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 2023

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 solar energy as a cornerstone in the transition to sustainable energy systems." 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 25 IEA PVPS participating countries are Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkiye, and the United States of America. The European Commission, Solar Power Europe and the Solar Energy Research Institute of Singapore are also members.

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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 cooperation. 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 2023. Information from this document will be used as input to the annual trends in photovoltaic applications report.

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COVER PICTURE

The city of Lac-Mégantic in Quebec, Canada, is an inspiring example of the green transition with a rooftop array on the city sports centre consisting of 1 700 photovoltaic panels totalling 620 kW. The array is part of a community microgrid that includes battery storage, energy efficient buildings based on principles of sustainable development, and communication infrastructure to optimize energy use. (Photo credit: Hydro-Québec)

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1 INSTALLATION DATA

The PV power systems market is defined as the market of all nationally installed PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all their installation and control components. Other applications such as small mobile devices are not considered. In this report, PV installations are included in the 2023 statistics if the PV modules were installed and connected to the grid between January 1st and December 31st, 2023.

1.1 Applications for photovoltaics

This report examines grid-connected PV systems. The amount of off-grid capacity is difficult to track and considered negligible by comparison. However, off-grid PV applications (with or without battery storage), or hybrid systems combining PV with a small wind turbine or diesel generator, are becoming a more common form of electricity generation in remote northern communities. Installation capacity data for floating PV, agrivoltaics, building-integrated PV (BIPV), building-added PV (BAPV), and vehicle-integrated systems (VIPV) are not tracked. The continued decline in the cost of many PV system components has resulted in renewable generators that are highly cost competitive with legacy fossil fuel-based infrastructure. Ontario and Alberta represented approximately 57% and 35% of Canada's total cumulative installed PV capacity in 2023, respectively.

1.2 Total PV power installed

The cumulative national installed PV capacity at the end of 2023 was 5.33 GW_{AC}. This represents a growth of approximately 23% over the previous year. The increase in installed PV capacity for 2023 was 1.0 GW_{AC}. 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 mostly located in Ontario (1811 MW_{AC}) and Alberta (1663 MW_{AC}). 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) systems. Ontario's distributed capacity was the sum of all microFIT, small-scale FIT contracts, and net metering.

Data were collected by contacting local utilities or by accessing reports on contracted electricity supply. Respondents were requested to divide their installation data into centralized and decentralized systems. The level of detail reported by utilities to quantify PV capacity varies by province and territory, and the uncertainty in aggregated totals is expected to be ±3%.

Table 1: Annual PV power installed during calendar year 2023

		Installed PV capacity in 2023 [MW]	AC or DC
	Decentralized	478	AC
	Centralized	527	AC
	Off-grid	Not tracked	AC
	Total	1005	AC

The data collection process is described in Table 2. More than 95% of Canada's PV capacity data are reported by provincial utilities in AC format. For 2021, and all years prior, AC data were converted to DC using an AC/DC ratio of 0.85. Beginning in 2022, this was changed to 0.67 to better reflect utility-scale system performance. The coefficient is based on the 465 MW_{AC} / 692 MW_{DC} Travers PV array in Alberta, which is assumed to be a good representation of a typical commercial array. The same coefficient is applied for both centralized and decentralized systems.

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 AC. To convert from AC to DC, a conversion coefficient of 0.67 was used.
Is the collection process done by an official body or a private company/Association?	Data were jointly collected by the Government of Canada, the Canadian Renewable Energy Association, Rematek Energy Inc., and the Canadian Renewable Energy Association.
Link to official statistics (if this exists)	See works cited

Table 3 summarizes the centralized versus distributed PV power capacity increase between 2010 and 2023. Centralized PV systems are typically ground-mounted, provide bulk power, and exist on the supply side of electricity meters. They inject electricity and do not allow self-consumption. In this report, centralized PV systems are defined as having power capacity greater than 500 kW_p and may be connected to either the distribution grid or transmission grid. By contrast, distributed PV systems are connected to the distribution network, are on the demand side of the electricity meter, and are often embedded on a customer's premises allowing for self-consumption. Distributed systems may be 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. The AC/DC conversion coefficient of 0.85 was used from 2010 to 2021 inclusive. The coefficient was changed to 0.67 thereafter.

