

Solar PV manufacturing in Canada

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ABSTRACT

Canada is aggressively pursuing solar photovoltaic manufacturing. Ontario, the province leading the charge, is already the manufacturing hub for other products in Canada and currently boasts one of the most generous feed-in tariffs in the world. This incentive is closely tied to domestic content restrictions in order to foster Canadian photovoltaic manufacturing. In addition, a host of other tax incentives and research and development stimulus packages are making Canada an increasingly popular destination for both established manufacturers and start-up companies.

Introduction

Although sunny weather – and the resulting high solar fluxes and photovoltaic systems that go with it – are probably not on the top of anyone's list when you think of Canada, the "True North" is opening up some intriguing possibilities for solar photovoltaic manufacturers. Although the 2009 and 2010 Federal budgets clearly indicate that the Canadian Federal government is not directly investing to support financial incentives for PV, it is providing funding for sustainable energy infrastructure to the provinces [1, 2]. The manufacturing hub of Canada is Ontario, which is Canada's largest province (the equivalent of a U.S. state). It has more than 12 million well-educated people (more than 50% of whom have post-secondary education) and a very strong support of renewable energy. Following the success of many of the world's governments in this area [3], Ontario has moved to improve the economics of renewable energy projects by offering a feed-in tariff (FiT). Ontario currently boasts one of the most generous FiTs in the world, and an assortment of other incentives that have both established companies and startups flocking to the north.

The Ontario feed-in tariff

Renewable energy holds popular support throughout Canada; however, Ontario has made the most notable efforts towards expanding its renewable energy sector. In 2009, the Ontario Power Authority (OPA) launched the FiT program supported by the Green Energy and Green Economy Act 2009 [4] to procure renewable energy [5]. The Ontario FiT covers several renewable energy technologies, boasting the largest rates for solar PV, as shown in Table 1. (All economic values in Table 1 and throughout this paper are in \$CAD; at time of writing, ~\$US.)

FiT programs are based on contracts with a local utility to purchase energy generated by renewable energy technologies with variable capacity [6]. In the Ontario FiT case, this rate is guaranteed for 20 years, which has made installation of PV in the province quite profitable.

In addition to the obvious direct jobs created by installing PV systems in the province, the Ontario FiT directly encourages PV manufacturing in Ontario as a result of provincial content standards [7]:

- For solar PV projects with a contract capacity greater than 10kW, the minimum required domestic content level is 50% for FiT contracts that have a milestone date for commercial operation prior to January 1, 2011 and 60% thereafter.
- For micro-FiT contracts (<10kW), the minimum required domestic content level is 40% for FiT contracts that have a milestone date for commercial operation prior to January 1, 2011 and 60% thereafter.

With the use of local labour on the installation and balance of systems (BOS) components such as racking being made locally, it has been relatively easy for Ontario's PV development firms to meet the current domestic content standards. However, when the percentage increases in 2011, it will be necessary to have at least some of the main components manufactured in Ontario. The news has caused an explosion of announcements about PV materials, with several cell and module manufacturers setting up shop in Ontario (see Table 2). Currently, Canada's PV industry is in its infancy, but many companies are considering some form of assembly or manufacturing in Ontario to comply with the FiT domestic content restrictions.

“It has been relatively easy for Ontario's PV development firms to meet the current domestic content standards.”

Just as the impermanent nature of FiTs in Europe directed the industry down the more conservative route, so too has Canada's situation developed. Most of the companies listed in Table 2 are planning to start with assembly,

Size	Rate
MicroFIT* – Rooftop or ground-mounted	
Less than 10kW	80.2c/kWh
Rooftop-mounted systems	
10 – 250kW	71.3c/kWh
250-500kW	63.5c/kWh
Greater than 500kW	53.9c/kWh
Ground-mounted systems	
Less than 10MW	44.3c/kWh
Aboriginal adder	1.5c/kWh

Table 1. Ontario feed-in tariff rates.

