

Economic Impacts of the Solar PV Sector in Ontario 2008-2018

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Prepared by ClearSky Advisors Inc.

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Table of Contents

Executive Summary 3

1. Introduction 7

2. Investment 9

3. Job Creation 15

4. Electricity Customer Impacts..... 21

5. Cost Premium vs. Job Creation..... 25

Glossary 26

Appendices 28

Table of Figures 36

Bibliography 37

Executive Summary

Electricity supply in Ontario will undergo significant changes over the next 20 years. These changes will be driven by the need to replace and/or refurbish existing electricity generating facilities as well as by rising electricity demand.

- By 2030, almost 70% of required electricity generation will need to come from new or refurbished electricity generating facilities
- Despite conservation efforts, demand for electricity is expected to increase by 15% from 2010-2030

To prepare for these changes, the province has developed a Long-Term Energy Plan (LTEP) for the period of 2010 - 2030. By 2030, the LTEP calls for the vast majority of electricity generation in Ontario to come from nuclear power (46%), hydro-electricity (20%), wind (10%), and natural gas (7%), and for conservation measures to reduce demand by 14%. The solar photovoltaic (PV) industry is set to add to that mix an expected 1.5% of total generation by 2030.

To meet targets laid out in the LTEP, ClearSky Advisors expects that approximately 3,000 MW dc of solar PV will be installed and operational in Ontario by 2018. This report examines a number of the economic outcomes that would arise from that level of market activity.

Specifically, the report provides analysis of: (1) private sector investment, (2) job creation, and (3) cost to Ontario electricity customers.

Economic Impacts of Solar PV in Ontario		
	In 2011	2008 - 2018
Private Sector Investment	\$2 billion	\$12.9 billion
Job Creation ¹	8,200	74,000
Marginal Monthly Cost of Solar PV to Average Ontario Electricity Customer	\$1.42	\$4.91 (in 2018)
Marginal Cost of Solar PV as a Percent of Average Monthly Electricity Bill	1.1%	3.0%

Key Findings

Ontario's Solar PV Industry Today

Ontario is currently a leading jurisdiction for solar PV in North America.

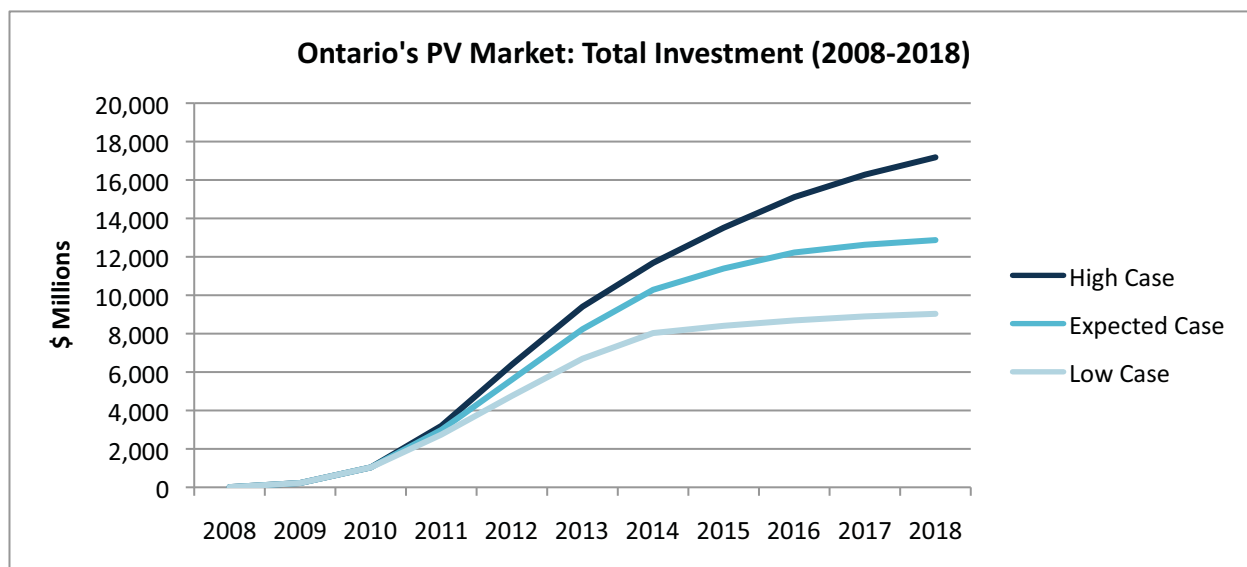
- In 2010, Ontario ranked second for solar PV installations amongst US states and Canadian provinces and territories (167 MW dc)
- The province is expected to remain the second largest solar PV market in North America in 2011
- By the end of 2011 there will be more than two dozen solar PV module and inverter manufacturers in the province

¹ Jobs are measured in Person-Years of Employment (PYE). One PYE equals 40 hours of employment a week for a period of 52 weeks.

Private Sector Investment

Ontario's Feed-in Tariff (FIT) program and Renewable Energy Standard Offer Program (RESOP) have attracted significant private sector investment in solar PV facilities by guaranteeing a fixed payment for each kWh of electricity these facilities produce.

- By 2018, Ontario's solar PV market is expected to drive \$12.9 billion of total private investment
- Between \$4.1 - \$7.9 billion of total private investment will be spent in Ontario



Job Creation

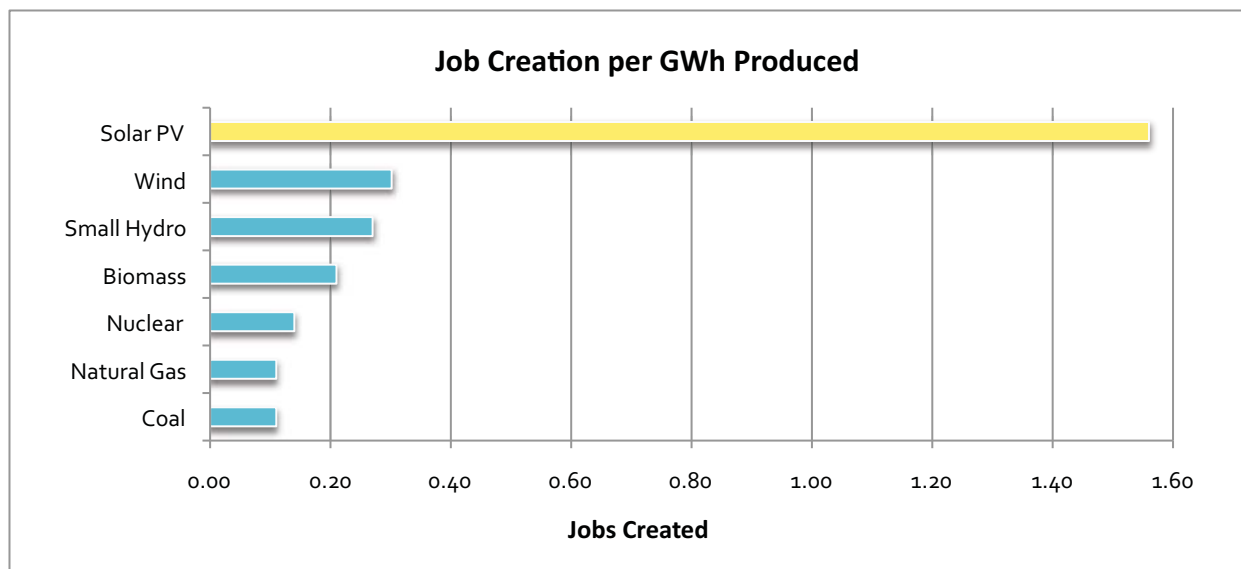
In comparison to large centralized electricity generation facilities, a larger portion of every dollar spent on solar PV goes towards labour. Primarily, the solar PV industry creates jobs in operations and maintenance, construction labour, warehousing and distribution, and manufacturing.

Ontario's solar PV industry is set to drive significant job creation in the province.

- In 2011, the province's solar PV industry will provide the equivalent of 8,200 full-time jobs² in Ontario
- In 2012, that number will grow to over 11,400 full-time jobs
- By 2018, Ontario's solar PV industry is expected to have created over 74,000 jobs
- Solar PV will result in an average of approximately 25 jobs in Ontario per installed MW³

² Jobs are measured in Person-Years of Employment (PYE). One PYE equals 40 hours of employment a week for a period of 52 weeks.

³ This number includes all direct and indirect jobs that will result from the Ontario PV market between 2008-2018

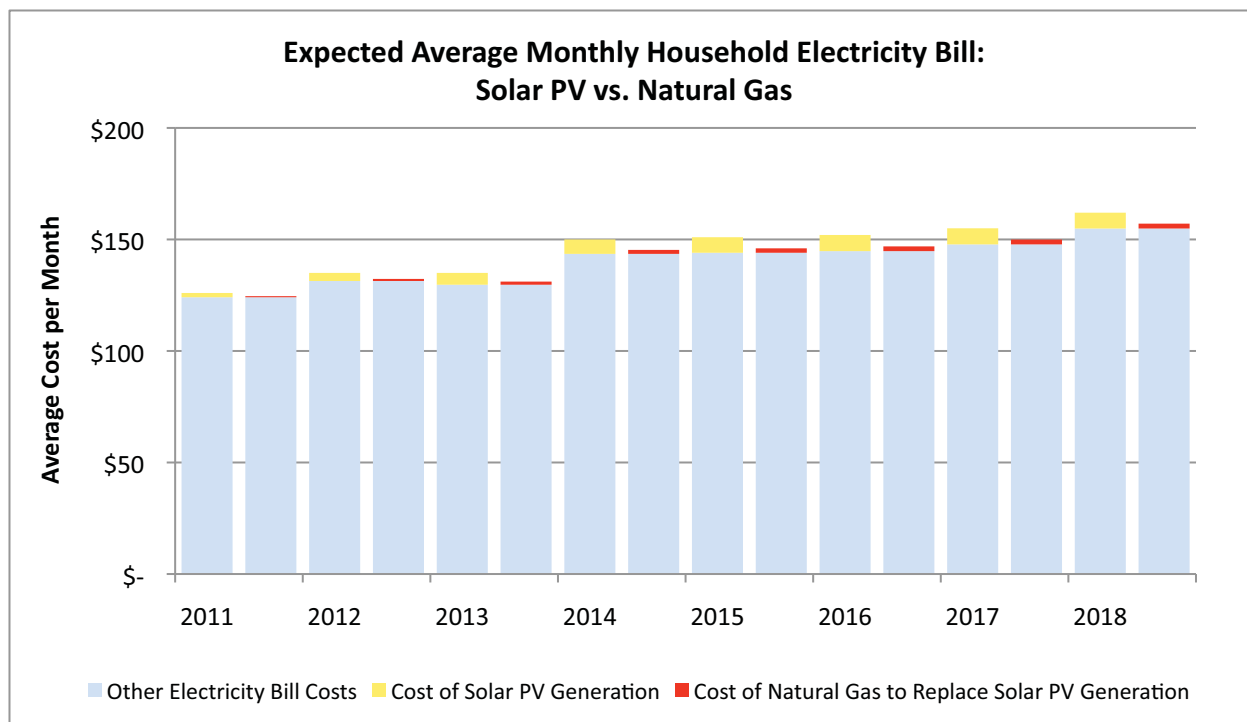


- Per unit of electricity generation, solar PV creates 11 times more jobs than natural gas or coal
- Per dollar spent on electricity generation, solar PV creates 4.8-5.3 times more jobs than natural gas or coal

Cost to Electricity Customers

Over the coming years, electricity customers in Ontario will face increased costs for a number of reasons. A small percentage of these cost increases will be due to solar PV.

