Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in Canada 2020

Natural Resources Canada, CanmetENERGY in Varennes
Canadian Renewable Energy Association (CanREA)

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Canadian Renewable Energy Association
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What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6 000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic (PV) solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Copper Alliance are also members.

Visit us at: www.iea-pvps.org

What is IEA PVPS Task 1?

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 2020. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

Suffield, Alberta, 23 MW PV array consisting of bifacial modules and single-axis trackers. Photo credit: Matt Schuett (BluEarth Renewables)

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

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1 INSTALLATION DATA

The PV power systems 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 2020 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2020, although commissioning may have taken place at a later date.

1.1 Applications for photovoltaics

This report considers only grid-connected PV systems. The amount of off-grid capacity is difficult to track and considered negligible by comparison. However, off-grid solar PV applications (with or without battery storage), or hybrid systems including a small wind turbine or diesel generator, can be found throughout Canada. These systems are often located in remote northern communities.

Installation capacity data for floating PV, building-integrated PV (BIPV), building-added PV (BAPV), and vehicle-integrated systems (VIPV) are not tracked. This report contains aggregated PV data. However, a distinction between rooftop and ground-mounted PV is possible for Ontario, which reports additional information on contracted generation facilities besides nameplate capacity [1].

The continued decline in the cost of generating solar electricity has resulted in grid-connected PV systems approaching grid-parity throughout Canada, with applications varying by province. Ontario represented approximately 88% of Canada's total cumulative installed capacity in 2020. Other provinces and territories are also increasing their PV capacity and some have their own specific support mechanisms for renewables. Growing PV capacity is evident in Alberta, Saskatchewan, and Manitoba. In particular, Canada's largest PV array to date will be operational in 2022: a 465 MW facility located in Vulcan County, Alberta.

Grid-connected PV generating facilities are linked either to the transmission or distribution systems. Transmission-connected PV generation refers to large capacity projects connected to the high-voltage grid (lines with voltages greater than 50 kV). Distribution-connected generation, also called embedded generation, is small-scale generation contributing to local distribution systems and communities. As shown in Figure 1, most of the installed capacity growth over the past several years has been distribution rather than transmission-connected. In addition, the cumulative PV capacity subject to net metering was estimated to be approximately 284 MW_{DC}.

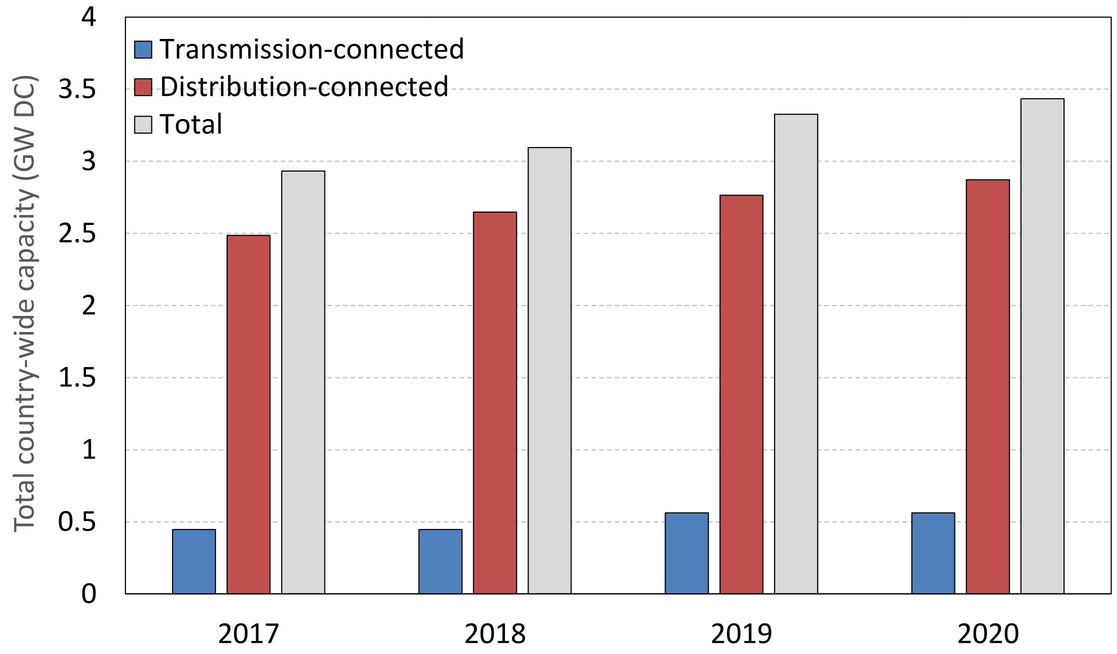

Figure 1: Cumulative distribution versus transmission-connected PV capacity

1.2 Total photovoltaic power installed

The national cumulative installed PV capacity at the end of 2020 was 3,65 GW_{DC}. This represents a growth of approximately 9.7% over the previous year. Table 1 shows the increase in installed PV capacity for 2020 which was 325 MW_{DC} and was assumed to consist entirely of distribution-connected capacity.