**As of July 1, 2010, there have been over 16,000 applications made for the micro-FiT program and the size of the systems indicate most are ground-mounted. The OPA has thus proposed that ground-mounted solar PV projects of 10kW or less will be eligible to receive a price of 58.8 cents per kilowatt-hour rather than the roof-mounted micro-FiT rate.*

which consists of some of the back-end processing including wiring and laminating, rather than start-to-finish manufacturing of modules. In addition to the manufacture of materials, cells and modules for the PV industry, there has been an even greater explosion of BOS manufacturers in the region in the past year, as seen in Table 3.

Again, much of the manufacturing listed in Table 3 is for inverter assembly of parts made elsewhere, although there is a growing interest on the part of existing Ontario firms with skill sets in the area of racking design and manufacture in entering the PV BOS space. It should be noted that the company lists in Table 2 and 3 should not be considered exhaustive as the number of companies entering the Ontario market is rising at a breathtaking pace. This is particularly important given the context – the installed PV capacity of all of Canada was in the tens of MWs even in 2008 when installations were dominated by small-scale systems on cottages and off-grid applications.

Company	Product (expected date of operation)	Webpage/press release
Arise Technologies Corp.	Solar-grade silicon – pilot production	www.arisetech.com
Bosch	Thin-film PV (in partnership with SET)	www.thestar.com/business/article/773554--bosch-latest-to-tap-ontario-s-solar-market
Calisolar, Inc. (formerly 6N Silicon)	Solar-grade silicon	www.calisolar.com
Canadian Solar	PV modules (2010)	phx.corporate-ir.net/phoenix.zhtml?c=196781&p=irol-newsArticle&ID=1361594&highlight=
Cyrium Technologies	Solar cells for concentrated photovoltaics	www.cyriumtechnologies.com/index.htm
Everbrite Solar	Thin-film PV modules (2010)	www.everbritesolar.com/Home/tabid/61/Default.aspx
Flexible Solar Cell Technologies	Flexible solar cells, in development	www.flexiblesolartech.com/
German Solar Corporation	Solar arrays (early 2010)	www.lecdc.com/index.php/lecdc/show_NEWS/1040
Greenpower Farms	PV modules (November 2010)	www.greenpowerfarms.com/index-3.html
Heliene Canada	PV modules (August 2010)	www.heliene.ca/products/index.aspx?l=0,9,10,22
Menova Energy	“Power-Spar” - solar concentrator to provide heat, hot water, and electrical power	www.power-spar.com/Power-Spar/index.php
Morgan Solar	Concentrated PV (2011)	www.morgansolar.com/about.php
Opsun Panels	PV modules (third quarter 2010)	www.opsunpanels.com/press.html
Photowatt Ontario, Inc.	PV modules (third quarter 2010)	www.photowattontario.com/about.html
PRISED Solar, Inc.	Silicon refinement development	www.pridesolar.com/Standard/Default.aspx
Quadra Solar	Concentrated PV	www.quadrasolar.com/
Routes AstroEngineering	Space-grade PV modules for satellites	www.routes.com/pdf/Solar%20Panels%20Jul-05.pdf
Samsung	PV manufacturing (2013)	www.thestar.com/news/ontario/article/753816--mcguinty-heralds-samsung-green-energy-deal?bn=1
Silfab SpA	PV modules (July, 2011)	www.silfab.eu/it/releases.php/1277
Siliken Renewable Energies	PV modules (fourth quarter 2010)	www.siliken.com/comunicacion/noticias/ficha?contentId=1031&languageId=1
Solar Semiconductor	PV modules (2010)	www.solarsemiconductor.com/abt-news-aokville-plant.htmlZ
Solar Source Corp. of Canada/HHV	Crystalline PV modules (2011)	www.solarbancorp.wordpress.com/
SolGate	Solar PV modules, 75-230W	www.solgatesolar.ca

Table 2. Ontario’s photovoltaic materials, cell and module manufacturers.