- It is expected that, from 2011-2018, solar PV will add 70 cents per year to the average Ontario electricity customer's average monthly bill, compared with likely alternatives
- By 2018, the cost of adding solar PV to the electricity supply will amount to \$4.91 per month for the average Ontario electricity customer, or 3% of their monthly electricity bill



Methodology

Primary data for this research was collected through interviews and surveys with a wide range of solar PV industry stakeholders. In total, ClearSky Advisors conducted over 150 in-depth interviews and completed nearly 100 surveys. Overall, we interviewed:

- large and small project developers, representing 87% of the MW volume of executed FIT contracts
- module manufacturers that represent 89% of expected module production capacity in Ontario
- inverter manufacturers that represent 85% of expected inverter production capacity in Ontario

Extensive secondary research was also undertaken to support our findings.

Forecasts for investment, job creation and electricity customer impact were generated through a ClearSky Advisors model that incorporates established and recognized 3rd party tools (e.g. Jobs and Economic Development Impact Model- PV1.10.03) with in-house modelling. Wherever possible, inputs were taken from official and trusted 3rd party sources such as: OPA, Ministry of Energy, peer reviewed journals, etc.

Note: For more information on our approach, please see Appendix A

1. Introduction

Background

The technologies and applications used to generate our electricity have a range of impacts. They affect our economy, our health, our environment, and our local innovation. For example, investment in coal creates cheap electricity but has expensive health and environmental impacts. On the other hand, investment in solar PV creates premium priced electricity but also supports a high level of local spending, job creation, and innovation. A different balance between costs and benefits exists for each type of power generation.

The question of what value can be expected from various investments in electricity infrastructure should be of particular interest to Ontarians. In order to meet electricity demand in 2030, Ontario will need to build or refurbish 70%⁴ of its electricity supply mix. As such, Ontarians and their government have big decisions to make about what kind of generation they wish to support in the province.

This report has been commissioned by the Canadian Solar Industries Association (CanSIA) to analyse some of the economic outcomes of increasing the proportion of solar photovoltaic (PV) generation in Ontario's electricity supply mix. Specifically, for the period of 2011-2018, CanSIA asked us to quantify:

- (1) total investment and local spending
- (2) job creation in Ontario
- (3) electricity customer impacts.

The Long-Term Energy Plan

Ontario released a proposal for an updated Long-Term Energy Plan (LTEP) in the fall of 2010. In February, 2011 the Ministry of Energy issued a Supply Mix Directive based on the plan which took the LTEP one step closer to implementation. These documents chart a path for Ontario's future electricity supply mix (from 2010-2030)⁵.

The LTEP and Supply Mix Directive have both set a target of 10,700 MW of renewable generation, excluding hydroelectric, by 2018. Similarly, the LTEP has called for 1.5% of total generation in Ontario to come from solar PV by 2030. ClearSky Advisors expects that meeting both of these targets will require approximately 3,000 MW dc of solar PV to be installed in Ontario by 2018.

Scenarios

The analysis in this report has been conducted using three market scenarios for the period of 2011-2018. A high level description of our market forecast may be found in Appendix B.

⁴ Ontario Power Authority. (2011). *Integrated Power System Plan (IPSP) Planning and Consultation Overview*. OPA; Ontario Ministry of Energy. (2010). *Ontario's Long-Term Energy Plan: Building our Clean Energy Future*. Government of Ontario

⁵ For a cost analysis of the LTEP and the role of solar PV role within the LTEP please see Appendix C "Cost of the Long-Term Energy Plan"

- Our high case scenario anticipates 3,800 MW dc of installed solar PV by 2018
 - This could occur if solar PV were to make up a larger than expected share of the 10,700 MW of renewables targeted in the LTEP or if Ontario's overall target for renewables were to increase compared to the current LTEP
- Our expected case scenario anticipates 3,000 MW dc of solar installed by 2018
 - This would occur based on the LTEP's targets for generation from solar PV (i.e. 10,700 MW of renewables by 2018 and 1.5% of total electricity generation by 2030)
- Our low case scenario anticipates 2,000 MW dc of solar installed by 2018
 - This could occur if solar PV were to make up a smaller than expected share of the 10,700 MW of renewables targeted in the LTEP or if Ontario's overall target for renewables were to decrease compared to the current LTEP

Note: The modelling of these scenarios includes many variables. The statements above demonstrate only a high level conceptualization of each scenario. For more details see Appendix A.

Throughout this report, where only one set of outcomes is presented (i.e. for job creation and electricity customer impacts) the findings are based on our expected case scenario which, in turn, is based on LTEP targets.

For the sake of clarity:

- **unless explicitly attributed to another scenario, all of the results in this report are based on 3,000 MW dc of installed and operating solar PV in Ontario by 2018.**

Electricity Costs

Another key assumption running through this report is that the cost of generation from solar PV should be compared to the cost of generation from new natural gas. This assumption is central to our analysis of the cost impacts of solar PV on electricity customers in Ontario.

Why are we comparing solar PV to natural gas?

Solar PV is essentially a form of peaking power. In other words, it supplies electricity when demand is highest (i.e. during the day when the sun is shining). Traditionally in Ontario either coal or natural gas are used to meet peak electricity demand. This report considers the costs of both of these forms of electricity generation; however, since Ontario has elected to phase out coal-fired generation, we considered natural gas the primary alternative to solar PV.

Why are we using the cost of new electricity generation as the basis for comparison?

By 2030, almost 70% of required electricity generation will need to come from new or refurbished electricity generating facilities. Solar PV will be a part of the new generation required to serve electricity demand in the province. As such, the cost of solar PV is most accurately compared with the cost of other new generation.

2. Investment

Largely, investment in Ontario's solar PV market is driven by two provincial government programs. The first is the Renewable Energy Standard Offer Program (RESOP), which is no longer offering new contracts for solar PV generation. The second is Ontario's Feed-in Tariff (FIT) program, which replaced RESOP in offering contracts for solar PV generation.

Both the RESOP and FIT programs provide fixed tariff rates to independent power producers for renewable energy generation. Independent power producers may include both individuals and private companies who have received contracts through the FIT and/or RESOP program and will receive a set payment for every unit of electricity that their solar PV facility generates. In short, it is private investors who invest in Ontario's solar PV market and electricity customers who pay for the electricity that solar PV generates.

This report deals with investment into Ontario's solar PV market in two ways.

- First, it presents cumulative total investment and cumulative spending in Ontario. Figures 1-3 tie total project investment to the year in which the project is connected. By presenting the data in this way, it is easy to visualise the impact of various market scenarios.
- Second, it presents total annual investment and annual spending in Ontario. Figures 4-5 separate investment into two phases and demonstrate how annual investments will change over time.

Construction Costs and O&M Costs

Investment in Ontario's solar PV market can be broken into the following categories: (1) the construction phase and (2) the Operations and Maintenance (O&M) phase.

The construction phase includes the one-time costs which are required to build an operational solar facility. Costs during the construction phase include:

- equipment such as solar PV modules, inverters, and mounting
- labour for installation
- permitting and engineering
- business overhead.

The O&M phase includes the ongoing costs which are required to maintain the performance of a solar facility. Costs during the O&M phase include:

- performance monitoring
- labour (for cleaning, replacing broken or worn-out system components, etc.)
- the replacement of equipment which is not covered by warranties.

2.1 Total Investment

Total investment includes all costs associated with the construction and operation of solar PV facilities in Ontario. Total investment into Ontario's solar PV market will be determined by three factors: (1) the volume of solar PV installed, (2) the cost of those installations, and (3) ongoing O&M costs.

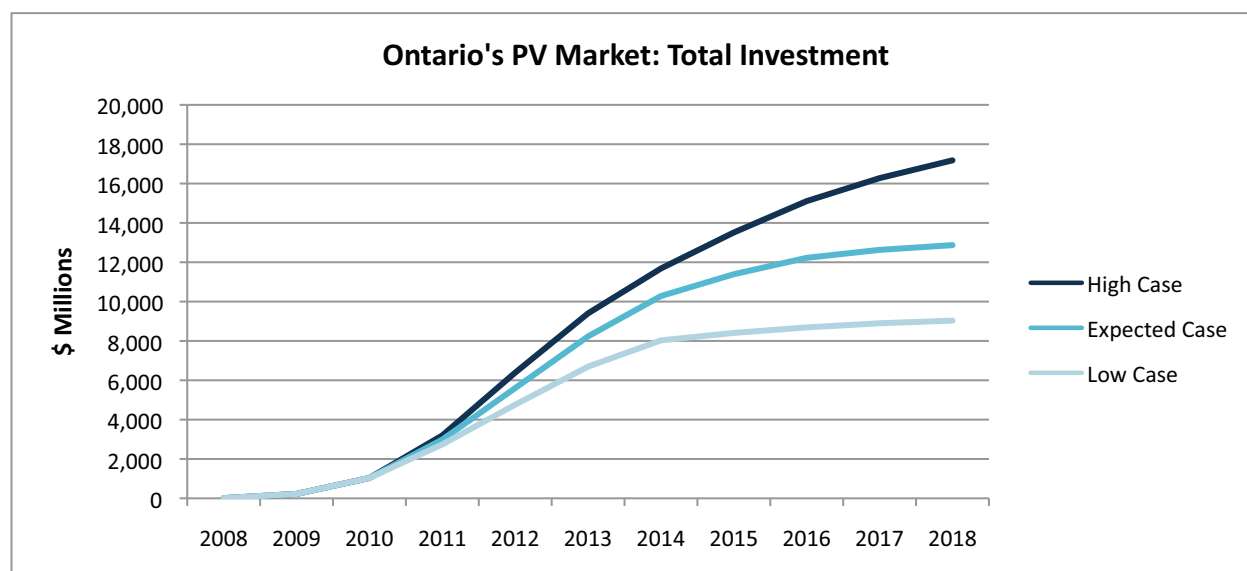


Figure 1 - Ontario's Solar PV Market: Total Investment

- By 2018, Ontario's solar PV market is expected to drive \$12.9 billion of total investment
- By reducing installed solar PV from approximately 3 GW (expected case scenario) to approximately 2 GW (low case scenario), total investment would be reduced by \$3.8 billion

2.2 Spending in Ontario

Spending in Ontario will be determined by two factors: (1) the amount of total investment in Ontario's solar PV market, and (2) the proportion of total investment that is spent locally (e.g. on Ontario-made equipment, local labour, local engineering services, etc.). The proportion of local spending will be primarily influenced by the type of project (e.g. residential, commercial rooftop etc.) and the level of manufacturing and service provision that occurs in Ontario.