Table 1 summarizes Canada's centralized and decentralized PV capacity. Centralized PV installations, by definition, have no self-consumption and only inject electricity to the grid. Distributed PV, by contrast, allows self-consumption. Centralized PV capacity was assumed to be almost entirely located in Ontario (2130 MW_{DC}) and Alberta (165 MW_{DC}). For Ontario, centralized capacity was determined as the sum of all Renewable Energy Standard Offer Programme (RESOP), Green Energy Investment Agreement (GEIA), and large-scale Feed-in Tariff (FIT) (>0,5 MW_{AC}) systems. Ontario's distributed capacity was the sum of all microFIT, small-scale FIT contracts, and net metering.

Table 1: Annual PV power installed in 2020

		Installed PV capacity in 2020 [MW]	AC or DC
	Decentralized	174,8	DC
	Centralized	150,2	DC
	Off-grid	Not tracked	DC
	Total	325,1	DC

The data collection process is described in Table 2. Ontario, Alberta, Nova Scotia, and Newfoundland and Labrador report their PV capacities in AC, while the rest report in DC. The Ontario PV capacity data in this report were limited to systems contracted through the Independent Electricity System Operator (IESO) and the Ontario Energy Board (OEB). Net metering data for Ontario, reported by the OEB, refers to embedded generators that do not participate in the IESO-administered market.

Table 2: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	PV capacity data in this report are in DC. To convert from AC to DC, a conversion coefficient of 0,85 was assumed.
Is the collection process done by an official body or a private company/Association?	Data were collected by an official body, Natural Resources Canada, through the Renewable Energy Integration program.
Link to official statistics (if this exists)	See works cited
Estimated accuracy of data:	±3%

Table 3 summarizes the centralized versus distributed PV power capacity increase between 1995 and 2020. Centralized PV systems are typically ground-mounted, provide bulk power, are on the supply side of electricity meters, and perform the function of a centralized power station. For the purposes of this report, centralized PV systems are defined as having power capacity greater than 0,5 MW_{AC} and may be connected to either the distribution grid or transmission grid. By contrast, distributed PV systems have a power capacity equal to or less than 0,5 MW_{AC}, are connected to the distribution network, and are on the demand side of the electricity meter. Distributed systems are often located on residential or commercial buildings and can be further categorized as BIPV or BAPV depending on whether the modules replace conventional building materials.

Table 3: Cumulative installed PV power in 4 sub-markets

Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralized [MW] (Ground, floating, agricultural…)	Total [MW]
1995	1,64	0,21	0,01	1,86
1996	2,31	0,24	0,01	2,56
1997	3,12	0,25	0,01	3,38
1998	4,2	0,26	0,01	4,47
1999	5,53	0,29	0,01	5,83
2000	6,84	0,30	0,01	7,15
2001	8,48	0,34	0,01	8,83
2002	9,63	0,37	0,00	10,00

2003	11,43	0,40	0,00	11,83
2004	13,37	0,47	0,04	13,88
2005	15,62	1,07	0,06	16,75
2006	18,98	1,44	0,06	20,48
2007	22,86	2,85	0,06	25,77
2008	27,48	5,17	0,06	32,72
2009	35,2	12,25	47,12	94,57
2010	60,1	27,74	193,29	281,13
2011	61,05	131,16	366,11	558,29
2012	NA	218,68	547,29	765,97
2013	NA	273,19	937,29	1 210,48
2014	NA	540,85	1 302,23	1 843,08
2015	NA	735,81	1 782,50	2 518,31
2016	NA	792,66	1 871,65	2 664,31
2017	NA	926,34	2 006,29	2 932,64
2018	NA	1 087,65	2 007,23	3 094,88
2019	NA	1 178,61	2 148,12	3 326,73
2020	NA	1 353,48	2 298,31	3 651,79

Figure 2 shows the installed capacity by province and territory for grid-connected PV power and the number of utility interconnected PV systems as of December 31, 2020. Data on PV energy storage sites are not tracked. There were a small number of provinces and territories that did not report their PV capacity figures in 2020. Thus, PV capacity is underestimated for the Northwest Territories, Nunavut, Quebec, and Prince Edward Island, for which the last available year in which data were obtained is shown in parentheses.