By encouraging the development of renewable energy in Ontario, the government hopes that the FiT Program will [8]:

- help Ontario phase out coal-fired electricity generation by 2014 – the largest climate change initiative in Canada
- boost economic activity and the development of renewable energy technologies
- create new green industries and jobs.

Completion of these goals is imperative. Coal is on its deathbed in Canada, as a recent announcement from the Federal government demanded that when each of the remaining 51 coal-burning units in Canada reaches the end of its economic life, it will have to meet with new standards or close down with no exceptions or carbon trading [9]. Meanwhile, Ontario will have all of its coal plants either shuttered or only burning biomass by as early as 2014.

In addition to meeting the provincial government’s campaign promise of shutting down all coal-fired electricity in the province and ushering in a

renewable energy era, the government also sees support of PV as an economic development tool. Support for this view was recently provided by a financial analysis for investment in a theoretical 1GW turnkey amorphous silicon PV manufacturing plant. The financial analysis looked at six scenarios and quantified the benefits for both the provincial and federal governments for [10]:

- full construction subsidy
- construction subsidy and sale
- partially subsidizing construction
- a publicly owned plant
- loan guarantee for construction
- an income tax holiday.

The revenues for the governments are derived from: taxation (personal, corporate, and sales); sales of panels in Ontario; and saved health, environmental and economic costs associated with offsetting coal-fired electricity. The study found that in less than 12 years, both governments enjoyed positive cash flows from these investments even for the most aggressive plans. Furthermore, the scenarios both saw governments

earning well over 8% on investments from hundreds of millions to \$2.4 billion [10]. The results showed that it is, financially speaking, in the best interest of both the Ontarian and Canadian federal governments to implement aggressive fiscal policy to support large-scale PV manufacturing.

“The Ontario government is actively pursuing agreements with PV companies to stimulate manufacturing in Ontario in addition to the policies outlined in the FiT.”

It is also apparent that the Ontario government is actively pursuing agreements with PV companies to stimulate manufacturing in Ontario in addition to the policies outlined in the FiT. Earlier this year, the Ontario government signed a \$7 billion agreement between and Samsung C&T Corporation and the Korea Power Electric

Corporation (KPEC) for both solar PV and wind manufacturing facilities – an agreement that was spurred on by the stability ensured by the FiT program [11]. The government is supplying the Korean consortium with a \$437 million economic “adder” to the FiT to ensure that manufacturing jobs are created, with the stipulation that they will set aside scarce transmission capacity in the western part of the province to ensure the group does not have too long to wait in the grid-connection queue. The Premier of Ontario, Dalton McGuinty, has made it clear that if any other consortia – local or foreign – want to talk about manufacturing, energy development and job creation on a large scale, then he is listening [12].

Innovation incentives

In addition to deployment of PV, Canada also strongly encourages research and development work related to renewable energy. Each province has its own programs: Ontario has 1) up to \$1.5m investment opportunity through the Eastern Ontario Development Fund; and 2) Advanced Manufacturing Incentive Strategy (AMIS), which provides interest-free loans for up to five years to encourage companies to invest in leading-edge technologies and processes. At the Federal level there are two programs