Year	Off-grid [MW_{AC}] (including large hybrids)	Grid-connected distributed [MW_{AC}]	Grid-connected centralized [MW_{AC}]	Total [MW_{AC}]	Total [MW_{DC}]
2010	51.09	23.58	164.30	238.96	281.13
2011	51.89	111.49	311.19	474.57	558.32
2012	-	185.88	465.20	651.07	765.96
2013	-	232.21	796.70	1 028.91	1 210.48
2014	-	459.72	1 106.90	1 566.62	1 843.08
2015	-	625.44	1 515.13	2 140.56	2 518.31
2016	-	673.76	1 590.90	2 264.66	2 664.31
2017	-	787.39	1 705.35	2 492.74	2 932.64

2018	-	924.50	1 706.15	2 630.65	3 094.88
2019	-	1 001.82	1 825.90	2 827.72	3 326.73
2020	-	1 114.32	1 953.56	3 067.89	3 609.28
2021	-	1 176.80	2 676.84	3 853.64	4 533.69
2022	-	1 303.15	3 019.94	4 323.09	6452.37
2023	-	1 780.75	3 547.29	5 328.04	7952.30

Figure 1 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, 2023. Data on PV energy storage sites are not tracked. If a jurisdiction did not report its PV capacity figures in 2023, data from the last available year are shown in parentheses. Table 4 provides national figures on power generation and electricity demand as well as an estimate of total PV energy production. Total energy generation capacity for 2023 was calculated using Statistics Canada's annual electricity generation estimates [1]. Total electricity demand was estimated from the Canadian Energy Regulator's report on Energy Futures and Statistics Canada's supply and demand figures for primary and secondary energy [2]. To estimate PV energy production, the total power (MW_{DC}) was multiplied by the average yearly Canadian PV potential which was assumed to be 1 150 kWh/kW_p. The average PV potential was determined using satellite-based insolation data and assuming a conservative performance ratio of 75% [3].

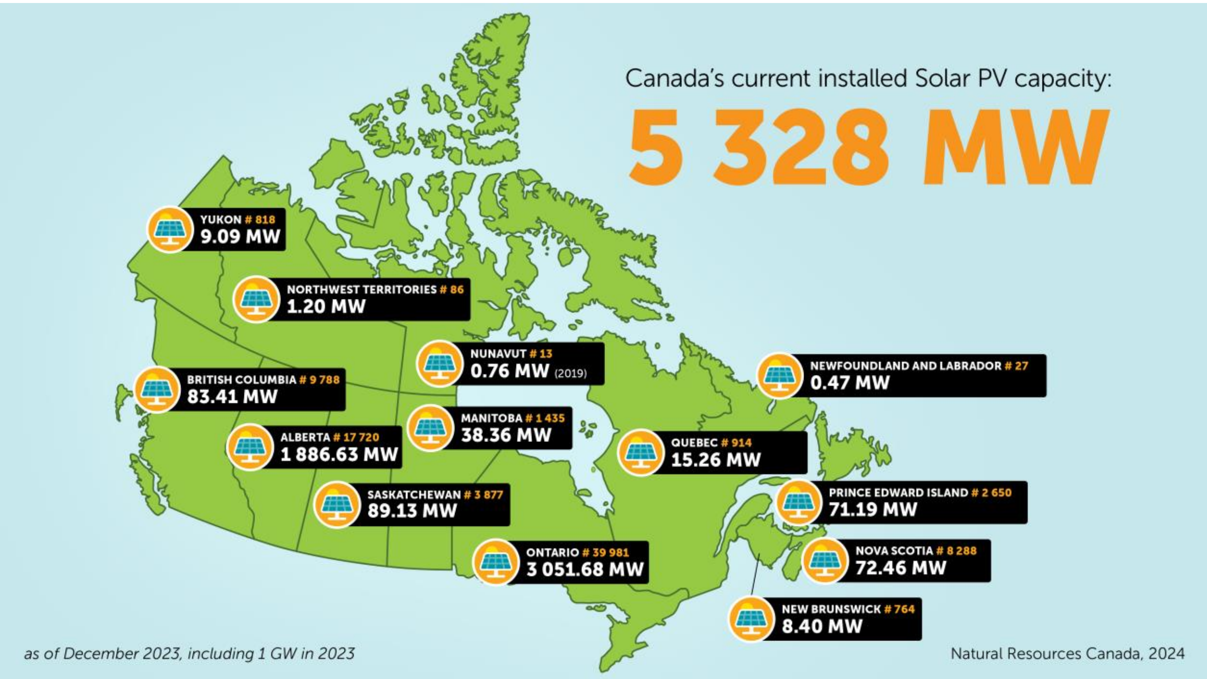

Figure 1: Map showing the PV power capacity (MW_{AC}) and number of installed systems for the provinces and territories. The total number of installed systems across the country is estimated to be 86 361.