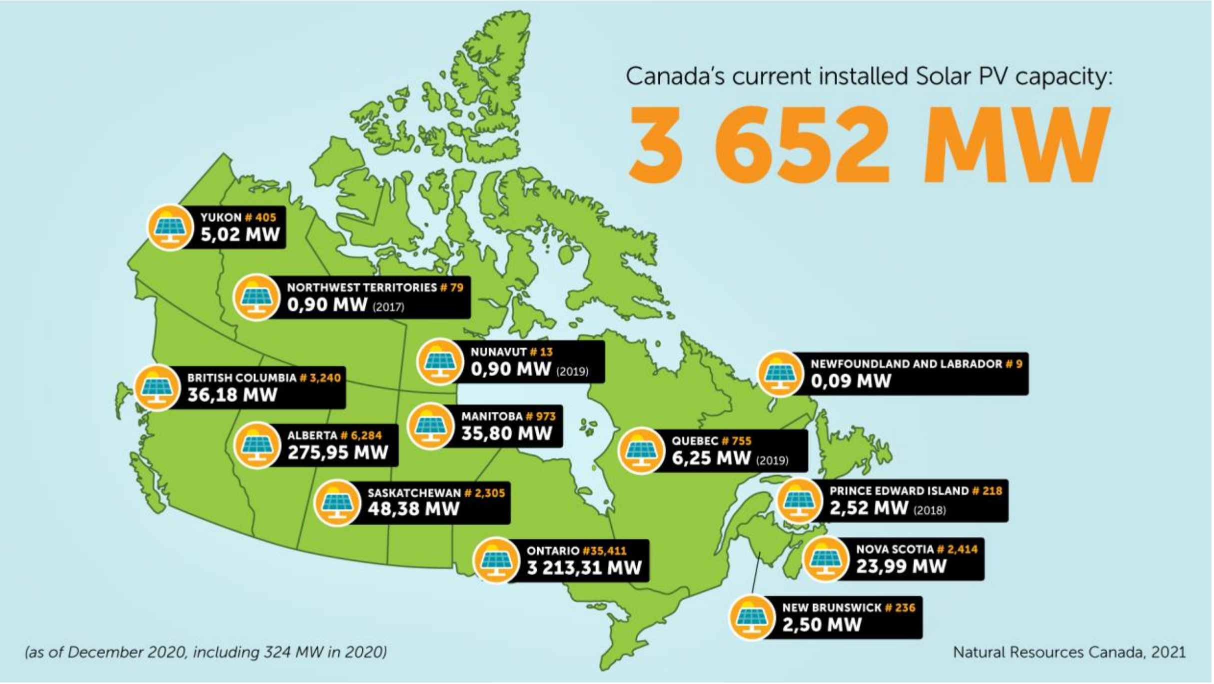

Figure 2: Map showing the PV power capacity (MW_{DC}) and number of installed systems for the provinces and territories. This map is for illustrative purposes only. Distance scale is approximate.

Table 4 provides details on the total PV capacity connected to the distribution and transmission grids. Capacity connected to the low-voltage distribution grid was the sum of Ontario's distribution grid-connected capacity plus the capacity of all other provinces and territories. Total capacity connected to the high-voltage transmission grid was composed only of Ontario's transmission-connected PV systems.

Table 4: Other PV market information

	2020
Number of PV systems in operation in your country	52 342
Decommissioned PV systems during the year [MW]	Not tracked
Repowered PV systems during the year [MW]	Not tracked

Table 5 provides national figures on power generation and electricity demand as well as an estimate of total PV energy production. Total power generation capacity for 2020 was calculated using the Statistics Canada data for 2017 [2] for all energy sources and NSR PV capacity data for 2020. To derive the 2020 total power generation capacity, a 1% annual growth rate was assumed [3]. Total renewable power generation capacities were calculated in a similar manner except using technology-specific growth rates derived from the previous years (0,4% growth for hydro, and 3,6% for wind) [4]. Total electricity demand was estimated from Statistics Canada's supply and demand for primary and secondary energy [5]. New power generation and renewable power generation capacities installed in 2020 were estimated using Statistics Canada data for wind, tidal and hydro [4], with NSR data for PV capacity. To estimate PV energy production, the total nameplate power was multiplied by the average yearly Canadian PV potential which was assumed to be 1 150 kWh/kWp. The average PV potential was determined using satellite-based insolation data and assuming a typical performance ratio of 0,75 [6]. PV electricity production was calculated as a percentage of total generation based on Statistics Canada annual electricity generation estimates [2].