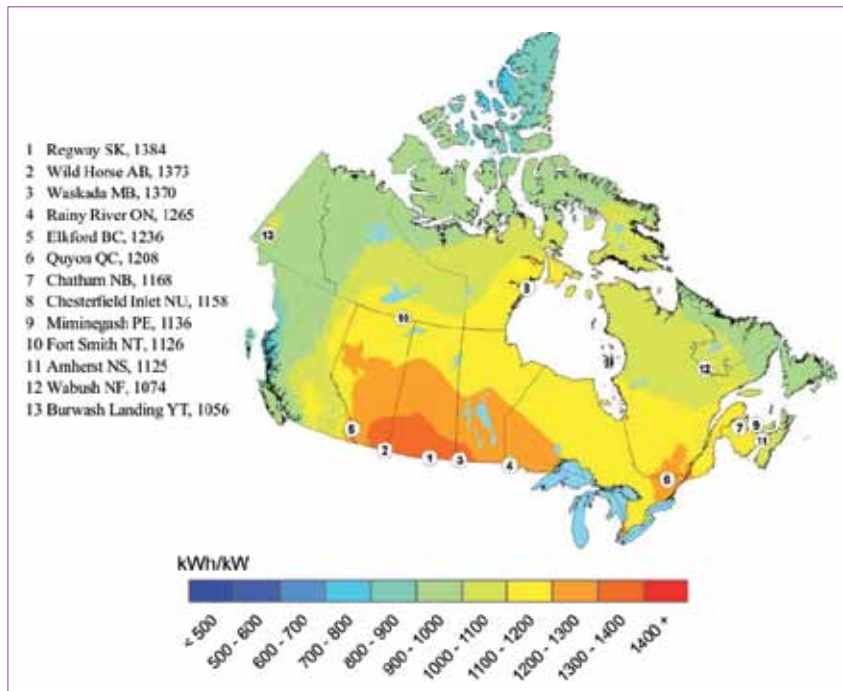


Figure 1. Yearly solar photovoltaic potential map for latitude tilt in Canada and ‘PV hotspots’ in each province and territory in Canada [14].

that are helpful to PV manufacturers: IRAP and SR&ED. IRAP, the Industrial Research Assistance Program, provides technical and business advisory services and financial assistance to small and medium-sized enterprises [13]. This program would be best suited for start-

up companies. The Federal and Ontario Scientific Research and Experimental Development (SR&ED) incentives generate significant tax savings; among the most generous in the G7, these incentives can cut the cost of R&D from \$100 to less than \$41 (see Table 4).

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EQUIPMENT

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Company	Product (expected start date)	Webpage/press release
Abuma Manufacturing	Solar mounting & trackers	www.abuma.com/
Advanced Solar Investments	Polymer racking for flat rooftops	www.advancedsolarinvestments.com/
Anchor Danly	Mounting frames	www.anchoranly.com/
Atlas Tube	Solar mounting frames	www.atlastube.com/
Cachelan	Web-based monitoring of solar systems	www.cachelan.com
Conergy Ltd.	Ground- and roof-mounting Systems	www.conergy.ca
Conserval Engineering	Mounting system for PV/solar thermal modules	www.solarwall.com/en/products/solarwall-pvt/solarduct-pvt.php
Domcast Metals	Racking & support structures	www.domcastmetals.com
Dyco Solar Inc.	Solar roof, pole & ground mounts	www.dyco.ca/index.html
Eco Energy	Solar electronics, charge controllers, low voltage disconnectors for PV systems	www.eco-energy.ca/
Extrudex Aluminum	Solar roof and ground mounts	www.extrudex.com/
Flextronics -Enphase Energy	Microinverters (May 2010)	www.enphaseenergy.com/downloads/Enphase_Press_Release_Ontario.pdf
Fusetek	Fuses for solar PV applications	www.fusetek.com/
Green Sun Rising	PV and solar thermal mounting hardware	www.greensunrising.com/indexNew.htm
Greenfield Hydroponics	PV-powered greenhouse	www.greenfield-hydroponics.com/
HB Solar	PV flat roof mounting system	www.ingo@hbsolar.ca
Hybridyne Power Electronics	Inverters	www.hybridynepowerelectronics.com/Page_02.05.htm
Opsun Panels	Mounting systems	www.opsunpanels.com
PLP Solar	Roof ground mounts, large ground mounts, power enclosures	www.preformed.on.ca
Polar Racking	Commercial rooftop racking	www.polarracking.ca
Samsung	Inverters (2013)	www.theenergycollective.com/TheEnergyCollective/57131
Sasco Strut	Mounting frames	www.sascocan.com
SatCon Power Systems	Development & manufacturing of power electronics & control systems for alternative energy	www.satcon.com/company/index.html
Schletter Canada	Solar mounting systems (May 2010)	www.schletter.de/us/component/content/article/180.html
Schneider Electric (Xantrex)	Inverters (August 2010)	www.schneider-electric.ca/
Sciencetech, Inc.	Solar simulator systems	www.sciencetech-inc.com
Siemens Canada Ltd.	Inverters (November 2010)	www.siemens.ca/web/portal/en/press/
SMA Solar Technology AG	Inverters (2010 Q3)	www.sma.de/en/
Solar Converters, Inc.	Power controls for renewable energy systems	www.solarconverters.com
Solar Signals, Inc.	Off-grid solar-powered transportation signs (roads, marine, rail)	www.solarsignals.com
Solera Sustainable Energies Company	PV system controls	www.soleraenergies.com
Spectra Aluminium	Aluminium racking	www.solarsignals.comspectraaluminum.com/Markets-Served
Spectra-Nova Technologies	Solar cell & module test equipment, spectral response units, & array simulators	www.spectra-nova.com
SunLink Corporation	Solar roof and ground mounts (2010)	www.sunlink.com/files/sunlink-04-13-10-Ontario.pdf
Sun-Link Solar Tracker	Solar trackers	www.sunlinksolartracker.com
Sunrise Power	Inverters & mounts	www.sunrisepower.ca/Products.html
Sustainable Energy Technologies	Inverters (2010) – packaged systems with Bosch (2010)	www.sustainableenergy.com

