

National Survey Report of PV Power Applications in Canada 2013



PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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COVER PICTURE

This 2.3 megawatt PV system was designed by Sentinel Solar for Vine Fresh Produce Ltd., a greenhouse operator, based in Strathroy, Ontario Canada. (photo credit: Sentinel Solar, Vaughan, Ontario).

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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 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 24 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), Thailand (THA), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission (EC), the European Photovoltaic Industry Association (EPIA), the US Solar Electric Power Association (SEPA), the US Solar Energy Industries Association (SEIA) and the Copper Alliance are also 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 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 2013. 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 2013 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2013, 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 2013. 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, 23 % of the installed MW capacity was for residential and building applications, and 77 % for several large ground mounted 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.

1.2 Total photovoltaic power installed

As shown in Table 1, the cumulative PV power capacity grew to 1 210,48 MW (± 3 %) in 2013. The off-grid capacities are not reported in 2013, but were estimated at about 1 % of the total installed capacity in 2013. That figure is anticipated to have decreased relatively in 2013 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.

The combined installed capacity of both rooftop and ground-mounted photovoltaic installations grew by 58% compared to 2012. Grid-connected applications installed on buildings in Canada in 2013 amounted to 54,51 MW of distributed generation, compared to 87,52 MW in 2012. There was a significant increase in centralized grid-connected projects with 390,00 MW installed in 2013, compared to 181,18 MW in 2012. This brings the total capacity installed in 2012 to 444,51 MW for grid-connected applications.

Table 1: PV power installed during calendar year 2013

AC			MW installed in 2013 (mandatory)	MW installed in 2013 (optional)	AC or DC
Grid-connected	BAPV	Residential	54,51		DC
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential	NA		
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF		390	DC
		CPV			
	Off-grid	Residential	NA		
		Other	NA		
		Hybrid systems			
	Total			444,51	

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: $\pm 3\%$

Table 3: PV power and the broader national energy market.

<i>MW-GW for capacities and GWh-TWh for energy</i>	2013 numbers	2012 numbers
Total power generation capacities (all technologies)	135 GW ¹ (611.31 TWh ²)	134 GW ¹ (594.9 TWh ²)
Total power generation capacities (renewables including hydropower)	NA	84 GW ¹ (62.5%)
Total electricity demand (= consumption)	510.99 TWh ²	502.94 TWh ²
New power generation capacities installed during the year (all technologies)	NA	NA
New power generation capacities installed during the year (renewables including hydropower)	NA	NA
Total PV electricity production in GWh-TWh	1.39 TWh	0.881 TWh
Total PV electricity production as a % of total electricity consumption	0.27 %	0.18 %

Table 4: Other informations

	2013 Numbers (optional)
Number of PV systems in operation in your country (a split per market segment is interesting)	1 210 MW
Capacity of decommissioned PV systems during the year in MW	NA
Total capacity connected to the low voltage distribution grid in MW	NA
Total capacity connected to the medium voltage distribution grid in MW	NA
Total capacity connected to the high voltage transmission grid in MW	NA

¹ Canada's Energy Future 2013, Canadian National Energy Board, <http://www.neb-one.gc.ca/clf-nsi/nrgynfntn/nrgyrprt/nrgyfr/2013/nrgftr2013-eng.html>

² Key Canadian Electricity Statistics (release June 2014), Canadian Electricity Association, <http://www.electricity.ca/media/Electricity101/KeyCanadianElectricityStatistics10June2014.pdf>

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

Sub-market	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Stand-alone domestic	0.10	0.19	0.31	0.45	0.61	0.86	1.38	2.15	2.54	3.32
Stand-alone 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

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

Sub-market	2012	2013
Stand-alone domestic	NA	NA
Stand-alone non-domestic	NA	NA
Grid-connected distributed	218.68	273.19
Grid-connected centralized	547.29	937.29
TOTAL (MW)	765.97	1 210.48

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.