Table 5: PV power and the broader national energy market

	2020	2019
Total power generation capacities [GW]	150,88	148,05
Total renewable power generation capacities (including hydropower) [GW]	98,61	97,53
Total electricity demand [TWh]	545,73	540,33
New power generation capacities installed [GW]	2,83	1,47
New renewable power generation capacities (including hydropower) [GW]	1,08	0,89
Estimated total PV electricity production (including self-consumed PV electricity) in TWh	4,15	3,83
Total PV electricity production as a % of total electricity consumption	0,69	0,64
Average yield of PV installations (in kWh/kWp)	1 150	1 150

1.3 Key enablers of PV development

Whether connected to PV or not, enabling technologies such as decentralized storage and electric cars, buses, and trucks can increase a grid's hosting capacity and provide storage capacity. Zero emission vehicles (ZEV), comprised of both battery-electric and plug-in hybrids, demonstrated 25% year-on-year growth as compared to 2018. During the fourth quarter of 2019, according to vehicle registration data, there were 7 933 battery-electric and 4 303 plug-in hybrid vehicles sold [7]. With federal purchase incentives introduced in May 2019, ZEVs now comprise around 3.5% of passenger vehicle sales in Canada (10% in British Columbia and 7% in Quebec) [8]. Electric bus adoption in Canada is growing and pilot projects are underway in Montreal, Vancouver, and Toronto. Domestic electric bus production is centred in Quebec (Nova Bus) and Manitoba (New Flyer Industries). Electric bus operation in Canada is mostly hybrid buses. The federal government has set a target of 5 000 electric buses in the country-wide fleet by 2025 [9]. In terms of centralized storage, although PV battery system data are not publicly available, work is underway to track these installations under the research directives of the Canada Smart Grid Action Network (CSGAN). In addition to battery systems, hydrogen production is also being explored. Hydro Quebec, a provincially owned utility, recently signed a deal with Germany-based Thyssenkrupp to build an 88 MW green hydrogen facility in Varennes. Once completed in 2023, it will produce 11,000 metric tonnes per year [10].

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Crystalline silicon module prices vary by manufacturer and module type (monocrystalline and multicrystalline). However, the trend for decrease in module spot prices remains similar in all markets. In the Canadian market over the past several years, there is a growing transition from 60-cell to 72-cell modules in residential installation, from traditional mono to mono PERC, and from regular cells to split cells. Table 6 shows whole-sale price estimates applied to high efficiency monocrystalline modules of 290 W and above (such as PERC, HIT, n-type, or back-contact cell types). Value-added taxes are excluded.

Table 6: Typical module prices

Year	Lowest price of a standard module crystalline silicon [$/W]	Highest price of a standard module crystalline silicon [$/W]	Typical price of a standard module crystalline silicon [$/W]
2016	0,66	0,90	0,78
2017	0,75	0,81	0,80
2018	0,61	0,65	0,63
2019	0,50	0,74	0,62
2020	0,40	0,74	0,44

2.2 System prices

PV system prices, shown in Table 7 and Table 8, take into account hardware costs such as mounting materials and inverters, as well installation and development. Prices do not include recurring charges after installation such as battery replacement or operation and maintenance.

Table 7: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices [$/W]
Off-grid 1-5 kW	A stand-alone PV system is a system that is installed to generate electricity for a device or a household that is not connected to the public grid.	Not tracked
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity for grid-connected households (typically roof-mounted systems on villas and single-family homes).	2,50 - 2,75
Residential BIPV 5-10 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity for grid-connected households (typically, on villas and single-family homes).	Not tracked

Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	2,00 - 2,50
Small commercial BIPV 10-100 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	Not tracked
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity for grid-connected large commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1,80 - 2,50
Large commercial BIPV 100-250 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	Not tracked
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity for grid-connected industrial buildings, warehouses, etc.	1,80 - 2,00
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power stations. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	1,60 - 1,80
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power stations. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	1,25

Table 8: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW [$/W]	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW [$/W]	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW [$/W]	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10-50 MW [$/W]
2016	3,00 - 3,50	2,00 - 3,00	2,00 - 3,00	2,00
2017	2,50 - 3,20	1,80 - 2,50	1,80 - 2,50	1,80
2018	2,93	1,80 - 2,50	1,80 - 2,50	1,46
2019	2,50 - 2,75	1,80 - 2,50	1,80 - 2,00	1,25
2020	2,40 - 2,70	1,80 - 2,25	1,60 - 2,00	1,25

2.3 Cost breakdown of PV installations

The cost breakdown of a typical 5-10 kW roof-mounted, grid-connected, distributed PV system on a residential single-family house is presented in Table 9. The cost structure is from the customer's point of view and does not reflect the installer companies' overall costs and revenues. The "average" category in Table 9 represents the average cost for each category. It takes the whole system into account and summarizes the average end price to the customer. The "low" and "high" categories are the lowest and highest cost that has been reported within each segment. These costs are individual posts, i.e. summarizing these costs may not give an accurate system price.