Note: Ontario's FIT program requires that a certain percentage of solar project costs come from Ontario goods and labour or "Domestic Content". Solar PV FIT projects in Ontario are required to have either 40%, 50%, or 60% Domestic Content. Solar PV RESOP projects, on the other hand, do not have Domestic Content requirements.

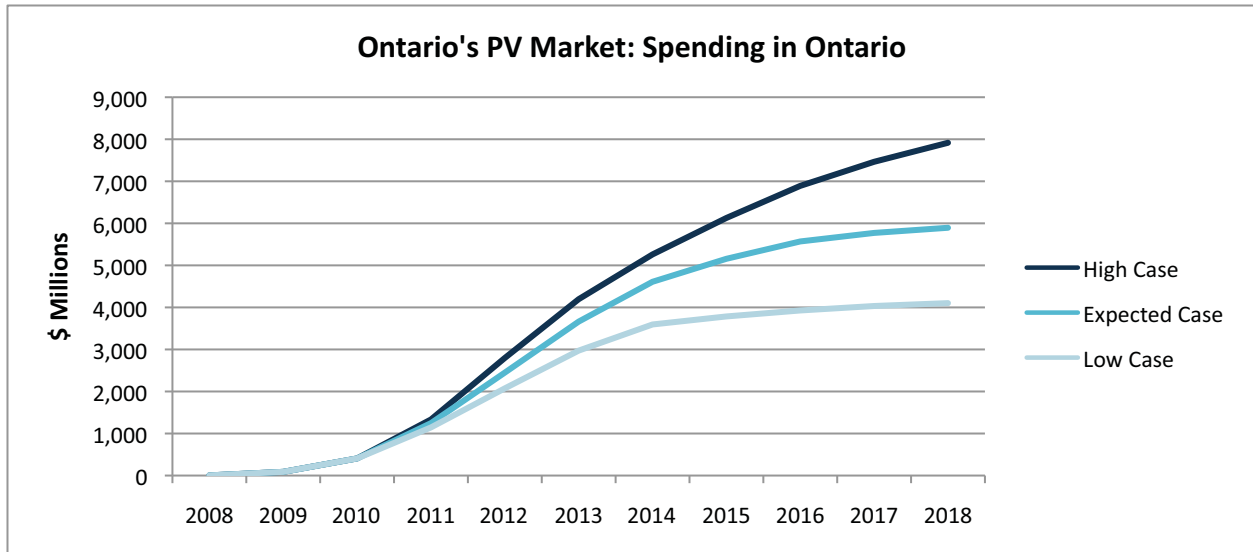


Figure 2 - Ontario's Solar PV Market: Spending in Ontario

- By 2018, Ontario's solar PV market will drive between \$4.1 – \$7.9 billion of spending in the province
- By reducing installed solar PV from approximately 3 GW (expected case scenario) to approximately 2 GW (low case scenario), spending in Ontario would be reduced by \$1.8 billion

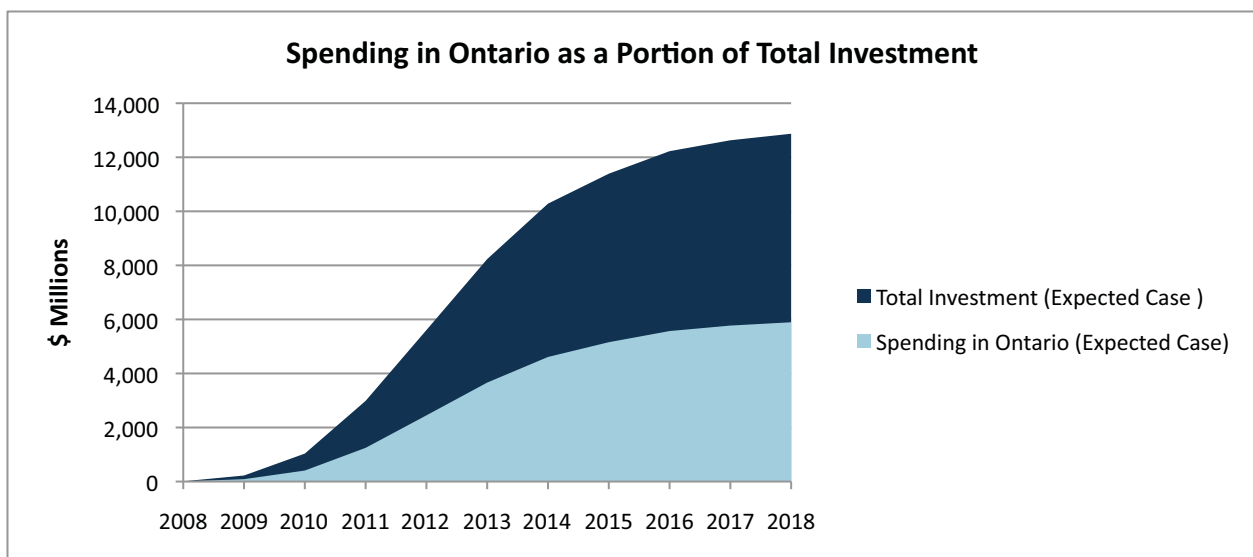


Figure 3 - Spending in Ontario as a Portion of Total Investment

- By 2018, spending in Ontario will account for 46%⁶ of total private investment in Ontario's solar PV market
- The percentage of total private investment which is spent in Ontario will increase over time
 - In part, this is due to Domestic Content requirements

⁶ This number is the weighted average of the amount of local spending that will occur across all solar PV installations in the province. It includes all RESOP program (which has no Domestic Content requirements), FIT program (which mandates 40%, 50%, or 60% Domestic Content), and other solar PV installations in the province.

2.3 Total Investment Over Time

Until now, we have presented investment in Ontario's solar PV market by linking it to the year in which projects are connected. That is not the way that investment in the sector actually occurs. In reality, in Ontario, investment begins long before a project is connected and continues throughout the project's life.

Moreover, the investment required per unit of installed capacity will decrease over time. The experience and expertise gained during early projects is expected to lead to lower costs through:

- a streamlined approval and permitting process
- efficiencies throughout the development process
- reduced equipment costs.

Figure 4 separates investment in the construction phase (one-time costs) from investment in the O&M phase (ongoing costs) and demonstrates how that investment will occur on an annual basis.

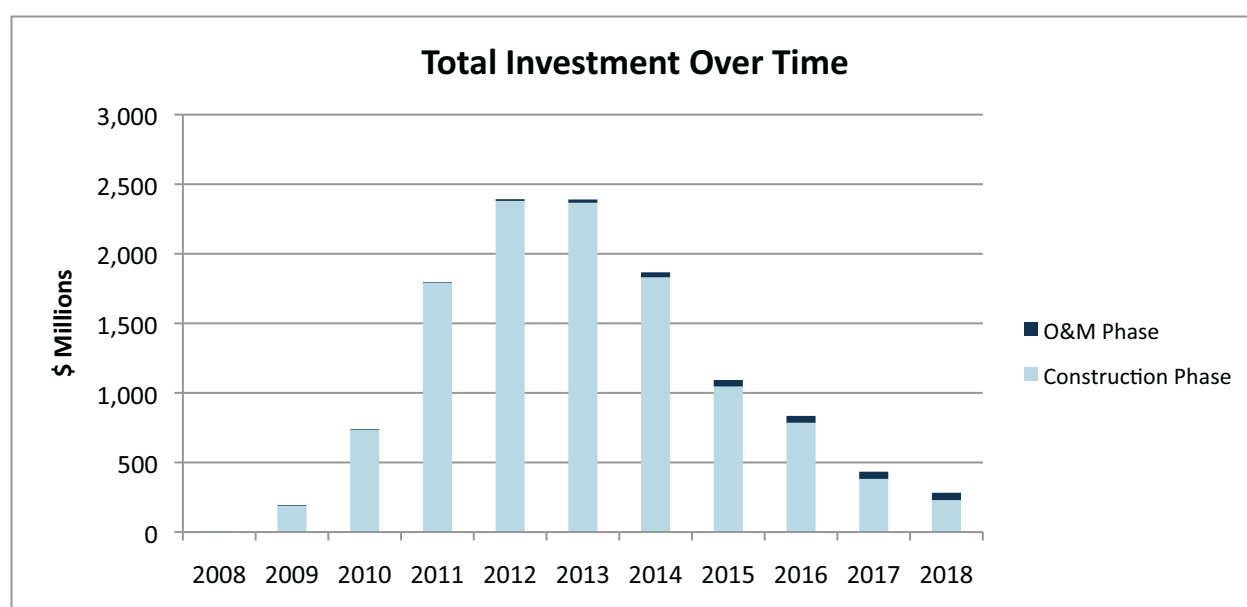


Figure 4 - Total Investment Over Time

- Total investment will peak in 2012-2013 at approximately \$2.4 billion
- Investment in construction of new projects will decrease from that time on
- After 2018, and lasting until at least 2030 (due to the duration of solar PV contracts), investment in O&M, which extends the life of projects, will remain quite constant at approximately \$53 million annually

Note: The investment figures above are based solely on Ontario solar PV installations between 2008-2018. They do not include additional investment due to the export of Ontario manufactured solar PV equipment or to Ontario solar PV projects beyond 2018. As such, total investment is likely to be higher than what is shown here.

2.4 Spending in Ontario Over Time

Figure 5 demonstrates the amount of total investment in Ontario's solar PV market that will be spent in the province on an annual basis.