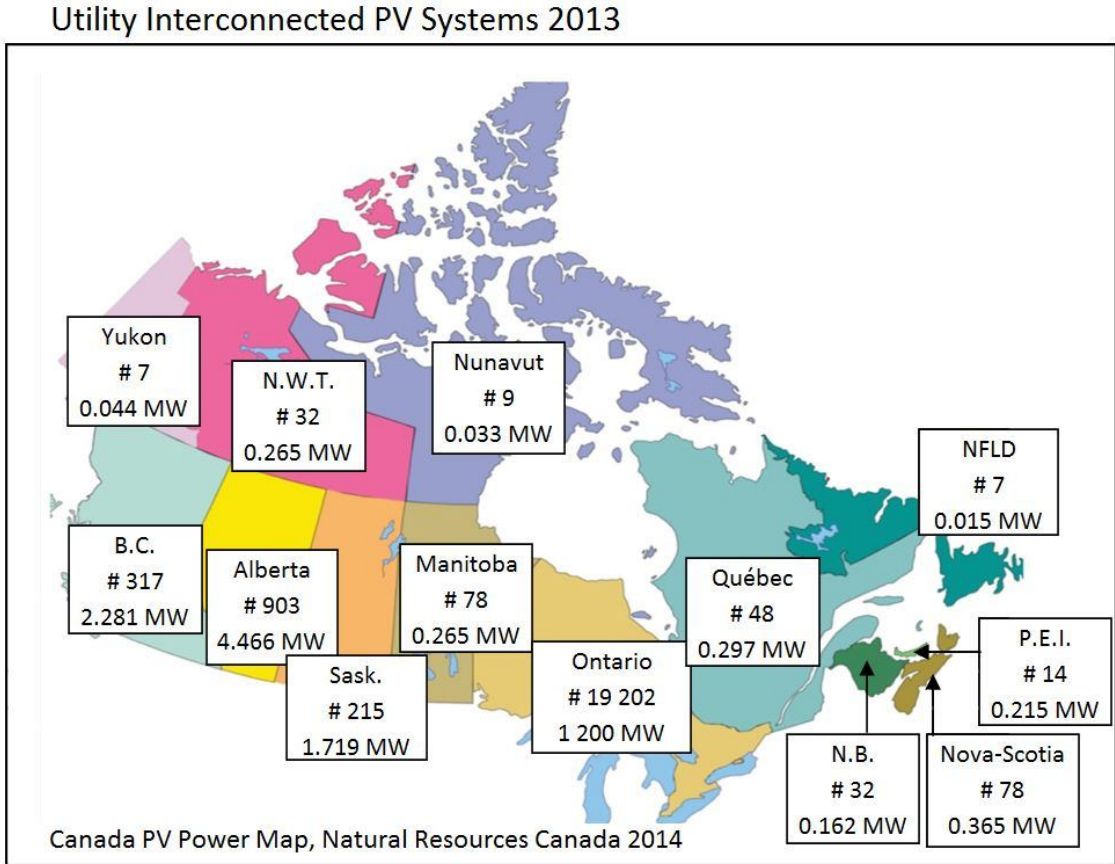


Figure 1: Grid-connected PV Systems in Canada 2013

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 0,95 CAD/Watt in 2013. This represents a 17 % decrease from 2012 module prices. The minimum module price achieved in 2013 was 0,80 CAD/ Watt for imported modules.

Table 6: Typical module prices for a number of years (in Canadian dollars)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Standard module price in CAD (wgt avg)	10.70	9.41	7.14	6.18	5.53	4.31	5.36	4.47	3.91	3.31
Best price										

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Standard module price in CAD (wgt avg)	2.27	1.52	1.15	0.95						
Best price			0.85	0.80						

2.2 System prices

The industry reported system prices for grid-connected systems. The average installed turnkey price for grid connected applications was 2,88 – 3,44 CAD, but this price may vary regionally. A summary of typical system prices is provided in the following tables (table 7 & 8). From 2012 to 2013 the range of system prices for applications decreased between 14 to 18 %.

Table 7: Turnkey Prices of Typical Applications (in Canadian dollars)

Category/ Size	Typical applications and brief details	2013 prices per W
OFF-GRID Up to 1 kW		NA
OFF-GRID >1 kW		NA
Grid-connected Rooftop up to 10 kW (residential)	Building applied PV on residential rooftop	3.44
Grid-connected Rooftop from 10 to 250 kW (commercial)	Building applied PV on commercial rooftops	3.27
Grid-connected Rooftop above 250kW (industrial)	Building applied PV on commercial rooftops	3.27
Grid-connected Ground-mounted above 1 MW	Large utility-scale PV systems	2.88
Other category existing in your country (hybrid diesel-PV, hybrid with battery...)		

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						
Commercial and industrial	6.00	5.27	4.00	3.27						
Ground-mounted utility	4.00	3.50	2.80	2.88						

2.3 Financing

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. 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 9: PV financing scheme

Average Cost of capital	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

2.4 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 599,5 TWh in 2012 with the largest consumers of electricity being the provinces of Quebec (199,7), Ontario (141,1), BC (69,5) and Alberta (66,2) respectively.