Table 9: Cost breakdown for a grid-connected roof-mounted, distributed residential PV system of 5-10 kW

Cost category	Average [$/W]	Low [$/W]	High [$/W]
Hardware			
Module	0,55	0,50	0,74
Inverter	0,43	0,30	0,60
Mounting material	0,21	0,18	0,46
Other electronics (cables, etc.)	0,14	----	----
Subtotal Hardware	**1,33**		
Soft costs			
Planning	----	----	----

Installation work	0,74	----	----
Shipping and travel expenses to customer	----	----	----
Permits and commissioning (i.e. cost for electrician, etc.)	0,14	----	----
Project margin	0,195	----	----
Subtotal Soft costs	**1,08**		
Average VAT			
Total (including VAT)	**2,41**		

2.4 Financial parameters and specific financing programs

In Canada, financing from institutional lenders is available for projects, or portfolios of projects, that meet certain financial thresholds. There are fewer financing options for residential and small commercial projects, but the number of options for low-cost capital is growing.

2.5 Specific investment programs

As outlined in Section 3.2, there are a variety of investment mechanisms across the country. In Ontario, for example, the IESO operates the majority of PV support programs, which closed to new applicants in 2016. The last IESO-contracted PV facilities were commissioned in 2020. Other examples of support programs are Alberta's "Residential & Commercial Solar Program", "Municipal Solar Program" and "Indigenous Solar Program", which helped make it the second province to install more than 5 MW of PV in a single year. The "Residential & Commercial Solar Program" was cancelled in 2019. Additional details are provided in Table 10.

Table 10: Summary of existing investment schemes

Investment Schemes	Additional Information
Third party ownership (no investment)	Several companies offer third party ownership and leasing services. This had been the dominant financing mechanism for residential solar under Ontario's FIT programs, but now the practice is less common for net metering installations in that province. Third-party ownership models for net metering are more common in Alberta and Nova Scotia.
Renting	A number of companies offered rented systems in Canada in 2020. However, it is more common that after a specified term the system becomes the property of the renter (i.e. leasing).

Financing through utilities	No utilities offered on-bill financing specifically for PV as of the end of 2020.
Community investment in PV plants	Several solar energy co-operatives have been incorporated to facilitate investment in, and ownership of, PV systems.
International organization financing	The Green Energy Investment Agreement (GEIA), initiated in 2010, mandated investment and cooperation between the Government of Ontario, Samsung, and the Korea Electric Power Corporation.

2.6 Additional country information

Canada's electricity sector is provincially regulated and comprised primarily of vertically integrated crown corporations or investor-owned utilities with a deregulated energy-only market system in the province of Alberta and a partially deregulated market in Ontario. Electricity demand in Canada was estimated to be 545 TWh in 2020 with the largest producers of electricity being the provinces of Quebec, Ontario, British Columbia, and Alberta.

Table 11: Country information (electricity prices vary by province and territory and figures quoted in this table represent an average rate across selected cities) [11]

Retail electricity prices for a household [¢/kWh]	13,01
Retail electricity prices for a commercial company [¢/kWh]	8,99
Retail electricity prices for an industrial company [¢/kWh]	8,99

3 POLICY FRAMEWORK

This chapter describes the support policies for PV. Direct support policies may be aimed at incentivizing or simplifying existing programs. Indirect support policies change the regulatory environment in a way that can push PV development.

Table 12: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2020	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	yes	-	yes	-	yes	-
Feed-in premium (above market price)	-	-	-	-	-	-
Capital subsidies	yes	-	yes	-	-	-
Green certificates	-	-	-	-	-	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	-	-	-	-	-	-
Self-consumption	yes	yes	yes	yes	-	-
Net-metering	yes	yes	yes	yes	-	-
Net-billing	yes	yes	yes	yes	-	-
Collective self-consumption and delocalized net-metering	yes	yes	-	-	-	-
Sustainable building requirements	-	-	-	-	-	-
BIPV incentives	-	-	-	-	-	-

3.1 National targets for PV

There is no specific target for PV set by the federal, provincial or territorial governments. However, the federal government has committed to 90% of Canada's electricity coming from non-emitting sources by 2030.