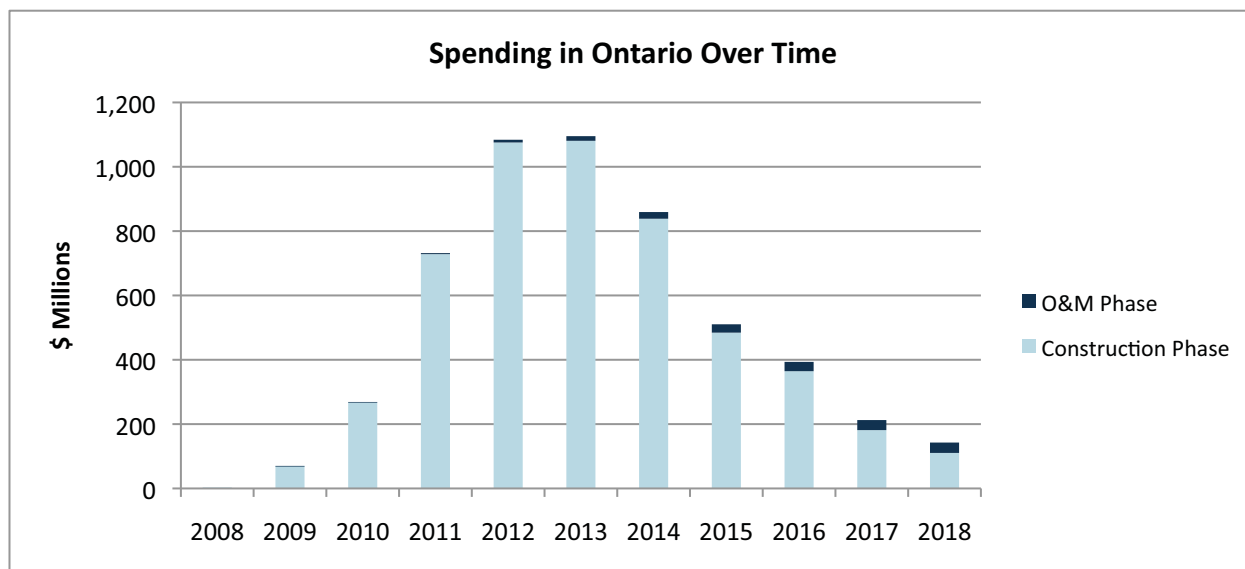


Figure 5 - Spending in Ontario Over Time

- Spending in Ontario will peak in 2013 at approximately \$1.1 billion
- Spending on construction of new projects will decrease from that point on
- After 2018, and lasting until at least 2030 (due to the duration of solar PV contracts), spending on O&M in Ontario will remain quite constant at \$33 million annually

2.5 Spending in Ontario with Ongoing Manufacturing Exports

All of the investment and spending numbers above are tied directly to solar PV installations in Ontario (i.e. the Ontario solar PV market) from 2008-2018. If Ontario-based manufacturing, project development, or services are used outside of the province (as is already occurring and is likely to increase), spending in Ontario will exceed the figures presented above.

For example, ongoing solar PV manufacturing in Ontario could have a substantial impact on local spending. Figure 6 demonstrates the impact on local spending if Ontario-based module manufacturers were able to sustain the peak level of sales required to meet Ontario demand (i.e. \$ of module sales in 2013) from 2013 onwards (i.e. from 2013 – 2030).

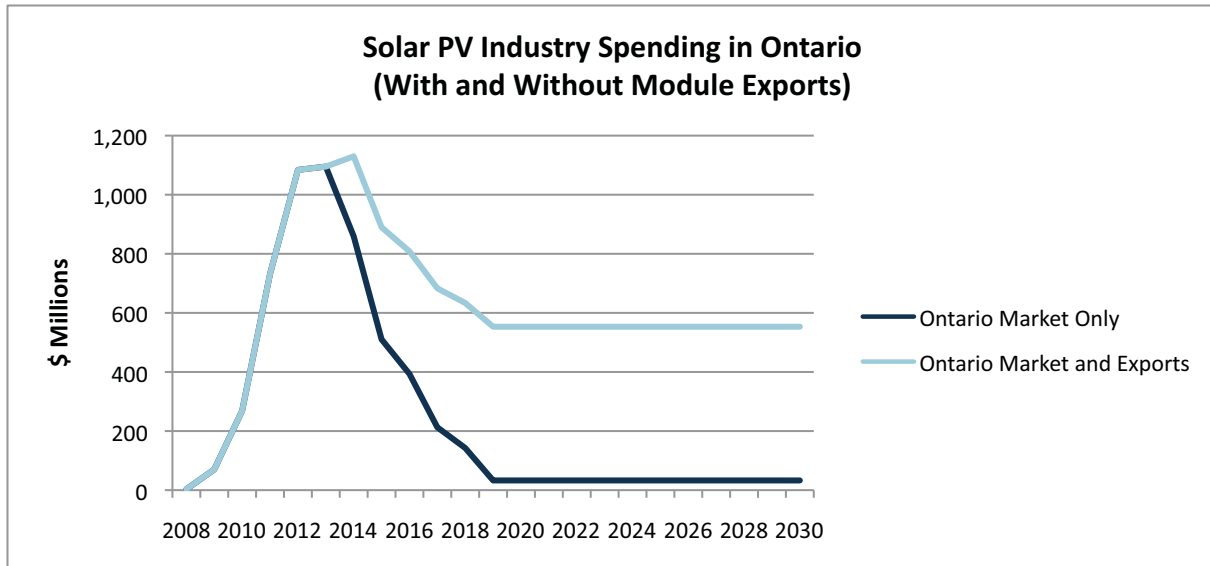


Figure 6 – Solar PV Industry Spending in Ontario (With and Without Module Exports)

- Given the level of manufacturing exports described above, local spending would increase from \$5.8 billion to over \$14 billion
- By 2019, local spending would stabilize at about \$550 million annually
- If other Ontario-based manufacturing (i.e. inverters and racking) and services (i.e. engineering) for the PV industry were also to continue serving markets outside Ontario, ongoing spending in the province would be even higher

3. Job Creation

Solar PV is a strong driver of job creation. Over the life of a solar PV contract in Ontario, local jobs are created primarily in the operations and maintenance, construction labour, warehousing and distribution, and manufacturing sectors.

Of all Ontario's electricity generating options, solar PV creates the most employment opportunities per unit of electricity produced and does so at the lowest cost per job. This fact, as demonstrated by the numbers below, helps to explain why the province of Ontario and other governments from around the world are including solar PV as part of their electricity supply mix.

Note: All jobs cited in this report represent one person-year of employment. As the name suggests, person-years of employment (PYE) represent one year's worth of employment for one individual (i.e. 40 hours per week for 52 weeks).

3.1 Solar PV Job Creation vs. Job Creation from Other Forms of Power Generation

By installing 3,000 MW dc of solar PV in Ontario, the province will create many times more employment than would be created by installing an equivalent amount of generating capacity from other forms of electricity generation.

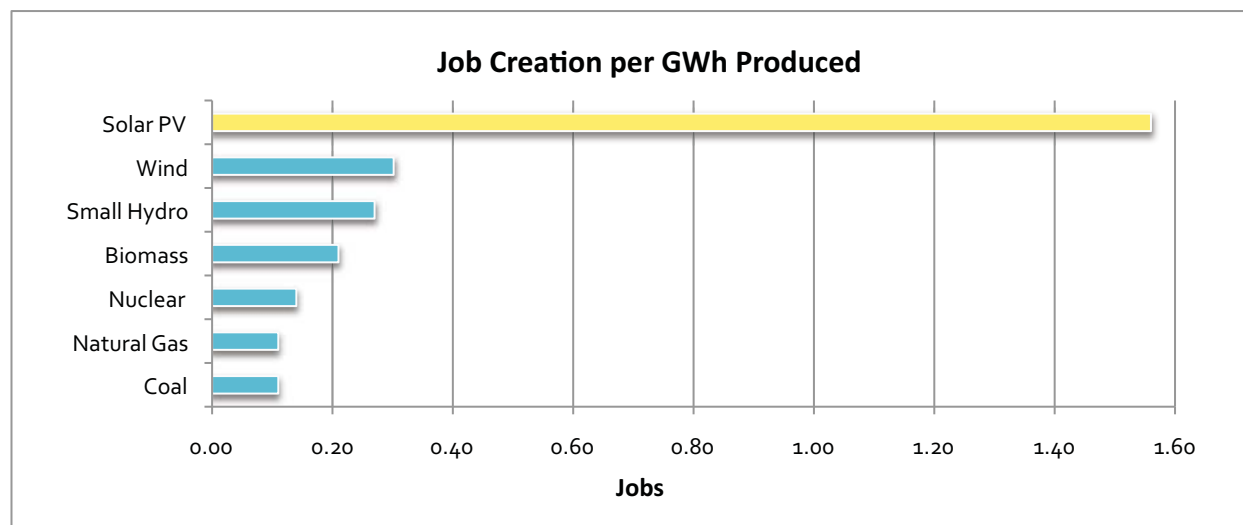


Figure 7 - Job Creation per GWh Produced

- Solar PV in Ontario⁷ creates more jobs per unit of electricity produced than traditional forms of electricity generation in Ontario; 14 times more than coal, 14 times more than natural gas, and 11 times more than nuclear
- In general, renewable and green sources of electricity generation create more jobs per unit of electricity produced than nuclear and fossil fuel alternatives

⁷ Solar PV in Ontario is explicitly discussed because of the duration of local FIT and RESOP contracts and the amount of solar radiation in the province impact job creation per unit of energy produced

In addition to creating more jobs than other forms of electricity generation, solar PV also creates those jobs at a lower cost to Ontarians. Figure 8 presents the cost to Ontario electricity customers for each job created by various electricity generation technologies.