Table 10: Country information

Retail Electricity Prices for an household (range)	68,7 – 154,5 CAD / MWh
Retail Electricity Prices for a commercial company (range)	82,7 – 210,2 CAD / MWh
Retail Electricity Prices for an industrial company (range)	37,8 – 140,2 CAD / MWh
Population at the end of 2013 (or latest known)	35 158 300
Country size (km ²)	9 985 000
Average PV yield (according to the current PV development in the country) in kWh/kWp	1 150

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 11 summarizes the different PV support measures. The most significant PV-specific support measures are in Ontario through a feed-in tariff policy.

Table 11: PV support measures (summary table)

	On-going measures	Measures that commenced during 2013
Feed-in tariffs (gross / net?)	Yes (Province of Ontario)	Ontario Annual Targets (2014-2017) 50 MW microFIT (≤ 10 kW) 150 MW FIT (≤ 500 kW) Large Procurement program development >500 kW (competitive; non FIT) 140 MW in 2014 and 2015
Capital subsidies for equipment or total cost	No	-
Green electricity schemes	No	-
PV-specific green electricity schemes	No	-
Renewable portfolio standards (RPS)	Yes (<i>province of PEI</i>)	-
PV requirement in RPS	No	-
Investment funds for PV	Yes, (private sector, Co-operatives)	-
Income tax credits	Yes – (federal, and province specific)	-
Prosumers' incentives (self-consumption, net-metering, net-billing..)	net metering regulations common	-
Commercial bank activities e.g. green mortgages promoting PV	Yes	-
Activities of electricity utility businesses	Many Utilities develop and own PV projects	-
Sustainable building requirements	Yes (voluntary for commercial and institutional certification)	-

3.2 Direct Support measures

3.2.1 Support measures existing in 2013

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

Ontario - In 2013 there was a total FIT capacity available of 123.5 MW (projects \leq 500 kW) this included 70 MW allocated to 2013 as well as an additional 53.5 MW of unused capacity from the previous round of FIT procurement. There was also 30 MW of microFIT (projects \leq 10kW) capacity available in 2013. The Minister of Energy announced annual targets of 50 MW for microFIT systems (\leq 10 kW) and 150 MW for FIT projects (\leq 500kW) from 2014 to 2017.

FIT stresses community involvement and participation through a ranking and priority points system that places an emphasis on community (aboriginal, municipal and public sector and co-operative) partnerships (see section 7.3).

Also as part of the FIT program an Unconstructed Rooftop Solar Pilot (URSP) 15 MW was introduced to allow buildings that were not already constructed to participate in FIT. FIT projects are required to be on existing buildings.

Projects larger than 500 kW were taken out of the FIT program and into a competitive Large Renewable Procurement program currently under development. These large solar PV procurement targets were identified as 140 MW for 2014 and 140 MW for 2015.

Some Ontario First Nation communities have been identified with a need for plans to develop and implement solutions for onsite renewable generation projects that reduce dependency on diesel fuel.

Quebec - In Quebec, the "Programme d'aide à l'installation d'équipements solaires opérationnels" (PAIESO) was phased out at the start of 2013. It was replaced by a tax credit program (Ecorenov) for homeowners for which PV is eligible as an eco-friendly home renovation. The amount of the tax credit corresponds to 20% of the portion of an individual's eligible expenses that exceeds \$2,500, up to a maximum tax credit of \$10,000 per eligible dwelling.

Yukon Territory - Through a micro-generation incentive program, the government will offer participants a financial payment for the surplus electricity they produce. The rate will be set at \$0.21 per kilowatt-hour for communities connected to the grid and \$0.30 per kilowatt-hour in communities powered by diesel generation. This initiative is aimed to provide a tariff that will reimburse customers for the amount of electricity exported to the grid at a rate reflective of the avoided cost of new generation in the territory³.

Northwest Territories - Solar energy technologies are identified in the NWT Greenhouse Gas Strategy as a measure to help limit and reduce emissions. This strategy is aimed at displacing part of diesel electricity generation in the NWT⁴.

The NWT Solar Energy Strategy target is to work with communities, industry and businesses, to install solar systems with the capability to supply up to 20 percent of the average load in NWT diesel communities.