3.2 Direct support policies for PV installations

3.2.1 Federal commitments

Canada’s current target for reducing greenhouse gas emissions is 40 - 45% below 2005 levels by 2030. The Government of Canada’s framework for emissions reduction and renewable energy is outlined in the 2016 Pan-Canadian Framework on Clean Growth and Climate Change. This was supplemented in December 2020 with another plan containing 64 federal policies [12]. The Pan-Canadian Framework includes carbon pricing, emissions reductions, adaptation, and support for low carbon technologies. Country-wide carbon pricing was implemented in 2018. The price began at $20 per CO_2 equivalent tonne in 2019 and increases by $10 per year to reach $50 per tonne in 2022. The program does not apply to provinces that implement their own carbon pricing schemes so long as they define an equivalent price. The Smart Renewables and Electrification Pathways Program provides $964 million over four years to support renewable capacity, energy storage, and grid modernization projects [13]. In terms of targeted support for PV, the Canada Greener Homes Grant provides $1 000 per installed kilowatt for residential customers with a maximum of up to $5 000 per household [14]. There is also the Accelerated Capital Cost Allowance (ACCA) and the Canadian Renewable and Conservation Expense (CRCE) tax incentive [15].

3.2.2 Solar PV support measures by province and territory

Alberta: EQUS, a Rural Electrification Association, provides electrical distribution services throughout 26 municipal districts. EQUS offers up to $15 000 in loans to its members to finance PV installation. The Clean Energy Improvement Program provides financing for residential and commercial property owners with long-term financing to cover renewable energy projects which are repaid through property taxes. This program is part of several Property Assessed Clean Energy (PACE) programs being implemented by various provincial and municipal governments. Alberta's solar incentive program was cancelled on June 11, 2020.

British Columbia: The cities of Nelson, Penticton, and Vancouver offer loans for home energy projects, many of which are paid back through electric utility bills. There are two renewable energy incentive programs: a 7% provincial sales tax exemption for PV installations (which also includes micro-hydro), and a Renewable Energy System Program in the districts of Nanaimo and Lantzville which offer incentives for PV, solar thermal, and geothermal.

Manitoba: Manitoba Hydro offers support for PV upgrades for homeowners through its Home Energy Efficiency Loan and Energy Finance Plan programs. The cost of the system is repaid through the electric utility bill with the full amount being due if the home is sold before the loan is fully repaid.

New Brunswick: The New Brunswick Credit Union offers renewable energy loans through its Greener Home Loans program. The provincial utility NB Power offers a 0,20 - 0,30 $/W rebate on PV systems through its Total Home Energy Savings Program.

Newfoundland and Labrador: There are no support measures targeted specifically to PV.

Northwest Territories: The Alternative Energy Technologies Program is managed through the Artic Energy Alliance and offers homeowners a 50% rebate on the cost of renewable energy generation projects, including PV. The Northwest Territories are also implementing the regulatory framework for a PACE program similar to what is used in Alberta.

Nova Scotia: The province has two separate PACE programs. One is administered through the Clean Energy Financing Program to the cities of Bridgewater, Lunenburg, Digby, Barrington, Yarmouth, Amherst, and Cumberland. The second is administered through Solar

City and applies exclusively to the city of Halifax, offering a 10 year 4,75% fixed interest loan attached to the home owner’s property. The province also has a Solar Homes program offering a 0,60 $/W rebate on the purchase of PV systems.

Nunavut: There are no support measures targeted specifically to PV.

Ontario: Almost all of Ontario’s installed capacity is contracted with long-term power purchase agreements through the IESO. Financing from institutional lenders has been available for projects, or portfolios of projects, that meet certain financial thresholds. For residential and small commercial projects, options for low cost capital are growing. Structured around the popular PACE framework, the city of Toronto uses a Home Energy Loan Program to provide loans for renewable energy projects that are paid back through property tax billing.

Prince Edward Island: The province’s Solar Electric Rebate Program, Efficiency-PEI, offers a 1,00 $/W incentive for PV systems. Its Energy Efficiency Loan Program offers a 7-year loan at a fixed interest rate of 5%.

Quebec: The province has eight clean energy incentive programs and 27 types of energy efficiency rebates. Beyond net metering, there are currently no support policies directly targeted to PV.

Saskatchewan: There are no support measures specifically targeted to PV.

Yukon Territory: Through its Good Energy Renewable Energy Rebate, the Yukon Government offers a rebate of 800 $/kW for off-grid residents installing PV, or other renewables such as wind, hydro, and geothermal. The Yukon's version of the PACE program is the Rural Electrification and Telecommunications Program and is used to fund PV projects for off-grid homeowners.

3.2.3 BIPV development measures

There are currently no policies to support BIPV either provincially or federally.