Table 4: PV power and the broader national energy market

	2023	2022
Total power generation capacities [TWh]	619.8	640.1
Total renewable power generation capacities (including hydropower) [TWh]	408.1	434.6
Total electricity demand [TWh]	594.0	588.9
New power generation capacity-installed [GW]	Not tracked	Not tracked
Estimated total PV electricity production (including self-consumed PV electricity) [TWh]	9.15	7.4
Total PV electricity production as a percentage of total electricity consumption	1.54	1.26
Average yield of PV installations (kWh/kW_p)	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. There were approximately 188 751 electric vehicles purchased in Canada in 2023, consisting of both battery-electric and plug-in hybrids [4]. In terms of centralized storage, although PV battery energy storage system data are not publicly available, work is underway to track these installations. Additional storage capacities are available as pumped hydro and compressed air. Most projects are utility-scale and behind-the-meter storage, which are connected to the transmission or distribution grid [5].

Table 5: Information on key enablers

	Description	2023 Volume	Total Volume	Source
Residential heat pumps [# of units sold]	Linear growth assumption	21 200	902 600	Canada Energy Regulator [6]
Electric cars [# of units sold]	BEV + PHEV	188 751	562 452	Statistics Canada [4]

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Crystalline silicon module prices vary by manufacturer and module type. In terms of technology trends, the Canadian market mirrors global trends with a transition from monofacial to bifacial, from PERC to higher efficiency TOPCon and SHJ cell types, and from full to half-cut cell arrangements. Recent projects are expected to favour bifacial PV and single axis tracking systems. Table 6 shows wholesale price estimates with value-added taxes excluded.

Table 6: Typical module prices

Year	Lowest price of a standard module crystalline silicon [CAD/W]	Highest price of a standard module crystalline silicon [CAD/W]	Typical price of a standard module crystalline silicon [CAD/W]
2019	0.50	0.74	0.62
2020	0.40	0.74	0.44
2021	0.41	0.78	0.46
2022	0.45	0.80	0.63
2023	0.41	0.52	0.46

2.2 System prices

PV system prices, shown in Table 7 and

Table 8, incorporate the cost of modules, racking, inverters, other balance-of-system components, and installation. Prices do not include recurring charges after installations such as battery replacement or operation and maintenance. Additional costs incurred due to the remoteness of a site, or any specialized installation requirements, are not considered. Value-added taxes are excluded.

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

Category/Size	Typical applications	Current prices [CAD/W]
Off-grid 1 – 5 kW	A stand-alone PV system that generates electricity for a device or a household and is not connected to the grid.	Not tracked
Residential BAPV 5 – 10 kW	A grid-connected, roof-mounted, or distributed PV system that produces electricity for grid-connected households such as roof-mounted systems on apartment buildings and single-family homes.	2.30 – 3.90
Residential BIPV 5 – 10 kW	A grid-connected, roof-mounted, or distributed PV system that produces electricity for grid-connected households	Not tracked

	such as roof-mounted systems on apartment buildings and single-family homes.	
Small commercial BAPV 10 – 100 kW	A grid-connected, roof-mounted, distributed PV system that produces electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agricultural buildings, grocery stores, etc.	2.00 – 3.20
Small commercial BIPV 10 – 100 kW	A grid-connected, building integrated, distributed PV system that produces electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agricultural buildings, grocery stores, etc.	Not tracked
Large commercial BAPV 100 – 250 kW	A grid-connected, roof-mounted, distributed PV system that produces electricity for grid-connected large commercial buildings, such as public buildings, multi-family houses, agricultural buildings, grocery stores, etc.	1.90 – 2.40
Large commercial BIPV 100 – 250 kW	A grid-connected, building integrated, distributed PV system that produces electricity for grid-connected commercial buildings, such as public buildings, multi-family houses, agricultural buildings, grocery stores, etc.	Not tracked
Industrial BAPV > 250 kW	A grid-connected, roof-mounted, distributed PV system that produces electricity for grid-connected industrial buildings, warehouses, etc.	1.68 – 2.22
Small centralized PV 1 – 20 MW	A grid-connected, ground-mounted, centralized PV system that works as a central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	1.65 – 1.90
Large centralized PV > 20 MW	A grid-connected, ground-mounted, centralized PV system that works as a central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	< 1.31