The Grid-Connect Micro Generation project allows customers with grid interconnected renewable micro generating equipment to apply to receive credit for electricity produced in excess by their system, above what is consumed by the building.

³ http://www.energy.gov.yk.ca/pdf/20131023_micro_generation_policy.pdf

⁴ <http://www.nwtclimatechange.ca/greenhouse-gas-strategy>

3.2.1.2 Prosumers' development measures

Net metering is permitted in most provinces and territories. Some programs limit the generation by capacity or a customer's annual consumption. For example, 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.

3.2.1.3 Building Integrated Photovoltaic (BIPV) development measures

Ontario's Unconstructed Rooftop Solar Pilot 15 MW procurement target permitted unconstructed buildings to be part of the FIT program which had represented a barrier to most BIPV projects in past iterations of the program.

The 2nd Annual BIPV Conference was held in Toronto in April bringing together industry stakeholders to further the development of a BIPV industry in Canada.

3.2.1.4 Rural electrification measures

The ecoENERGY for Aboriginal and Northern Communities Program (EANCP) supports aboriginal and northern communities to develop and implement renewable energy projects. The program's objective is to reduce greenhouse gas emissions by supporting the development of projects in a community that directly allow greenhouse gas intensive electricity or heat sources to be replaced by greener energy producing systems, including solar photovoltaic. All Aboriginal and northern communities in Canada, including those that are off-grid, are eligible for funding through EANCP. Eligible recipients include Band Councils, Tribal Councils, National Aboriginal organizations and other Aboriginal organizations, Aboriginal community groups, Territorial governments and northern organizations⁵.

3.2.1.5 Other measures including decentralized storage and demand response measures

Ontario intends to offset all electricity demand growth with conservation measures through to 2032 (30 TWh forecast). Under this initiative the province is presently working towards a 7 TWh target of conservation by 2020. Presently, PV generation may be included in these programs as one strategy to fulfil this mandate.

The Minister of Energy also identified 50 MW of Energy Storage to be included into the procurement process by the end of 2014.

3.2.2 Support measures phased out in 2013

In Quebec the Programme d'aide à l'installation d'équipements solaires opérationnels⁶ (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) and was phased out at the start of 2013.

3.2.3 New support measures implemented in 2013

Ontario initiated the first year of its annual 150 MW of FIT projects (≤ 500 kW) and 15 MW of the Unconstructed Rooftop Solar Pilot. (See section 3.2.1). Quebec also implemented a tax credit program (Ecorenov⁷) for homeowners for which PV is eligible as an eco-friendly home renovation.

⁵ ecoENERGY for Aboriginal and Northern Communities Program Results:

<http://www.aadnc-aandc.gc.ca/eng/1334855478224/1334856305920>

⁶ Programme d'aide à l'installation d'équipements solaires opérationnels:

<http://www.efficaciteenergetique.mrnf.gouv.qc.ca/en/business-clientele/municipalities/programme-daide-a-l-installation-dequipements-solaires-operationnels/#sthash.V0iGOUQ0.dpuf>

⁷ <http://www.revenuquebec.ca/en/salle-de-presse/nouvelles-fiscales/2013/2013-10-17.aspx>

The amount of the tax credit corresponds to 20% of the portion of an individual's eligible expenses that exceeds \$2,500, up to a maximum tax credit of \$10,000 per eligible dwelling.

3.2.4 Measures currently discussed but not implemented yet

The Large Renewable Procurement (LRP) program in Ontario will be implemented in 2014 and will provide capacity targets specific to PV of 140 MW in both 2014 and 2015. This capacity will be procured on a competitive basis.

Ontario's Ministry of Energy also identified 50 MW of Energy Storage to be included into the procurement process by the end of 2014.

The Ontario Energy Board (OEB) has initiated a consultation to modify the portion of volumetric charges serving as cost recovery measures to a fixed cost for small residential customers.

3.2.5 Financing and cost of support measures

Ontario's Feed-in Tariff support scheme is financed by the government of Ontario. The price schedule is subject to review in November of each year and the posted price is effective January 1st.

Renewable Fuel	Project Size Tranche*	FIT Price (¢/ kWh)
Solar (PV) (Rooftop)	≤ 10 kW	39.6
	>10 ≤ 100 kW	34.5
	>100 kW	32.9
Solar (PV) (Non-Rooftop)	≤ 10 kW	29.1
	>10 kW	28.8

3.3 Indirect policy issues

Alberta continues to work toward its renewable energy framework. There is significant support from the public around incorporating solar for power generation as well as a need to reduce the use of significant coal powered generation in the province.