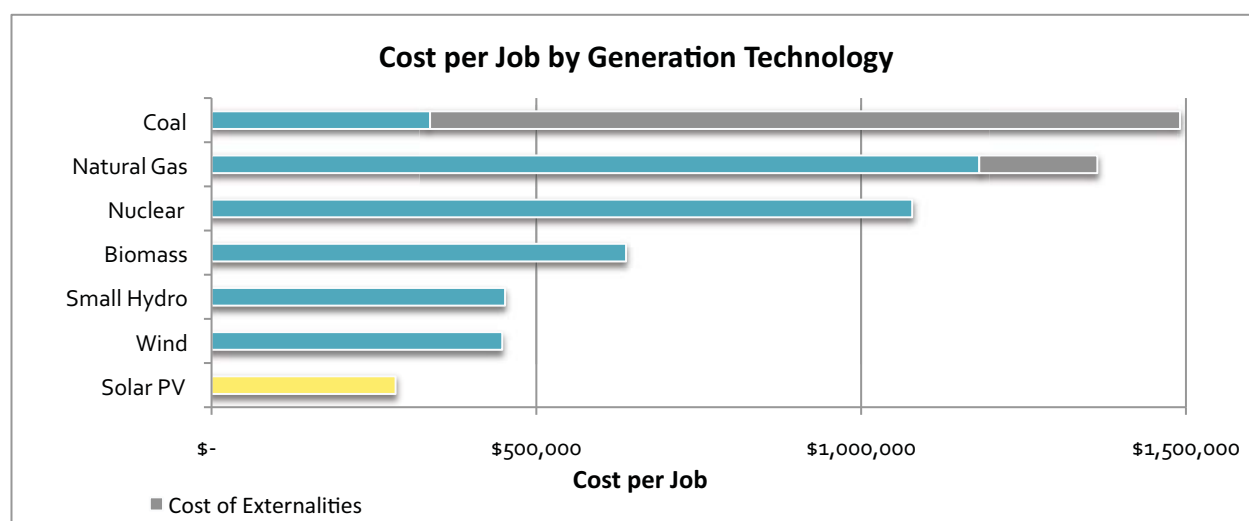


Figure 8 - Cost per Job Created by Technology

- For every dollar Ontarians spend on their electricity bills, more jobs can be created through solar PV generation than through other forms of electricity generation
- Excluding externalities, natural gas jobs cost 4.2 times as much as solar jobs while coal jobs are 1.2 times as costly
- When externalities are included, natural gas jobs are 4.8 times the cost of solar jobs and coal jobs are 5.3 times more expensive

Note: An externality is a cost that is a result of a financial transaction but that is not monetized within that transaction. For example, in the electricity sector, electricity from coal-fired generation is very inexpensive but it has expensive health and environmental impacts. When we pay for coal-fired generation we pay only for the electricity that we receive, not for the negative health and environmental impacts it causes. The costs of those impacts are called externalities and they are borne by parties external to the transaction.

3.2 Solar PV Job Creation in Ontario by Installation Year

Figure 9 demonstrates job creation linked to the year in which solar PV projects are connected to the electricity system. In other words, although not all jobs associated with a solar PV facility occur in the year the facility is connected, the graph displays them in that manner. It is a useful way to see the direct impact of annual installation volumes on job creation.

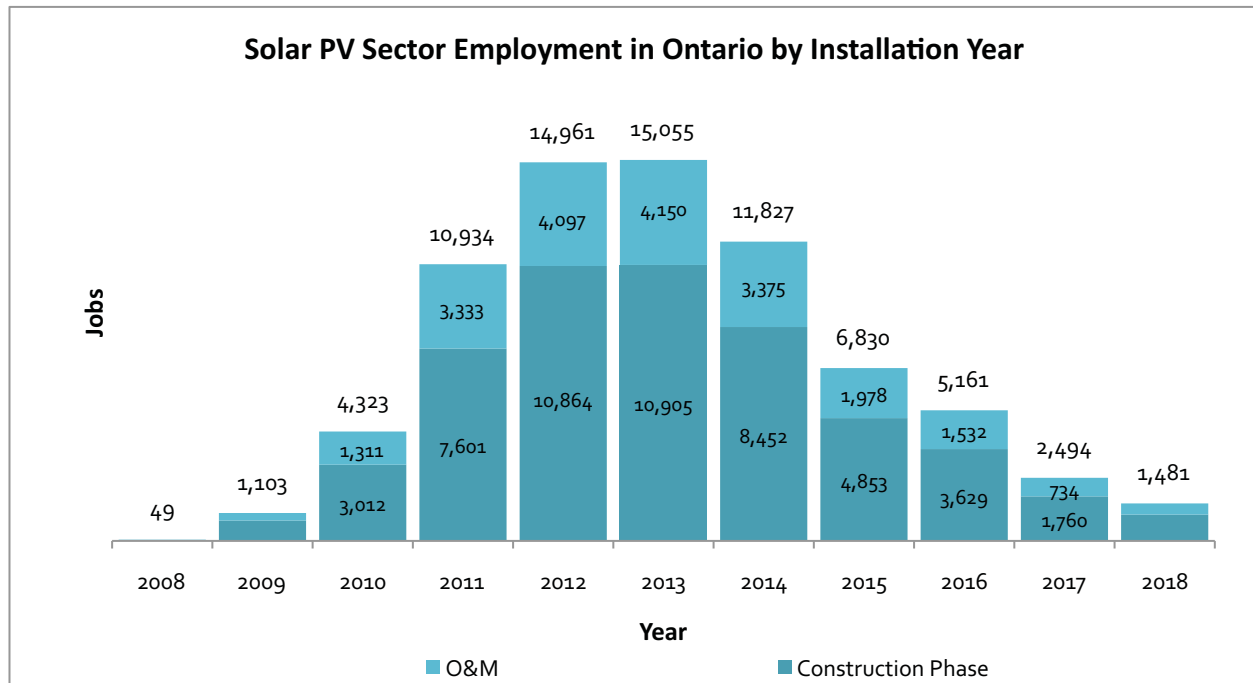


Figure 9 - Solar PV Sector Employment in Ontario

- In sum, installed solar PV capacity in Ontario from 2008-2018 is expected to create 74,217 jobs in the province
- Solar PV will create an average of approximately 25 jobs in Ontario per MW installed

Note: The job creation figures here are based solely on Ontario solar PV installations between 2008-2018. They do not include additional job creation due to the export of Ontario manufactured solar PV equipment or to Ontario solar PV projects after 2018. Total job creation is likely to be higher than what is shown here.

3.3 Solar PV Job Creation by Job Year

Figure 10 demonstrates job creation by the year in which employment is expected to occur. These numbers may be used as a proxy for the number of full-time employees in the solar PV industry in Ontario in any given year.

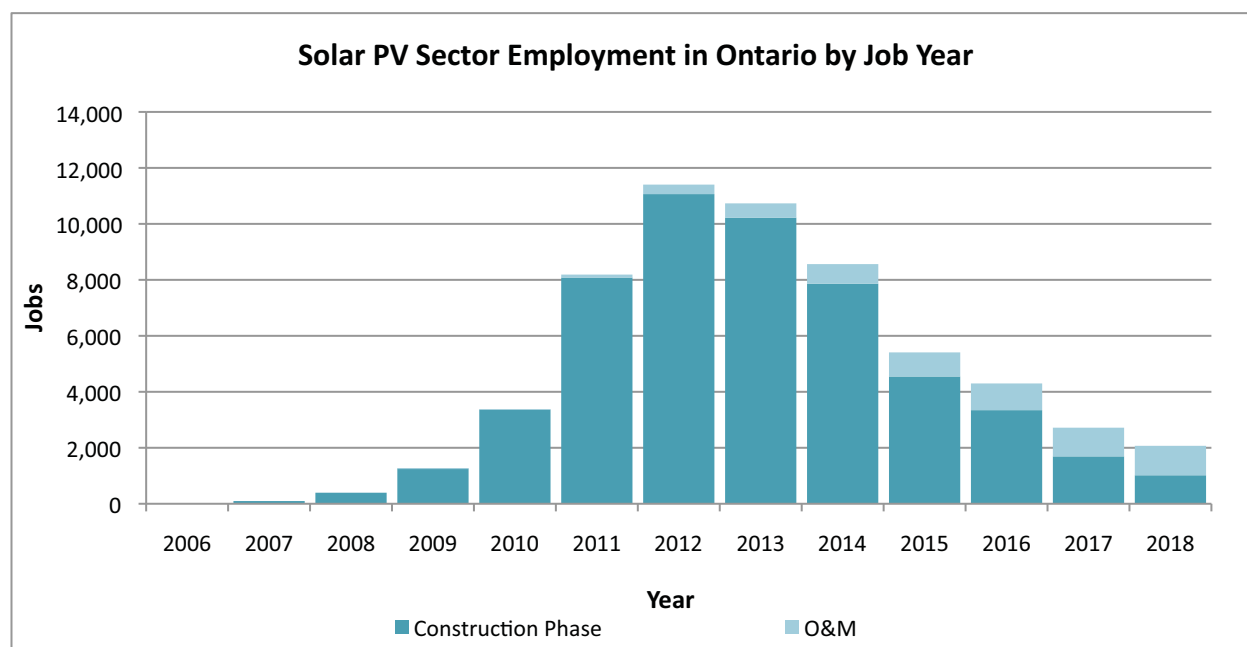


Figure 10 - Solar PV Sector Employment in Ontario by Job Year

- In 2011, the province's solar PV industry will provide the equivalent of 8,188 full-time jobs in Ontario
- In 2012, that number will grow to over 11,400 full-time jobs
- After 2018, approximately 1,100 ongoing, full-time jobs will be needed for the operation and maintenance of 3,000 MW dc of solar PV in Ontario

3.4 Solar PV Job Creation in Ontario with Ongoing Manufacturing Exports

The job creation numbers above are tied directly to solar PV installations in Ontario (i.e. the Ontario solar PV market) from 2008-2018. If Ontario-based manufacturing, project development, or services are used outside of the province, job creation in Ontario will exceed the figures presented above.

For example, ongoing solar PV manufacturing in Ontario could have a substantial impact on local job creation. Figure 11 demonstrates the impact on job creation if Ontario-based module manufacturers were able to sustain the peak level of sales required to meet Ontario demand (i.e. \$ of module sales in 2013) from 2013 onwards (i.e. from 2013 – 2030).