Table 8: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5 – 10 kW [CAD/W]	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10 – 100 kW [CAD/W]	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100 – 250 kW [CAD/W]	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10 – 50 MW [CAD/W]
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
2021	2.50 – 2.83	1.89 – 2.36	1.68 – 2.10	1.31

2022	2.42 – 2.82	2.07 – 2.71	2.22 – 2.50	1.31
2023	2.30 – 3.90	2.00 – 3.20	1.90 – 2.40	1.31

2.3 Cost breakdown of PV installations

The cost breakdown of a typical 5 – 10 kW roof-mounted, grid-connect, distributed PV systems on a residential single-family house is presented in Table 9.

The cost structure presented does not rationalize for volume and is from the customer's point of view without reflecting the installer companies' overall costs and revenues. The "average" category in Table 9 represents the average cost for each cost category and is the average of the typical cost structure. The average cost is taking the whole system into account and summarizes the average end price to customers. The "low" and "high" categories are the lowest and highest cost reported in each segment. These costs are individual posts, i.e. summarizing these costs does 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 [CAD/W]	Low [CAD/W]	High [CAD/W]
Hardware			
Module	0.55	0.45	0.75
Inverter	0.4	0.3	0.75
Mounting material	0.35	0.26	0.80
Other electronics (cables, etc.)	0.10	0.09	0.11
Subtotal Hardware	1.40	1.10	2.41
Soft costs			
Planning	-	-	-
Installation work	1.00	0.9	1.10
Shipping and travel expenses to customer	-	-	-
Permits and commissioning (i.e. cost for electricians, etc.)	0.13	0.1	0.15
Project margin	0.22	0.20	0.24
Subtotal Soft costs	1.35	1.20	1.49
Total (without VAT)	2.75	2.30	3.90

2.4 Financial parameters and specific financing programs

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.

To some degree, the financing of large utility-scale PV projects is specific to the power production paradigm of each province and territory encompassing the regional complexities of generation, distribution, supply, and demand. Some provincial grids may be operated by a single large vertically integrated utility, such as in the province of Quebec, whereas others may be partially publicly owned and privatized subject to varying degrees of deregulation and marketization, such as the province of Ontario. As marketization of a grid proceeds, the business of generation may become decoupled from the infrastructure of distribution and transmission. What this may mean for large-scale PV systems, in some scenarios, is volatility in electricity prices and difficulty in predicting the expected profits, or bankability, of a project selling into a wholesale market. Since uncertainty can be anathema to some institutional lenders and banks, and most PV projects are predominantly funded using a mix of debt and equity, the financing environment for large-scale PV projects may be particularly challenging in the absence of countervailing measures to hedge against risk.

2.5 Specific investment programs

As outlined in Section 3, there are a variety of investment mechanisms across the country to support PV development. 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 was the dominant financing mechanism for residential solar under Ontario’s FIT programs, but now the practice is less common for net metering installations. Third-party ownership models for net metering are more common in Alberta and Nova Scotia.
Renting	Several companies offered rented systems in Canada in 2023. 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 PV on-bill financing in 2023.
Community investment in PV plants	Several PV energy cooperatives have been incorporated to facilitate investment in and ownership of these 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 and territorially regulated and comprised primarily of vertically integrated crown corporations or investor-owned utilities with a deregulated energy-only market system. Electricity demand in Canada was estimated to be 594 TWh in 2023 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) [7]

Retail electricity prices for a household (consumption: 1 000 kWh) [¢/kWh]	7.81 (lowest) 16.41 (average) 29.80 (highest)
Retail electricity prices for a commercial mid-power company (power demand: 1 000 kW, load factor: 56%) [¢/kWh]	7.75 (lowest) 14.54 (average) 27.41 (highest)
Retail electricity prices for an industrial large-power company (power demand: 5 000 kW, load factor: 85%) [¢/kWh]	5.55 (lowest) 11.49 (average) 25.62 (highest)

3 POLICY FRAMEWORK

This chapter describes the support policies aiming to drive the development of PV. As shown in table Table 12, PV policies may, for example, address the upfront capital costs to produce or install PV systems, provide a source of revenue from the energy generated, or alter the regulatory environment in which these systems operate.