3.3 Self-consumption measures

Table 13: Summary of self-consumption regulations for small private PV systems in 2020

PV self-consumption	1	Right to self-consume	Throughout Canada
	2	Revenues from self-consumed PV	Applied as credits or monetarily depending on the jurisdiction
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	Offset in some instances, paid in others depending on the jurisdiction
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Applied as credits or monetarily depending on the jurisdiction
	5	Maximum timeframe for compensation of fluxes	Most typically one year
	6	Geographical compensation (virtual self-consumption or metering)	Typically uniform within a jurisdiction

Other characteristics	7	Regulatory scheme duration	Various, depending on jurisdiction
	8	Third party ownership accepted	Various, depending on jurisdiction
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Various, depending on jurisdiction
	10	Regulations on enablers of self-consumption (storage, DSM…)	Various, depending on jurisdiction
	11	PV system size limitations	Various, depending on jurisdiction
	12	Electricity system limitations	Various, depending on jurisdiction

3.4 Collective self-consumption, community solar and similar measures

Measures for collective self-consumption (e.g. PV systems for several apartments in the same building), virtual net-metering (allowing consumption and production in different places), and community solar (investment by private or public organizations) are rare. The only example of such an arrangement is a community-owned PV facility in Nelson, British Columbia, whereby members of the community invest on a per-panel basis and receive a credit on their hydro bill proportional to their investment [16]. In Ontario, the IESO is developing several virtual net-metering demonstration projects [17].

3.5 Tenders, auctions & similar schemes

Measures vary between jurisdictions. For example, in Ontario the IESO used three renewable energy procurement methodologies: standard offer, bilateral negotiations, and competitive bid, with the vast majority of PV contracts in Ontario awarded by standard offer. Solar PV contract periods are generally awarded over 20 years. The ways in which incentives are paid in Canada varies from region to region. Ontario's feed-in tariff is funded by electricity consumers. Other programs are funded through revenues from carbon pricing programs or provincial and municipal taxes.

3.6 Social policies

In terms of PV policy, support measures are largely left to the provinces and territories to define. However, as stated previously, PV is eligible for several national support programs announced by the Federal Government, including the $500 million Low Carbon Economy Challenge Fund, and the $100 million Smart Grid Program, and various tax incentive programs for industry [15].

As discussed in previous reports, 2017 was the last year for Ontario's microFIT and FIT programs. Ontario's net-metering regulation now forms the basis for future project development. Other sub-national measures of importance included Alberta's $36 million Residential and Commercial Solar Program (2017 to 2019).

3.7 Indirect policy issues

3.7.1 Rural electrification measures

Canada has approximately 300 off-grid communities with a total population of around 200 000 people. There is an ongoing transition in these communities from diesel fuel to renewable energy sources supported by the $220 million Clean Energy for Rural and Remote Communities program. A Federal Government initiative studying PV system performance, cost, and durability north of the 60th parallel also provides funding for the monitoring of PV arrays in remote communities.

3.7.2 Support for electricity storage and demand response measures

Ontario's Smart Grid Fund has resulted in several PV projects with electricity storage. The Federal Government's Smart Grid program, announced in 2017, is also expected to support combined solar and storage projects. Other measures were outlined in the 2020 federal policy update [12].

3.8 Financing and cost of support measures

As has been discussed previously, the ways in which incentives are paid in Canada varies by region. Over the past few years, governments in several countries have faced both financial and political pressures due to the high cost of feed-in-tariff programs. To control the rising costs of subsidies like FIT, there has been a shift towards "winner take all" methods of competitive bidding and auctions. However, the competitive bidding process tends to favour large suppliers while shutting out smaller companies, community groups, and cooperatives.

Although the cost of PV systems continues to fall, a distinction must be drawn between construction costs and auction prices. Construction costs continue to decline, driven by technological improvements and economies of scale. Nevertheless, the competitive pressures of auction-based purchasing strategies may drive down auction costs faster than construction costs. This has resulted in shrinking profit margins for investors and declining investor interest, as shown in Ontario's reduced PV capacity growth after 2015. Auction-based competition has, in some countries, resulted in the emergence of dive bidding and what has been termed the "winner's curse" whereby a successful bidder underbids in order to win the contract and then cannot deliver power at the agreed-upon price.

4 INDUSTRY

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

Canada continues to produce feedstock for the global solar industry through 5N Plus: a producer of high-purity tellurium, cadmium, zinc and related compounds (Table 14). 5N Plus is a Canadian company with 14 manufacturing facilities located throughout Canada, US, Malaysia, England, China, Belgium, and Laos. They have 18 sales offices in Asia, Europe, North and South America. First Solar is their primary customer and is the largest thin film PV producer worldwide. There are currently no producers of polysilicon, silicon ingots, or silicon wafers in Canada. However, pilot production of polysilicon in Sarnia by Ubiquity Solar may be a contributor in the coming years.

Table 14: Silicon feedstock, ingot and wafer producer's production information for 2020

Manufacturers	Process & technology	Total Production	Product destination	Price
5N Plus	CdTe & CIGS high purity compounds	350 tonnes (2010 est.)	First Solar and other thin film PV manufacturers	

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

Module manufacturing is defined as the industry performing the encapsulation process. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country. Table 15 presents data from four companies in Canada producing PV modules all of which have their facilities located in Ontario or Quebec and are involved in contract manufacturing for other multi-national companies. Together, these companies produced an estimated 475 MW/year of crystalline silicon modules. Notably, Stace also manufactures CPV modules.

