community-scale applications.

Federal and provincial research funding agencies such as NSERC[6], CFI[7], and the Ontario Centers of Excellence[8], diversified their investment in solar photovoltaics R&D to address PV systems research and building integration of PV in addition to solar cell research.

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. 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 renewables[9]. The Toronto and Region Conservation Authority (TRCA) received 1 million CAD in ecoEII funding for the Kortright Energy Yield Test Standard[10]. 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 13: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	10	1
State/regional	2	1
Total	14	

[6] National Science and Engineering Research Council of Canada at http://www.nserc-crsng.gc.ca/

[7] Canada Foundation for Innovation at http://www.innovation.ca/en

[8] Ontario Centre of Excellence at http://www.oce-ontario.org/Pages/Home.aspx

[9] ecoENERGY Innovation Initiative at http://www.nrcan.gc.ca/energy/science/2003

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

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

Canada continues to produce feedstock for the global solar industry through two companies, Silicor Materials and 5N Plus (Table 14).

In 2012 Calisolar was renamed to Silicor Materials. Silicor Materials is an American company with silicon purification operations in Canada. It has a R&D office in Germany, and is building a commercial manufacturing facility in Iceland.

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 the largest thin film PV module producer worldwide.

Table 14: 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	R&D only		
5N Plus	CdTe & CIGS high purity compounds	350 tonnes (2010 est.)		

5.2 Production of photovoltaic cells and modules (including TF and CPV)

Table 15 presents data from nine 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 nine companies produced an estimated 778 MW_p, largely for the domestic market in Canada. This represents a 23 % growth in production from 2013, and just below three quarters of the total production capacity in the country which amounted to 1 066 MW_p in 2014.

Of these seven manufacturers, five are Canadian companies. Canadian Solar is the largest of the Canadian companies. Canadian Solar Inc. is one of the top five module producers globally with a global market share estimated at 7% in 2014. Its two crystalline silicon PV module manufacturing facilities in Guelph and London, ON employed approximately 600 workers and had a maximum total annual production of 432 MW in 2014. The company also has additional PV module production capacity of over 2 000 MW in China.

Total PV cell and module manufacture together with production capacity information is summarised in Table 15 below.

Table 15: Production and production capacity information for 2014

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufacturers					
Celestica	sc-Si, mc-Si				240
Canadian Solar	sc-Si, mc-Si				432
MEMC / Flextronics	mc-Si				120
Silfab	sc-Si, mc-Si				144
Heliene	mc-Si				58
OSM Solarform	sc-Si, mc-Si				50
Solgate	sc-Si, mc-Si				22
TOTALS			**778**		**1 066**

5.3 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 online[11] from the CanmetENERGY website.

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.

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

6 PV IN THE ECONOMY

6.1 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 16, increased by 37%, from 5 925 jobs in 2013 to 8 100 in 2014. These positions span the PV value chain, including those in manufacturing, sales and installation, company R&D, and utility PV dedicated labour. The increase was both from manufacturing as well as the distributor and installation companies.

Table 16: Estimated PV-related labour places in 2014

Research and development (not including companies)	100
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	
Distributors of PV products	
System and installation companies	8000
Electricity utility businesses and government	NA
Other	NA
Total	8100

6.2 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 17. This includes the revenues of consultants, installers and manufacturers of both modules and balance of system components. The estimated revenue was 1 734,1 M CAD in 2014. This includes approximately 600 M CAD of revenues generated by module manufacturers. The export market accounted for 13 % of manufacturing revenues in 2014 which is a marginal increase from 12 % reported in 2013.

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 Silicon, 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 17: Value of PV business

Sub-market	Capacity installed *in 2014* (MW)	Price per W *(from table 7)*	Value	Totals
Off-grid domestic	NA	NA	NA	NA
Off-grid non-domestic	NA	NA	NA	NA
Grid-connected distributed	72,60	3,00	217,80	217,80
Grid-connected centralized	560,00	2,30	1 288,00	1 288,00
				1 505,80 M CAD
Export of PV products				*106*
Change in stocks held				*0*
Import of PV products				*NA*
Value of PV business				***1 611,80 M CAD***

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Each Canadian province and territory has jurisdiction over its electricity sector and as a result the market structure and regulations of each is unique (although several inter-ties do join the systems).

For example, Quebec, British Columbia, Manitoba and Newfoundland and Labrador are hydropower-dominated provinces characterized by low production costs, a dynamic export orientation and public ownership. Alberta and New Brunswick moved away from the centrally managed model through the creation of an independent system operator (ISO) and more competitive wholesale markets. Saskatchewan, Nova Scotia, and Prince Edward Island (PEI) are structured along vertically integrated utilities and highly dependent on fossil fuels, leading to high prices as in restructured provinces

7.2 Interest from electricity utility businesses

Given the diversity in market structures across Canada, the interest from electricity utility businesses is equally variable. In Ontario, several utilities have established unregulated subsidiaries to act as generators and participate in Ontario's Feed-In Tariff program while others simply interconnect projects and handle the settlement of payments. In other jurisdictions, utilities offer rebates, manage net-metering or offer solar financing products such as lease-to-own.

7.3 Interest from municipalities and local governments

There are over 3,500 urban and rural municipalities in Canada. All are driven to be economically and environmentally sustainable. Several municipalities continued to explore solar throughout 2014 including the Town of Banff who worked to introduce Canada's first municipal feed-in tariff (expected in 2015).

8 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. The Canadian Solar Industry Association (CanSIA) has established a Solar PV Distributed Generation Task Force to identify and remove barriers to streamline and reduce costs of permitting, connection and deployment of PV distributed generation in Ontario.

9 HIGHLIGHTS AND PROSPECTS

The Canadian market for Solar PV will continue to see significant activity in 2015. Much of this will be driven by Ontario's microFIT, FIT and LRP programs. Steady and continuous growth is also expected across the remainder of Canada. Inter-provincial collaboration on climate change policies are expected to be a driver for new solar policy. As the installed price of solar PV systems comes down, the levelized cost of electricity (LCOE) for solar PV is set to reach parity with the higher electricity tier rates in the various Canadian markets between now and 2020. Reaching this milestone for grid-connected PV in Canada will encourage Canadian households to both produce and import electricity to meet their needs.

In December 2014, the Canadian Solar Industry Association (CanSIA) released the 2020 Roadmap for the Canadian Solar PV Industry. The roadmap presents policy and industry actions that industry leaders believe are necessary to achieve the industry's vision for Canada by 2020[12].

[12] CANSIA Roadmap 2020, December 2014:
http://cansia.ca/sites/default/files/cansia_roadmap_2020_final.pdf

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°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 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, 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 Canadian dollar (CAD).

PV support measures:

Feed-in tariff	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

Compensation schemes (self-consumption, net-metering, net-billing…)	These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is not accounted and not invoiced) or net-billing schemes (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). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they 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
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