Table 12: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2023	**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	-	-	-	-	-	-
Merchant PV facilitating measures	-	-	-	-	-	-
Other (specify)	-	-	-	-	-	-

3.1 National targets for photovoltaics

The federal government has committed to 90% of Canada's electricity coming from non-emitting sources by 2030 and a net zero electricity sector by 2035. However, there is currently no specific PV capacity targets set by the federal, provincial, or territorial governments.

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 by the 2030 Emissions Reduction Plan [8]. Canada has also joined over 120 countries in committing to be net-zero by 2050 and, in 2021, assented the Canadian Net-Zero Emissions Accountability Act. These documents outline a variety of approaches such as 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 reached $65 per tonne in 2023. The program does not apply to provinces that implement their own carbon pricing schemes if they define an equivalent price. Additionally, launched in 2021, the Smart Renewables and Electrification Pathways Program provides $4.5 billion over fifteen years to support renewable capacity, energy storage, and grid modernization projects [9]. There is also the Accelerated Capital Cost Allowance (ACCA) and the Canadian Renewable and Conservation Expense (CRCE) tax incentive [10]. Beginning in 2023, two federal support mechanisms for PV and other low-carbon technologies were implemented: the Clean Technology Investment Tax Credit and the clean Technology Manufacturing Investment Tax Credit. Both provide a corporate tax refund equivalent to 30% of the cost of capital investment for a PV system or the cost of machinery for PV manufacturing initiated between March 28, 2023 and December 31, 2034 [11].

3.2.2 Solar PV support measures by province and territory

Support measures can be divided into 1) solar incentives such as tax breaks and rebates, 2) utility policies such as electricity time-of-use pricing, net metering, interconnection fees, and 3) system financing options such as low-interest loans, the Property Assessed Clean Energy (PACE) programs, or on-bill financing. PACE programs allow the system cost to be repaid through property taxes. The average cost per installed watt for each jurisdiction is given in Table 13. However, these prices are only an approximate guide and are dependent on system size, choice of installer, and additional market factors. The electricity bill rate design for each province and territory is also included since it provides a measure of the amount of money that may be saved by implementing PV. Better rate design maximizes the amount of money that can be saved for a given reduction in electricity usage and helps encourage distributed energy generation. Table 13 shows the percentage and dollar amount of money saved for the example case of a 50% reduction in electricity use from 1 500 kWh to 750 kWh per month in different parts of the country. In some cases, rebates for PV are bundled with support measures for co-located battery energy storage systems. For example, British Columbia's utility provides a maximum $5 000 rebate ($1 000/kW) for residential PV systems combined with a $5 000 rebate for battery storage ($500/kWh) [12]. One interesting PV option available in Ontario by the IESO is third-party ownership. This allows homeowners and other generators to benefit from net metering without having to cover the costs of installing or owning the PV asset.

Another example of a helpful measure is the updated commercial net metering program in Nova Scotia which raised the self-generation capacity limit from 100 kW to 1 MW [13].

Table 13: Summary of support measures by province and territory. Average electricity cost is based on a consumption of 1000 kWh per month.

Province or territory	Solar incentives	Rate design	Average electricity cost (¢/kWh)	System cost (CAD/W)
Alberta	City-specific support measures	44%, $45	28.5	2.60 – 3.27
British Columbia	7% Provincial tax exemption for all PV equipment, district and city-specific support measures	36%, $14	11.4	2.52 – 3.17
Manitoba	$0.5/W rebate up to $5 000, loan of up to $20 000 over 15-year term	47%, $9	10.2	2.72 – 3.42
New Brunswick	$0.2/W rebate	45%, $22	13.9	2.89 – 3.64
Newfoundland and Labrador	None	46%, $16	14.8	4.00 <
Northwest Territories	50% rebate (only for off-grid and non-hydro)	55%, $18	41.0	3.00 – 3.77
Nova Scotia	$0.3/W rebate up to $3 000, PACE loan with 10-year term	46%, $19	18.3	2.51 – 3.16
Nunavut	50% rebate up to $30 000	55%, $18	35.4	4.00 <
Ontario	PACE loan up to $125 000 repaid over 5 to 20 years	42%, $32	14.1	2.42 – 3.05
Prince Edward Island	$1.0/W rebate up to $10 000, PACE loan up to $40 000 repaid over 15 years	45%, $25	18.4	2.98 – 3.75
Quebec	None	49%, $13	7.8	2.65 – 3.33
Saskatchewan	PACE loan to $60 000 repaid over 20 years	44%, $32	19.9	2.88 – 3.63
Yukon	$0.8/W rebate up to $5 000 (only for off-grid)	48%, $15	18.7	3.02 – 3.80