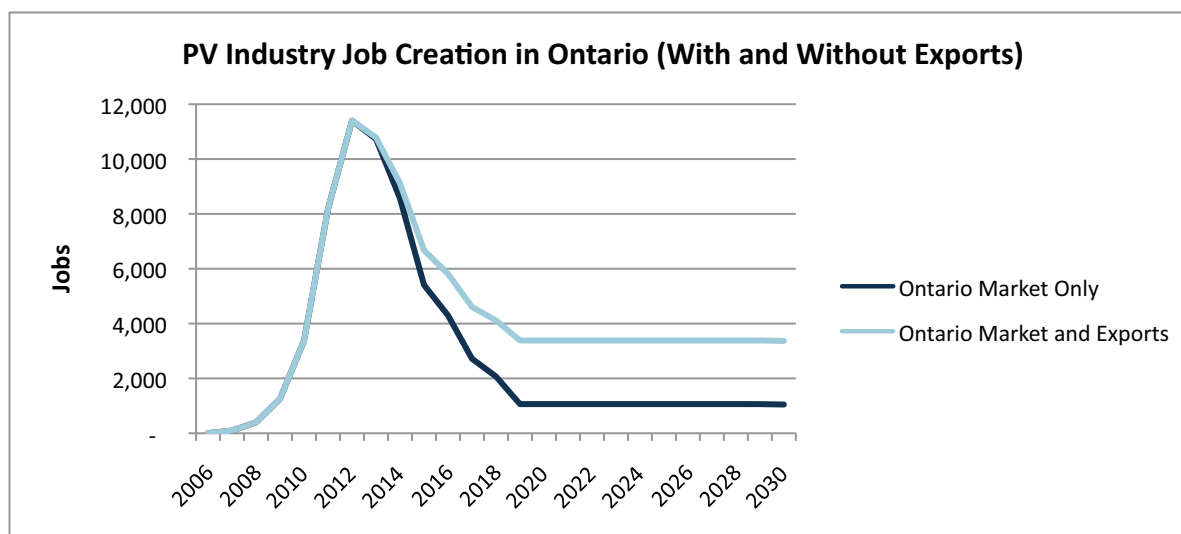


Figure 11 - Solar PV Sector Job Creation in Ontario (With and Without Exports)

- Given the level of manufacturing exports above, total employment in Ontario would increase from approximately 74,000 jobs to over 100,000 jobs
- After 2018, local employment in the solar PV industry would stabilize in the range of 3,400 jobs annually

3.5 Direct vs. Indirect Jobs

Job creation is normally classified into three categories: direct jobs (included), indirect jobs (included), and induced jobs (not included).

- Direct jobs are jobs that are created to immediately serve the actual supply chain; for example, these jobs include solar module manufacturing and project construction
- Indirect jobs are jobs that have been created to facilitate the development and maintenance of the supply chain; for example these jobs include renovations on manufacturing facilities and building the machines used to assemble solar modules
- Induced jobs are jobs that are created elsewhere in the economy as a result of spending from both direct and indirect workers and firms

Although induced jobs are real, they are difficult to quantify accurately. We have chosen to take a conservative approach to job forecasting and have included only direct and indirect jobs in this report.

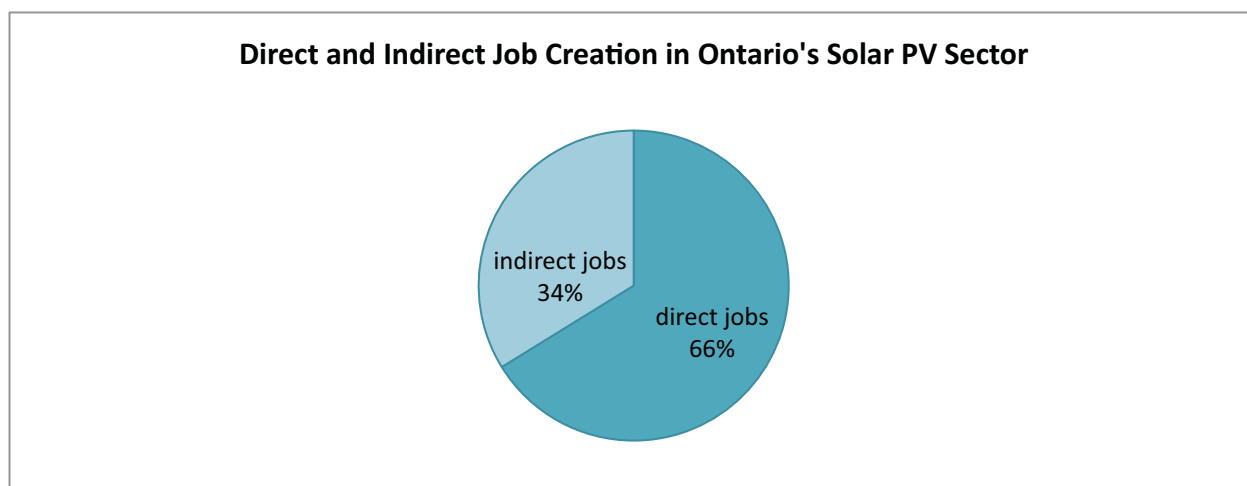


Figure 12 - Direct and Indirect Job Creation in Ontario's Solar PV Sector

Ontario's solar PV sector will create approximately:

- 49,000 direct jobs between 2008-2018
- 25,000 indirect jobs between 2008-2018.

3.6 Solar PV Employment by Type of Job

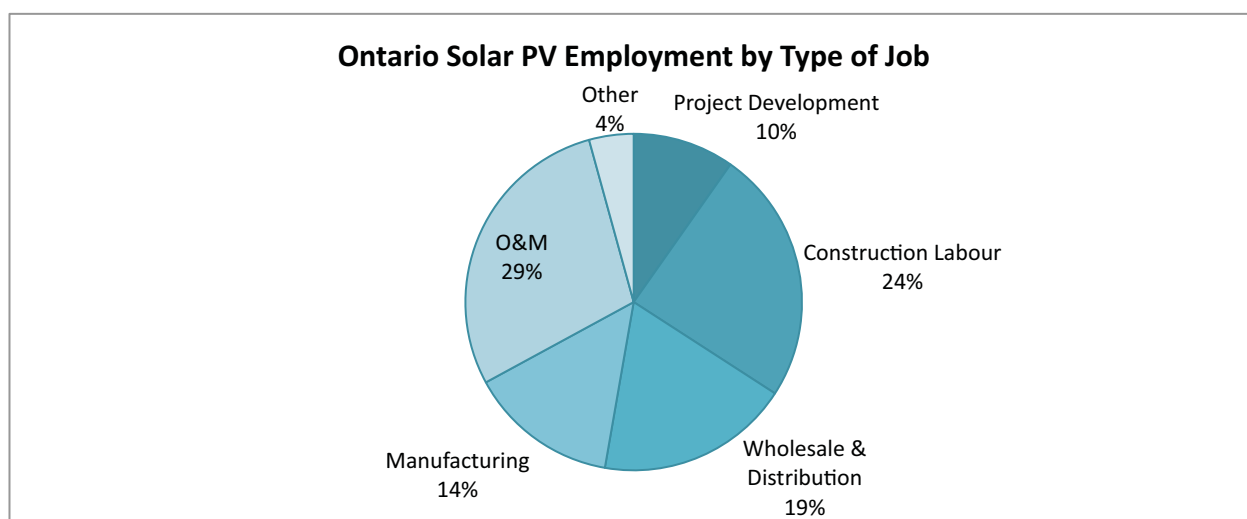


Figure 13 - Ontario Solar PV Employment by Type of Job

- Over the assumed 20-year life of solar facilities in Ontario, ongoing O&M jobs will account for nearly 30% of all job creation
- Manufacturing will account for a minimum of 14% of employment; this grows to 42% if we assume exports allow for continued manufacturing
- Construction labour will account for 24% of expected employment

4. Electricity Customer Impacts

By 2030, 70% of Ontario's electricity demand will need to be met by new or refurbished sources of electricity generation. Our future supply mix will be arrived at through difficult decisions with important implications (i.e. cost of electricity, job creation, health impacts, innovation etc.). Ontario electricity customers will pay for our new electricity supply mostly through their electricity bills, but also through their taxes and through damages to their environment. As such, it is important to have a fact-based discussion about the relative costs and benefits of various forms of electricity generation; to consider what electricity supply mix will give electricity customers in the province the best value for their money.

To accurately gauge the cost of installing solar PV in the province, it is most useful to consider the marginal cost of that electricity generation.

Note: The marginal cost of solar PV is the cost for generating electricity from solar PV that is over and above the cost of generating the equivalent amount of electricity from another form of electricity generation.

This measure is most useful because Ontario will need new generation facilities regardless of whether solar PV is installed or not. In other words, if solar PV is not installed in Ontario some other form of generation must be installed in its place. It is against the cost of that other generation that the cost of solar should be compared.

4.1 Comparing the Costs of Electricity

To understand exactly what the marginal cost is for solar PV in Ontario, we must have a clear picture of the prices for both solar PV and its alternatives. To properly compare costs, the following four questions must be answered.

1. What is the cost of solar PV in Ontario?

We project that the eight year (2011-2018) weighted average cost of all solar in Ontario will be 46.7 cents/kWh.

2. Should the cost of solar PV be compared against current electricity prices in Ontario?

Comparing the cost of solar to the cost of existing electricity generation facilities sets up a false choice for Ontarians. It suggests that we have the option of not investing in any new generation and can simply keep our existing facilities without further investments. In reality, many of Ontario's electricity generating facilities are nearing the end of their lives. Approximately 70% of Ontario's electricity generation will need to be built or refurbished by 2030.

As such, the cost of solar PV should be compared with the cost of electricity from new or refurbished electricity producing assets. The current low cost of electricity produced in Ontario is not a relevant benchmark for the cost of future generation.

3. Against which types of electricity generation should the cost of solar PV be compared?

While the costs and benefits of all sources of electricity generation should be considered for Ontario's future electricity supply mix, solar PV is essentially a form of peaking power generation. As such, the costs and benefits of solar PV can be best understood when compared with other forms of peaking power generation. Alternative sources of peaking power include natural gas, coal, and biomass.

Here, we compare solar PV with the province's traditional forms of peaking power: natural gas and coal.

4. Is cost per unit of generation a sufficient measure for the cost of electricity to Ontarians?

In short, the answer is no. Ontario has decided to phase-out coal fired generation because of the additional health and environmental costs that it imposes on Ontarians. Hundreds of premature deaths and over a thousand emergency room visits have been attributed to coal-fired generation on an annual basis⁸. Although these costs are not included in electricity bills, they are very real and are ultimately borne by Ontario taxpayers.

Figure 14 shows the cost per unit of generation for solar PV, natural gas, and coal including conservative assumptions for health and environmental externalities.