Table 3. Ontario's solar PV equipment manufacturers.

The eligible Ontario research institutes include universities and colleges of applied arts and technologies. The 20% refundable Ontario Business-Research Institute Tax Credit (OBRI TC) for manufacturers was determined using a

Federal 22.12% tax and an Ontario 12% rate, which gives a total of 34.12%. Finally, it should be noted that all companies considering locating in Canada or Ontario should seek professional tax advice.

Potential demand

Canada's population is concentrated along the U.S. border in relatively high solar flux areas and thus actually represents a considerable potential demand as seen in Fig. 1 [14], which shows the yearly solar PV

Description	R&D Expenditures	R&D Expenditures at eligible Ontario research institutes	Non-R&D Expenditures
Gross expenditures	\$100.00	\$100.00	\$100.00
Ontario – 20% OBRI Tax Credit		-\$20.00	
Federal investment tax credit – 20%	-\$20.00	-\$16.00	
Tax deductions			
\$80 x 34.12%			
\$64 x 34.12%			
\$100 x 34.12%			
	-\$27.30	-\$21.84	-\$34.12
Ontario exemption of Federal investment tax credit			
\$20 x 12.0%			
\$16 x 12.0%			
	-\$2.40	-\$1.92	
After-tax cost of \$100 expenditure	\$50.30	\$40.24	\$65.88

Table 4. Tax credit example.

potential map for latitude tilt in Canada and 'PV hotspots' throughout Canada.

A recent study introduced a five-step procedure to estimate the total rooftop PV potential, a process that involves the geographical division of the region; sampling using Feature Analyst extraction software; extrapolation using roof area-population relationships; reduction for shading, other uses and orientation; and conversion to power and energy outputs [15]. Wiginton et al. found that the potential annual energy production of over 30% of Ontario's demand can be met with province-wide rooftop PV deployment [16]. However, there

is also a considerable amount of land in Canada that has a large potential for energy production if used for solar farms. Specifically, a recent study [17] looked at the land with the lowest possible value for agriculture, the worst soil, and featured an appropriate slope and situation close to the electrical grid such that establishment of a solar farm in the area would be economic. With these criteria, over 90GW of potential was found for ground-based solar farms on marginal land in a relatively small area of south-eastern Ontario alone. Thus, it is clear that the potential for technically viable PV in Ontario and Canada as a whole is

enormous and provides a ready market for PV manufacturers.