3.2.3 BIPV development measures

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

3.3 Self-consumption measures

Table 14: Summary of self-consumption regulations for residential PV systems in 2023

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. There are, for example, several community-owned PV systems in British Columbia, whereby members invest on a per-panel basis and may receive a proportional credit on their hydro bill or be paid an annual dividend [14] [15]. In Ontario, the IESO is developing several virtual net-metering demonstration projects [16].

3.5 Tenders, auctions & similar schemes

Procurement methodologies include standard offer, bilateral negotiations, and competitive bid. However, in the coming years, most jurisdictions will likely use competitive procurement. Solar PV contract periods are generally awarded for 20 years. The way in which incentives are paid in Canada varies from region to region. Programs are funded through revenues from carbon pricing programs or provincial and municipal taxes.

3.6 Other utility-scale measures including floating and agricultural PV systems

There are currently no support measures for floating PV or agrivoltaics. However, the not-for-profit Agrivoltaics Canada association [17] provides a bridge between farmers, PV installers, academia, and provincial and federal funding organizations to begin several demonstration projects. Agrivoltaics Canada advocates for provincial policy support and changes in land-use designations to stimulate the deployment of PV systems on farmland.

3.7 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, the $100 million Smart Grid Program, the $520 million Clean Energy for Rural and Remote Communities program, the $4.5 billion Smart Renewables and Electrification Pathways program, and various tax incentive programs for industry [10]. For corporations, there is also the Clean Technology Investment Tax Credit and the clean Technology Manufacturing Investment Tax Credit described in subsection 3.2.1.

3.8 Indirect policy issues

3.8.1 Rural electrification measures

Canada has approximately 300 off-grid communities with a total population of around 200 000 people. There is an transition in these communities from diesel fuel to renewable energy supported by the $520 million Clean Energy for Rural and Remote Communities Initiative. 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.

3.8.2 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, started in 2018, supports combined solar and storage. Other measures were outlined in the 2020 federal policy update [18].

3.8.3 Support for encouraging social acceptance of PV systems

There are currently no programs at the national or regional level to study or encourage the social acceptance of PV systems.

3.9 Financing and cost of support measures

PV projects may be directly subsidized by reducing the upfront capital cost on the residential side using rebates and at the utility-scale corporate side using investment tax credits.

Financing at the energy production point may occur using feed-in tariffs or private or government-backed power purchase agreements (PPA) which may be an alternative to the merchant risk accrued by selling directly into the spot market. Over the past few years, governments in several countries have faced both financial and political pressures due to the cost of feed-in-tariff programs. If the FIT is too low, project deployment is sluggish. But if the FIT is too high, a glut of projects can lead to overcapacity and expensive payouts to system owners. To control FIT costs, there has been a shift in Canadian markets towards competitive bidding and auctions.

As a hedge against volatile electricity prices, some project owners favour a PPA to sell electricity at an agreed upon rate for a fixed period directly to a corporate entity. While a PPA can improve the bankability of a PV project, there are often many bidders interested in winning a small number of contracts. In the PV power supply sector, the barriers to entry are relatively small compared to fossil-based generators leading to fierce competition. This intense competitive pressure from a variety of renewable energy bidders, while driving down electricity prices for the consumer, can also sometimes compete away potential profits that could be gained from a reduced LCOE. If the costs of building a PV project are reduced, due to economies of scale and improvements in module manufacturing, but the revenue from a PPA is also reduced by vigorous competition between bidders offering to sell at lower prices, then profit margins can be eroded. Thus, although a PPA may offer greater security than selling into the spot market, the competitive pressures of auction-based purchasing may sometimes act as a break on further PV deployment.

Other alternatives to insulate against risk that may be employed for PV projects include so-called special purpose vehicles or subsidiaries and contract-for-difference (CfD) mechanisms. The CfD approach provides a degree of revenue stabilization while also protecting consumers from increased prices when electricity costs are high. However, the CfD funding mechanism is currently not used in Canada.