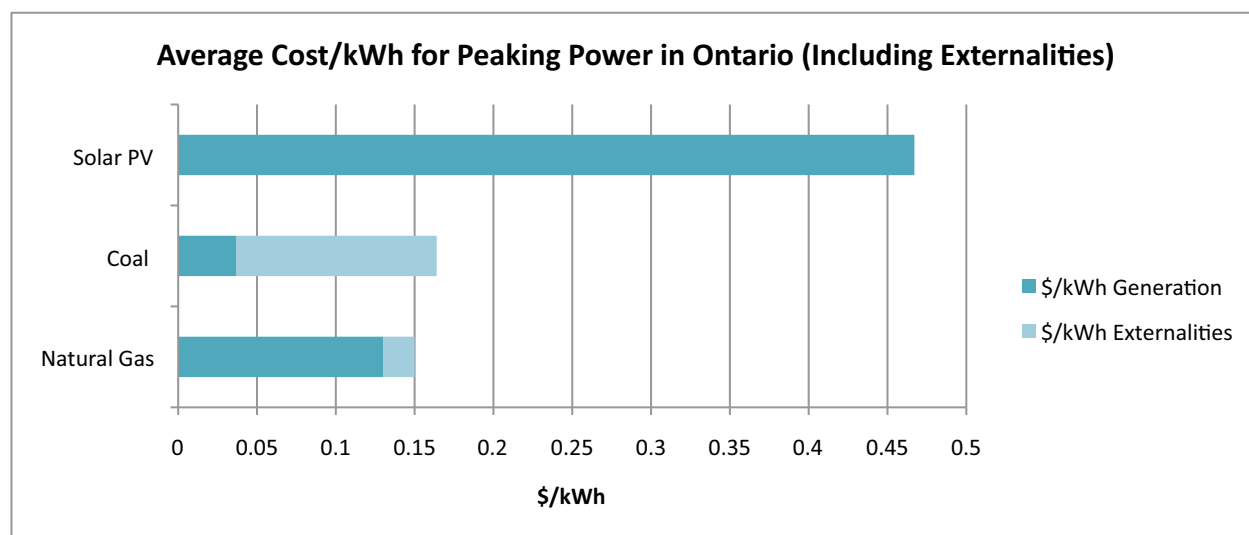


Figure 14 - Average Cost/kWh for Peaking Power in Ontario (Including Externalities)

- Including externalities, the marginal cost of solar PV relative to coal is 30 cents/kWh
- Including externalities, the marginal cost of solar PV relative to natural gas is 31.7 cents/kWh
- Solar PV is currently a more expensive form of electricity generation than are coal or natural gas

⁸ DSS Management Consultants Inc. (2005). *Cost Benefit Analysis: Replacing Ontario's Coal Fired Electricity Generation*. Toronto: Ontario Ministry of Energy.

It is most accurate to include the cost of externalities when comparing solar PV with fossil fuel generation. However, quantifying externalities can be challenging and including them in any analysis opens findings up to additional scrutiny. As such, the following analysis compares solar PV to natural gas and coal-fired generation both including conservative estimations of externalities (section 4.2) and excluding externalities altogether (section 4.3).

4.2 Impact on Ontario Electricity Customers Including Externalities

In order to put the marginal cost of solar PV in perspective, it is useful to think of its impact on the average Ontario electricity customer. Figure 15 compares the cost of solar PV with the costs of natural gas including externalities and coal including externalities.

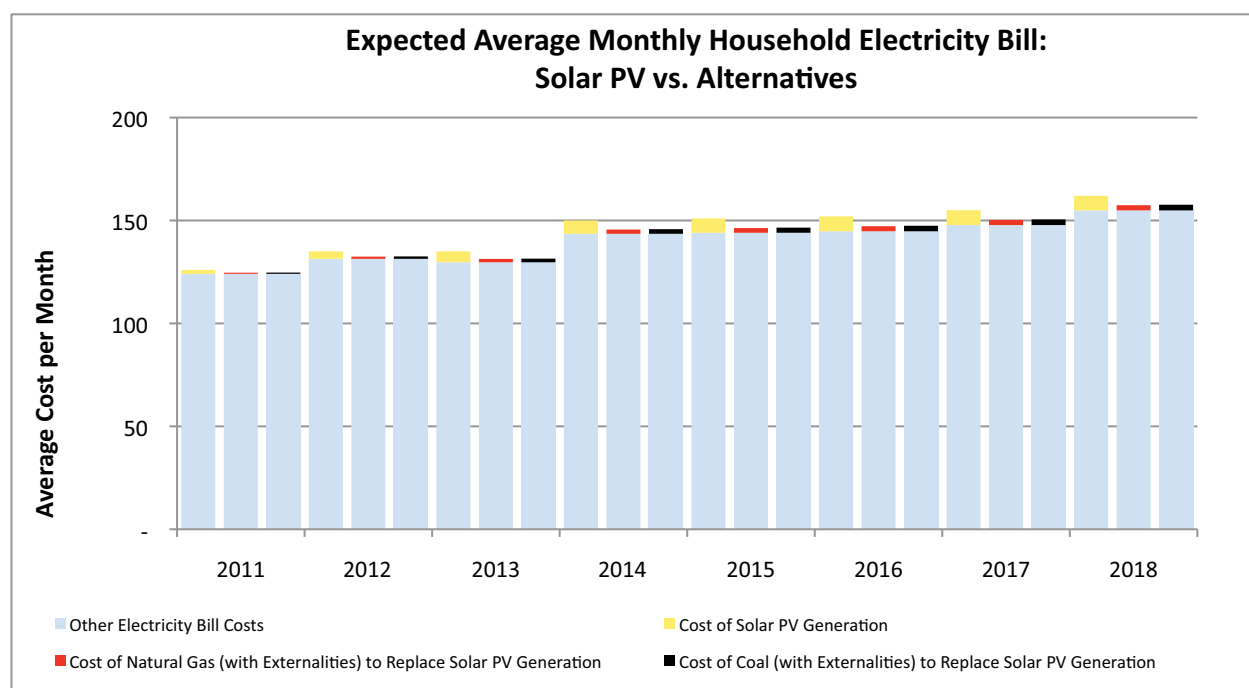


Figure 15 - Expected Average Monthly Household Electricity Bill: Solar PV vs. Alternatives

- In 2018, for the average Ontario electricity customer, the marginal cost of solar PV relative to natural gas will be \$4.58/month
 - In 2018, this will equal 2.8% of the average residential electricity bill in Ontario
- Using the same measure, the marginal cost of solar PV relative to coal will be \$4.34 or 2.7% of the average residential electricity bill in Ontario
- On average, by choosing to generate electricity from solar PV rather than natural gas, the average Ontario electricity customer's monthly bill will increase by \$0.65 annually between 2011-2018

4.3 Impact on Ontario Electricity Customers Excluding Externalities

To gauge the impact of solar PV on Ontario's economy, it is most accurate to include externalities in the cost of fossil fuels. However, this concept is somewhat complex. To provide clarity on the direct electricity customer impact of including solar PV in our electricity supply mix, we have compared the cost of solar PV with the costs of natural gas excluding externalities and coal excluding externalities.

When we exclude the external costs of fossil fuels, coal is clearly the least expensive option. However, Ontarians have already dismissed coal as part of our supply mix based on its heavy impact on health and the environment.

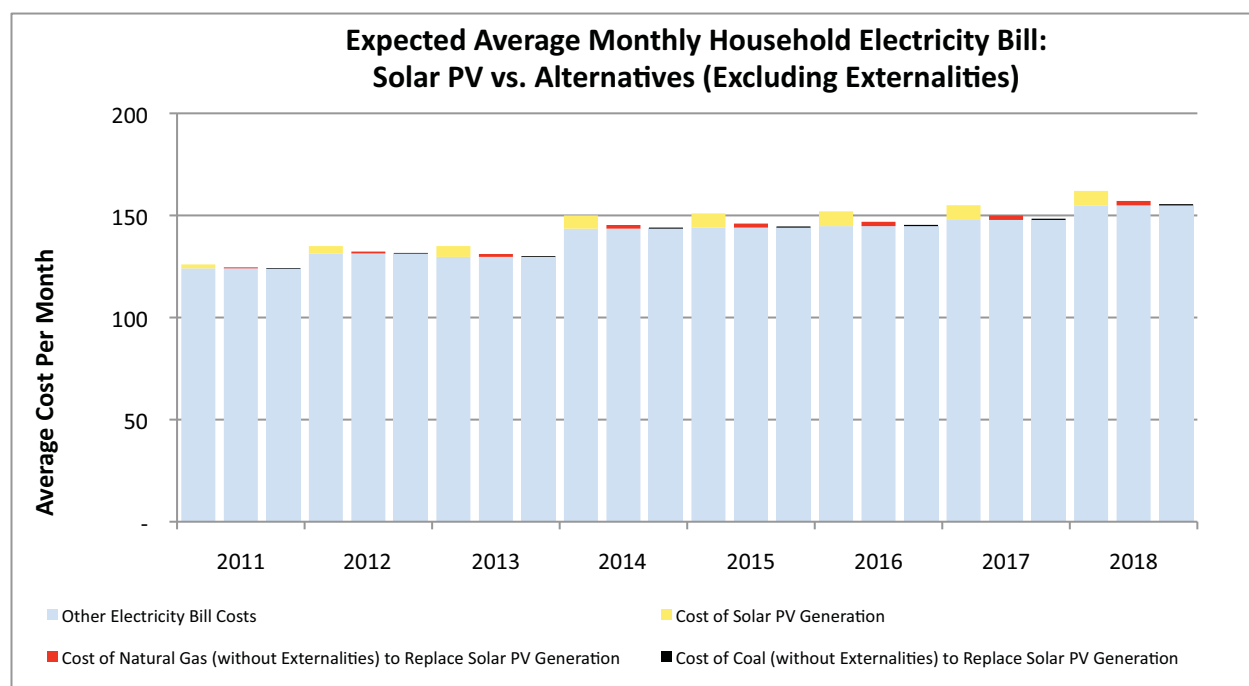


Figure 16 - Expected Average Monthly Household Electricity Bill: Solar PV vs. Alternatives (Excluding Externalities)

- In 2018, for the average Ontario electricity customer, the marginal cost of solar PV relative to natural gas will be \$4.91/month
 - In 2018, this will equal 3.0% of the average residential electricity bill in Ontario
- Using the same measure, the marginal cost of solar PV relative to coal will be \$6.47 or 4.0% of the average residential electricity bill in Ontario
- On average, by choosing to install solar PV rather than natural gas, the average Ontario electricity customer's monthly bill will increase by \$0.70 annually between 2011-2018

5. Cost Premium vs. Job Creation

There is a price to be paid for choosing solar PV over other forms of peaking power. The cost of generation from solar PV, between 2011-2018, will be greater than the cost of its alternatives. On the other hand, per dollar invested, solar PV creates many times more jobs than natural gas or coal.

Figure 17 displays the electricity generation and job creation returns from a \$1 million investment by electricity customers in either solar PV, natural gas, or coal⁹.