Table 15: PV cell and module production and production capacity information for 2020

Cell/Module manufacturer	Technology	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Canadian Solar	sc-Si, mc-Si	-	475	-	1 050
Heliene	mc-Si	-		-	
Silfab	sc-Si, mc-Si	-		-	
Stace	sc-Si, mc-Si, CPV	-		-	
Totals		-	**475**	**-**	**1 050**

4.3 Manufacturers and suppliers of other components

The balance of system technology market in Canada is mainly served by foreign companies with operations in Canada or production through contract manufacturing. However, domestic solar racking manufacturers including FastRack, Polar, Terragen and hb Solar dominate the Canadian market. Other companies that have Canadian development and manufacturing facilities include Eaton, Hammond Power Solutions, and Nexans. Typical balance of system components manufactured or supplied in Canada include inverters (central/string, microinverter, power optimizer), racking and mounting (rooftop, ground-mount, dual/single axis trackers), and wiring (cabling and combiner box). Among these components, the manufacturing of central inverters has experienced the largest growth and is primarily used for commercial rooftop and utility-scale systems.

5 PV IN THE ECONOMY

5.1 Labour places

The effect of PV in the economy was determined using the installed PV capacity in each province and territory. These data were input into a newly developed tool called the Economic Impacts of Electrification Initiatives (EI^2) model. This model was developed by the Trottier Energy Institute and Ecole Polytechnique through the NRCan-supported energy modelling initiative [18]. The estimate of the total number of jobs is an aggregate of two types: permanent operation and maintenance from installed capacity in previous years and temporary construction due to new installation in 2020. This partial estimate is highly conservative since it does not include solar PV system design and engineering, sales and marketing, project development and management, or legal/financial services and administration, which collectively constitute a significant share of jobs.

Table 16: Estimated PV-related full-time labour places in 2020

Market category	Number of full-time labour places
Research and development (not including companies)	105
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	5887
Distributors of PV products and installations	
Other	-
Total	**5992**

5.2 Business value

The value of PV business in Canada as it relates to the solar PV capacity installations for 2020 is estimated in Table 17. Similarly to Table 16, calculations were performed at the provincial and territorial level using installed PV capacity estimates as input to the EI^2 model. The EI^2 model incorporates financial multipliers specific to each region. Economic impacts were the sum of operation and maintenance associated with previously installed capacity and construction impacts due to new PV capacity in 2020. Operation and maintenance encompassed onsite labour, local revenue and supply chain effects. The construction phase quantified module and supply chain, project development and onsite labour output.

Table 17: Estimation of the value of the PV business in 2020 (VAT is excluded)

Sub-market	Capacity installed [MW]	Average price [$/W]	Value	Sub-market
Off-grid	-	-	-	-
Grid-connected distributed	1 353,48	-	-	-
Grid-connected centralized	2 298,31	-	-	-
Value of PV business in 2020 ($ amount in million)				852

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

Each Canadian province and territory has jurisdiction over its electricity sector. As a result, the market structure and regulations in each jurisdiction is unique (although several inter-ties do exist). 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 independent system operators and wholesale markets. Saskatchewan, Nova Scotia, and Prince Edward Island are structured along vertically integrated utilities and highly dependent on fossil fuels leading to higher prices.

6.2 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, and are considering offering solar financing products such as lease-to-own. Given the rapidly declining costs in solar electricity, some utilities such as Hydro Quebec sought to expand their PV capacity in 2020.

6.3 Interest from municipalities and local governments

There are over 3 500 urban and rural municipalities in Canada. Many are interested in environmental sustainability and continued to explore PV opportunities throughout 2020.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

Canada's PV sector has reached 3,65 GW_{DC} installed capacity, a growth of approximately 9.7% over the previous year. Across the country, there is strong growth in distributed PV systems among consumers particularly in Alberta, Saskatchewan, Nova Scotia, and British Columbia.

7.2 Prospects

Canada has joined over 120 countries in committing to net-zero emissions by 2050 and has strengthened its commitment to move towards a net-zero electricity system by 2035. Achieving Canada's greenhouse gas emissions reductions targets requires deep decarbonisation and electrification and represents a significant opportunity for Canadian PV industry development. According to the Canada Energy Regulator, Canada's future wind and PV capacity are expected to grow by 200% and 600% respectively by 2050. A combination of falling costs, climate change mitigation policies, and consumer demand point to increasing PV generation.

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