3.10 Grid integration policies

3.10.1 Grid connection policies

Interconnection policies determine the size of PV system that can be connected to the grid and the financial compensation that such systems receive for the electricity that they produce. The grid interconnection process, array size limits, and electricity rates paid for renewable electricity vary substantially by jurisdiction. The waiting time for grid interconnection is currently not tracked in this report.

3.10.2 Grid access policies

Grid access costs are part of the soft costs in Table 9 and are linked to installation and commissioning expenditures. Grid access policies, procedures, and interconnection times vary by province and territory and their effects on market development are not tracked in this report.

4 INDUSTRY

4.1 Production of feedstocks, ingots and wafers (crystalline silicon or thin film industries)

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 15). 5N Plus is a Canadian company with 14 manufacturing facilities located throughout Canada, the USA, 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.

Table 15: Silicon feedstock, ingot and wafer producer's production information for 2023

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

4.2 Production of PV cells and modules (including thin film 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 and junction boxes. The manufacturing of modules may only be attributed to a country if the encapsulation process takes place there. Table 16 present data from four Canadian companies producing PV modules, all of which have their facilities located in Ontario or Quebec, and which are involved in contract manufacturing for other multinational companies. Together, these four companies produce an estimated 475 MW/year of crystalline silicon modules.

Table 16: PV cell and module production and production capacity information for 2023

<table>
<tr><th rowspan="2">Cell/Module manufacturer</th><th rowspan="2">Technology</th><th colspan="2">Total Production [MW]</th><th colspan="2">Maximum production capacity [MW/yr]</th></tr>
<tr><th>Cell</th><th>Module</th><th>Cell</th><th>Module</th></tr>
<tr><td colspan="6">Wafer-based PV manufactures</td></tr>
<tr><td>Canadian Solar</td><td>c-Si, mc-Si</td><td>-</td><td rowspan="3">475</td><td>-</td><td rowspan="3">1 050</td></tr>
<tr><td>Heliene</td><td>mc-Si</td><td>-</td><td>-</td></tr>
<tr><td>Silfab</td><td>c-Si, mc-Si</td><td>-</td><td>-</td></tr>
<tr><td>Totals</td><td></td><td>-</td><td>475</td><td>-</td><td>1 050</td></tr>
</table>

4.3 Manufacturers and suppliers of other components

The balance of the 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 rooftops and utility-scale systems.

5 PV IN THE ECONOMY

5.1 Labour places

The effect of PV in the economy was determined from the installed PV capacity in each province and territory. These data were analysed using the Economic Impacts of Electrification Initiatives (EI^2) model developed by the Trottier Energy Institute and Ecole Polytechnique [19]. The estimate of the total number of jobs is an aggregate of two types: permanent operation and maintenance of installed capacity in previous years and temporary construction due to new installations in 2023. 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 17: Estimated PV-related full-time labour places in 2023

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	27 418
Distributors of PV products and installations	345
Other	-
Total	**27 868**

5.2 Business value

The value of PV business in Canada as it relates to the PV capacity installations for 2023 is estimated to be approximately $3.1 billion. 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 added to the construction impacts due to new PV capacity in 2023. Operation and maintenance encompassed onsite labour, local revenue, and supply chain effects. The construction phase related to modules and supply chain, project development, and onsite labour output.

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

Each Canadian province and territory operate their own electricity sector. As a result, the market structure and regulations in each jurisdiction are 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. Ontario, 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.

6.2 Interest from electricity utility businesses

Given the diversity in market structures across Canada, the interest from electricity utility businesses is variable. Some utilities have established unregulated subsidiaries to act as generators while others simply interconnect projects and handle the settlement of payments. In other jurisdictions, utilities offer rebates, manage net-metering, and are considering solar financing products such as lease-to-own.

6.3 Interest from municipalities and local governments

There are over 3 500 urban and rural municipalities in Canada interested in environmental sustainability and continued exploration PV throughout 2023.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

Canada's PV sector has reached 5.3 GW_{AC} of installed capacity, a growth of approximately 23% over the previous year. Canada has joined over 120 countries in committing to net-zero emissions by 2050 and net-zero electricity system by 2035. Achieving Canada's greenhouse gas emissions reduction goals requires significant decarbonisation and electrification representing an important opportunity for the Canadian PV industry.

7.2 Prospects

As the decarbonization of the electricity sector continues, PV and wind generating assets will continue to play a role in Canada’s new generating capacity while expanding to meet growing demand for vehicle charging and heat pump-based building heating.

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