In Ontario under the **Long Term Energy Plan (LTEP)** a key priority is **Conservation and Demand Management (CDM)**. Ontario intends to offset all electricity demand growth with conservation measures through to 2032 (30 TWh forecast). Under this initiative the province is presently working towards a 7 TWh target of conservation by 2020. Presently, PV generation may be included in these programs as one strategy to fulfil this mandate.

Ontario will bring online 10.7 GW of non-hydro renewables by 2021 and by 2025 will have 20 GW of renewables connected.

3.3.1 International policies affecting the use of PV Power Systems

Canada participated in an International Energy Agency study to highlight transitional measures to support PV residential prosumer markets⁸.

⁸ Residential Prosumers: Drivers and Policy Options 2014: <http://www.IEA-RETD.org>

3.3.2 The introduction of any favourable environmental regulations

Northwest Territories (NWT) - Solar energy technologies are identified in the NWT Greenhouse Gas Strategy as a measure to help limit and reduce emissions. This strategy is aimed at displacing part of the diesel electricity generation in the NWT.

3.3.3 Policies relating to externalities of conventional energy

In Alberta, the Climate Change and Emissions Management Corporation (CCEMC) was created in 2009 to be a key part of Alberta's climate change strategy and movement toward a stronger and more diverse lower-carbon economy. Program funding is sourced from the Climate Change and Emissions Management Fund and is collected by the Government of Alberta. Alberta's Specified Gas Emitters regulation identifies that companies that emit more than 100 000 metric tonnes of carbon dioxide equivalent per year must reduce emissions intensity by 12 per cent below their 2004-2005 baseline intensity. Organizations that are unable to meet their targets may be required to pay \$15 into the Climate Change and Emissions Management Fund for every tonne they exceed the allocated limit. One project is the city of Calgary utility, ENMAX, that is funded by CCEMC to pursue the Power of choice program and promote the residential use of solar energy⁹.

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

Carbon taxes are used in both British Columbia and Quebec as part of strategies to reduce Greenhouse Gas Emissions.

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

NA

⁹ ENMAX Power of Choice Program: <https://www.enmax.com/home/renewable-energy>

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 held its fourth national scientific conference at McMaster University in May 2013. The 4th Overview of PV Solar Cell R&D Capability in Canada was updated and made available on the CanmetENERGY website¹⁰. It reports on research efforts in Canada, including advances in innovative PV device 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 worldwide¹¹.

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.

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

Total public budgets in Canada for R&D, demonstration/field test programmes remained stable at 15 M CAD (Table 12). The R&D and demonstration/field test investments remained about the same, from 2012 to 2013. 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.

¹⁰ Overview of PV Solar Cell R&D Capability in Canada, 4th Ed. (2009-2012):

<https://www.nrcan.gc.ca/energy/renewables/solar-photovoltaic/publications/11932>

¹¹ International Energy Agency Solar Heating and Cooling – Task 40: <http://task40.iea-shc.org/>

Federal and provincial research funding agencies such as NSERC¹², CFI¹³, and the Ontario Centers of Excellence¹⁴, 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 (ecoEI) funds research and development to reduce barriers to the deployment of renewables¹⁵. The Toronto and Region Conservation Authority (TRCA) received 1 million CAD in ecoEI funding for the Kortright Energy Yield Test Standard¹⁶. 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 12: Public budgets for R&D, demonstration/ field test programmes (M CAD)

	R & D	Demo/ Field test
National/federal	11	1
State/regional	1	2
Total	15	

¹² National Science and Engineering Research Council of Canada at <http://www.nserc-crsng.gc.ca/>

¹³ Canada Foundation for Innovation at <http://www.innovation.ca/en>

¹⁴ Ontario Centre of Excellence at <http://www.oce-ontario.org/Pages/Home.aspx>

¹⁵ ecoENERGY Innovation Initiative at <http://www.nrcan.gc.ca/energy/science/2003>

¹⁶ 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 13).

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.

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 13: 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 & CIGS high purity compounds	350 tonnes (2010 est.)		

5.2 Production of photovoltaic cells and modules

Table 14 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 634 MW_p, largely for the domestic market in Canada. This represents a 38 % growth in production from 2012, and just above half of the total production capacity in the country which amounted to 1 121 MW_p in 2012.

Of these nine manufacturers, seven 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 4% in 2011. 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 600 MW in 2013. 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 14 below.