Conclusions

Due to far-sighted policies to support renewable energy such as the Green Energy Act in Ontario, Canada is becoming an increasingly popular destination for both established solar photovoltaic manufacturers and start-up companies.

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of the Canadian Solar Industries Association, Gillian Hatton and Jackie St. Pierre of the Ontario East Economic Development Commission, Christa Wallbridge and Jeff Garrah of Kingston Economic Development Corporation, and Ted Hsu of SWITCH.

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References

- [1] Department of Finance, Canada, 2009, "Canada's Economic Action Plan, Budget 2009", Public Works and Government Services Canada, Ottawa, January 27th, 2009.
- [2] Department of Finance, Canada, "Canada's Economic Action Plan Year 2, Budget 2010, Leading the Way on Jobs and Growth", Public Works and Government Services Canada, Ottawa, March 4th, 2010.
- [3] Renewable Energy Policy Network for the 21st Century, "Renewables Global Status Report 2009 Update".
- [4] Smitherman, G.. 2009, "Bill 150, An Act to enact the Green Energy Act, 2009 and to build a green economy, to repeal the Energy Conservation Leadership Act, 2006 and the Energy Efficiency Act and to amend other statutes", Legislative Assembly of Ontario.
- [5] Ontario Power Authority 2009, "Feed-in Tariff Program Development", [available online at <http://www.powerauthority.on.ca/fit/Page.asp?PageID=1226&SiteNodeID=1039>].
- [6] Pietruszko, S.M. 2006, "Feed-In Tariff: The Most Successful Support Programme", *Proc. 4th IEEE World Conference on Photovoltaic Energy Conversion*, pp. 2524-2527.
- [7] Ontario Power Authority 2009, "Feed-in tariff program FiT rules, Ver. 1.1", [available online at: http://fit.powerauthority.on.ca/Storage/98/10726_FIT_Rules.pdf].
- [8] Ontario Power Authority 2010, "What is the Feed-in Tariff Program?"; [available online at: <http://fit.powerauthority.on.ca/Page.asp?PageID=1115&SiteNodeID=1052>].
- [9] Payton, L. 2010, "Feds to kill coal power plants", *Toronto Sun*, [available online at: <http://www.torontosun.com/news/world/2010/06/23/14486256.html>].
- [10] Branker, K. & Pearce, J. M. 2010, "Financial Return for Government Support of Large-Scale Thin-Film Solar Photovoltaic Manufacturing in Canada", *Energy Policy*, Vol. 38, pp. 4291-4303.
- [11] Queen's Printer for Ontario 2010, "Newsroom: Ontario Delivers \$7 Billion Green Investment", [available online at: <http://news.ontario.ca/mei/en/2010/01/backgrounder-20100121.html>].
- [12] Hamilton, T. 2010 "Samsung deal keeps jobs from going south", *The Toronto Star*, [available online at: <http://www.thestar.com/business/cleanbreak/article/755239--hamilton-samsung-deal-keeps-jobs-from-going-south>].
- [13] Reference available online at <http://www.nrc-cnrc.gc.ca/eng/ibp/irap.html>.
- [14] Pelland, S. & McKenney, D.W. et al. 2006, "The Development of Photovoltaic Resource Maps for Canada", *31st Annual Conference of the Solar Energy Society of Canada*, Montréal, Canada.
- [15] Wiginton, L.K., Nguyen, H.T. & Pearce, J.M. 2010, "Quantifying Solar Photovoltaic Potential on a Large Scale for Renewable Energy Regional Policy", *Computers, Environment and Urban Systems*, Vol. 34, pp. 345-357.
- [16] Independent Electricity System Operator 2009, "Market Data: Zonal Demands", [available online at <http://www.ieso.ca/imoweb/marketdata/marketData.asp>].
- [17] Nguyen, H.T. & Pearce, J.M. 2010, "Estimating Potential Photovoltaic Yield with r.sun and the Open Source Geographical Resources Analysis Support System", *Solar Energy*, Vol. 84, pp. 831-843.