Table 14: Production and production capacity information for 2013

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
<i>Wafer-based PV manufactures</i>					
Celestica	sc-Si, mc-Si				220
Canadian Solar	sc-Si, mc-Si				432
MEMC/ Flextronics	mc-Si				120
Silfab	sc-Si, mc-Si				144
Eclipsall	sc-Si, mc-Si				65
Heliene	mc-Si				58
OSM Solarform	sc-Si, mc-Si				50
Solgate	sc-Si, mc-Si				22
Centennial	sc-Si, mc-Si				10
Total			634		1 121

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 online¹⁷ 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.

¹⁷ 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 15, increased by 52%, from 3900 jobs in 2012 to 5925 in 2013. 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. In 2013, CanSIA identified 600 Canadian organizations and companies that are providing their services in Canada to the PV industry.

Table 15: Estimated PV-related labour places in 2013

Research and development (not including companies)	105
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	5 820
Distributors of PV products	
System and installation companies	
Electricity utility businesses and government	NA
Other	NA
Total	5 925

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 16. 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 1 481,5 M CAD in 2013. This includes approximately 233 M CAD of revenues generated by inverter manufacturers. The export market accounted for 12 % of total revenues in 2013 which is an increase from 8 % reported in 2012.

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 Silcor 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 16: Value of PV business

Sub-market	Capacity installed in 2012 (M W)	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	54,5	3,44	187,5	187,5
Grid-connected centralized	390	2,88	1 123,2	1 123,2
				1 310,7
Export of PV products				170,8
Change in stocks held				0
Import of PV products				0
<i>Value of PV business</i>				1 481,5 M CAD

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

<ul style="list-style-type: none">- Each province is responsible for and regulates the generation, transmission and distribution of electricity as well as conservation and demand programs- Federal government is responsible for inter provincial and international power lines, international trade, nuclear energy, as well as codes and standards for conservation and demand- Many provinces have separate transmission and generation ownership- Canadian Market is primarily made up of a combination of wholesale open access and vertically integrated markets	<ul style="list-style-type: none">- Ontario has a wholesale and retail open access market; hybrid regulation and competition model- Alberta has a fully competitive wholesale market- Canada has significant transmission interconnections with the United States (net export 47 TWh to US 2012)- 61 percent of electricity generated in Canada is hydro-electric (2012)- Generation, Transmission and Distribution contributes approx. \$30.5 B to GDP (2012)
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7.2 Interest from electricity utility businesses

Numerous Electric Utilities develop and own their own projects. In Alberta ENMAX, the Calgary utility developed its Generate Choice program¹⁸ where it offers customers a selection of pricing programs for PV systems with nominal power capacity of 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 Program¹⁹, 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

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>

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.

7.3 Interest from municipalities and local governments

In the Ontario Feed in Tariff Program Community co-operatives, Municipal and Public Sector and aboriginal participants are eligible for contract capacity set asides as outlined below (CCSA) and priority ranking in the selection process.

Procurement Target (FIT)	123.5 MW
Municipal and Public Sector Entity CCSA	41.8 MW
Community CCSA	20.9 MW
Aboriginal CCSA	20.9 MW
• First Nation CCSA	13.9 MW
• Métis CCSA	7.0 MW

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) 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

In total, more than 1 120 MW of grid-connected PV capacity is under development in Ontario. This capacity is scheduled to come in service by the end of 2015. In addition Ontario's Long Term Energy Plan (LTEP) identifies targets for renewable energy supply. Ontario will bring online 10.7 GW of non-hydro renewables by 2021 and by 2025 will have 20 GW of renewables connected. This will represent almost half of Ontario's installed capacity (see also section 3.2.3 and 3.2.4).

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.

The Canadian Solar Industry Association (CanSIA) is preparing a 2020 Roadmap for the Canadian Solar PV Industry. The roadmap will be a collaborative document with input from industry stakeholders across the solar PV value chain and throughout Canada. It will create a vision for Canada's solar PV industry in 2020, that will present policy and industry actions that industry leaders believe are necessary to achieve the industry's vision.

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_p .

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. (Eg. 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 dollars.

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

<p>Compensation schemes (self-consumption, net-metering, net-billing..)</p>	<p>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</p>
<p>Commercial bank activities</p>	<p>includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems</p>
<p>Activities of electricity utility businesses</p>	<p>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</p>
<p>Sustainable building requirements</p>	<p>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</p>