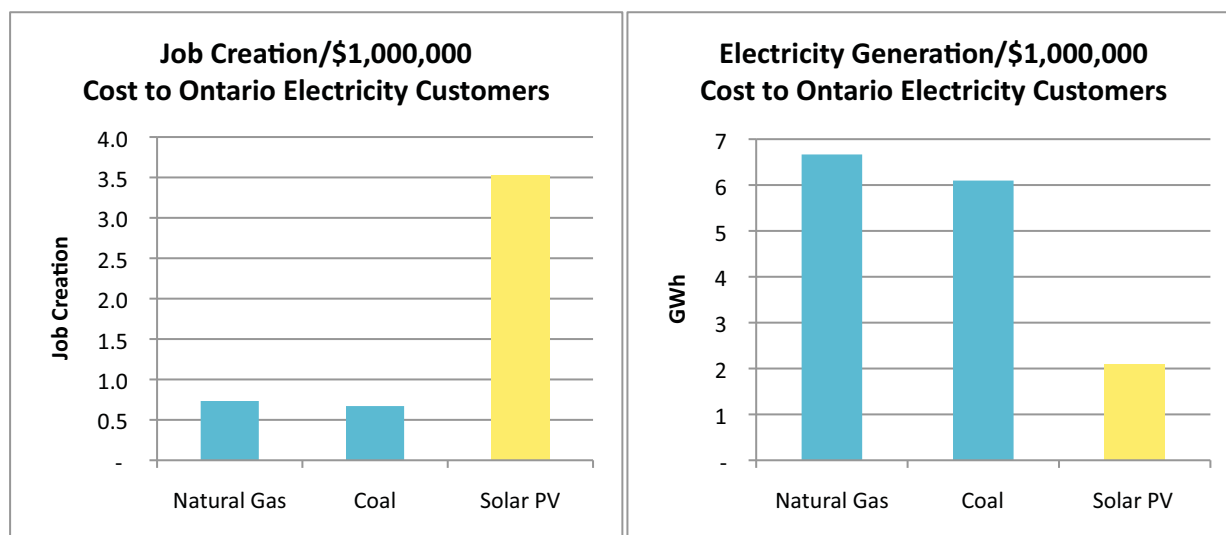


Figure 17 – Electricity Generation and Job Creation per \$1,000,000 Cost to Electricity Customers

- Solar PV will generate between 32% - 34% the electricity generated by natural gas or coal
- Solar PV will create between 4.8 – 5.3 times as many jobs as natural gas or coal

⁹ Fossil fuel externalities are included in these costs.

Glossary

Average Ontario Electricity Customer

Demand for electricity in the province can be separated into three segments: industrial demand, commercial demand, and residential demand. In this report, where the average Ontario electricity customer is referenced, we are referencing residential customers only. Based on figures presented in the LTEP the average residential electricity customer in Ontario consumes 800 kWh of electricity on a monthly basis¹⁰.

Direct Jobs

Direct jobs are jobs that are created to immediately serve the actual supply chain; for example, these jobs include module manufacturing and project construction.

Domestic Content

Ontario's Feed-in Tariff program has set levels of domestic content (for wind and solar projects) that must be adhered to in order to qualify for the program. Essentially, Domestic Content refers to goods and services that are necessary for the installation of an electricity generating facility and that are local to Ontario. For solar PV, levels of Domestic Content are either 40%, 50%, or 60%.

Externalities

An externality is a cost that is a result of a given transaction but that is not monetized within that transaction. For example, in the electricity sector, electricity from coal-fired generation is very inexpensive but it has expensive health and environmental impacts. When we pay for coal-fired generation we pay only for the electricity that we receive, not for the negative health and environmental impacts it causes. The costs of those impacts are called externalities and they are borne by parties external to the transaction.

Feed-in Tariff (FIT) Program

The program features stable prices under long-term contracts for electricity generated from renewable sources. The FIT program includes standardized rules and contracts for anyone interested in developing a qualifying renewable energy project. Prices are designed to cover project costs and allow for a reasonable return on investment over the contract term. Ontario's FIT program continues to accept applications and award contracts.

Indirect Jobs

Indirect jobs are jobs that have been created to facilitate the development and maintenance of the supply chain; for example these jobs include renovations on manufacturing facilities and building the machines used to assemble solar modules.

Induced Jobs

Induced jobs are jobs that are created elsewhere in the economy as a result of spending from both direct and indirect workers and firms.

¹⁰ Ontario Ministry of Energy. (2010). Ontario's Long-Term Energy Plan: Building our Clean Energy Future. Government of Ontario.

Long-Term Energy Plan (LTEP)

The Long-Term Energy Plan (LTEP) is a government document which charts the path for Ontario's energy future. The document was published by Ontario's Ministry of Energy in the fall of 2010.

The LTEP set a target of 10,700 MW of renewable generation, excluding hydroelectric, by 2018. Similarly, the LTEP has called for 1.5% of total generation in Ontario to come from solar PV by 2030.

Person-Years of Employment (PYE)

Person-Years of Employment are a common economic term used to measure job creation. One PYE is equal to one year of full time work (e.g. 40 hours of work per week for a period of 52 weeks).

Renewable Energy Standard Offer Program (RESOP)

Ontario's RESOP program was a method for procuring renewable energy featuring fixed payment rates for various types of renewable generation. The program is no longer accepting applications or awarding contracts.

Solar Photovoltaic (PV)

Solar PV is a form of electricity generation that converts solar radiation into direct current electricity.

Appendices

Appendix A - Methodology

Data Collection

Primary data for this research was collected through interviews and surveys with a wide range of industry stakeholders. Information was gathered between December, 2010 and June, 2011. In total, ClearSky Advisors conducted over 150 in-depth interviews and completed nearly 100 surveys. Overall, we interviewed:

- large and small project developers, representing 87% of the MW volume of executed FIT contracts;
- module manufacturers that represent 89% of expected module production capacity in Ontario; and
- inverter manufacturers that represent over 85% of expected inverter production capacity in Ontario,

Extensive secondary research was also undertaken to support our findings. This research was used to inform interviews, cross-check interview findings, compare Ontario with other markets, and generally to develop a deeper understanding of the economics of Ontario's solar PV sector. Notable examples of secondary sources include:

- publications by the Ontario Power Authority (OPA) including Ontario's Long-Term Energy Plan (LTEP), Integrated Power System Plan (IPSP) and quarterly updates
- peer-reviewed studies from academic sources and publications
- statements and plans by the Ministry of Energy, IESO, and OPG.

Our Approach

In order to analyse the economic impacts of solar PV in Ontario, a framework for projecting the future of the market is required. ClearSky Advisors regularly publishes market forecasts for the Ontario PV market and continuously acquires data from a broad and comprehensive group of stakeholders in Ontario's solar PV sector. To answer the questions CanSIA asked of us, it was necessary to extend our market forecast to 2018. To develop our market forecast, seven market segments and three market scenarios were analysed.

In addition to our market forecast, each question which CanSIA asked required a unique methodology. A high level summary of our approach to answering each question is included below.

- To forecast total investment, installation volumes were compared with installation costs and ongoing costs over time. This was done for each market segment in each scenario. Installation costs were forecast based on historic trends, market dynamics, interview data, and in-house analysis.
- Spending in Ontario was calculated by assigning a local spending multiplier to each market segment. This multiplier was arrived at by assigning local spending percentages to 10 different project cost components (i.e. modules, inverters, installation, etc.). Amounts for local spending were largely established through interviews and in-house analysis that we compared to industry practices outside of Ontario. In addition, inputs from a ClearSky Advisor's survey (completed by over 40 installers and developers active in the Ontario PV market) were used.
- Forecasts for job creation were generated through a ClearSky Advisors model that incorporates an established and recognized 3rd party tool (Jobs and Economic Development Impact Model-

PV1.10.01) with in-house modeling. Inputs for the model were taken from ClearSky Advisors' market modeling as well as trusted 3rd party sources (e.g.. economic multipliers specific to Ontario were obtained from Statistics Canada). These numbers were then cross-referenced against primary data acquired through interviews and our survey to verify accuracy.

- Levels of job creation by various generating technologies were taken from recent University of California, Berkeley research¹¹ that synthesizes data from 15 job studies. ClearSky Advisors adapted this research to reflect Ontario-specific conditions. For example, ClearSky Advisors adapted solar job creation to reflect solar insolation and the duration of solar PV generation contracts in Ontario.
- The cost of job creation was calculated by comparing job creation per unit of electricity with the cost per unit of electricity.
- Electricity customer impacts were calculated using trusted 3rd party sources combined with our analytical model. Our generation forecast is largely taken from Ontario's Long-Term Energy Plan (LTEP). With the exception of solar (for which price data has been taken from in-house forecasting), price information is taken from trusted sources such as: the Ontario Power Authority, Ontario's Ministry of Energy, and Moody's investment service. Cost data for fossil fuels include environmental and health externalities where they have been quantified by either peer reviewed publication or government data.

¹¹ Wei, M., Patadia, S., & Kammen, D. M. (2010). Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Create in the US? *Energy Policy* 38, 919-931.

Appendix B – Market Forecast

Many of the key findings presented in this report (i.e. investment, job creation, electricity customer impacts) are highly sensitive to the amount of solar PV that is to be installed in Ontario from 2011 - 2018. ClearSky Advisors regularly publishes in-depth market forecasts for the Ontario solar PV industry. While the detailed results of our market forecast are outside the scope of this report, we have included a brief, high level summary of our most recent market research in order to provide the reader with a framework for understanding how solar PV impacts Ontario's economy.

Historic Installations

Ontario is a young solar PV market that has experienced significant growth over the past three years.

- In 2008, 2 MW dc were installed in the province
- In 2009, 44 MW dc were installed in the province
- In 2010, 167 MW dc were installed in the province

Market Forecast 2011-2018

Looking ahead, there are a wide range of possible outcomes for Ontario's solar market. From 2011 – 2018, the rate of solar installation in Ontario will be impacted by a variety of factors. These include: political support, the cost of installing solar PV, future tariff rates for solar PV, transmission availability, the permitting process, and many other issues.

In order to capture the uncertainty that exists in the market, we have forecast high case, low case, and expected case scenarios. While the modelling of these scenarios includes many variables, each scenario is driven by a high level conceptualization of how the market will develop.

High Case Scenario

In the high case scenario, Ontario will install approximately 3,800 MW dc of solar PV by 2018.

The high case scenario is based on solar PV becoming a more significant part of the province's electricity mix than is currently targeted in the Long-Term Energy Plan (LTEP).

- This could occur if solar PV were to make up a larger than expected share of the 10,700 MW of renewables targeted in the LTEP or if Ontario's overall target for renewables were to increase compared to the current LTEP
 - The LTEP is to be updated every three years and the role for renewables may be increased based on market conditions
- Our high case scenario assumes a lower than expected attrition rate amongst existing contracts

Expected Case Scenario

In the expected case scenario, Ontario will install approximately 3,000 MW dc of solar PV by 2018.

The expected case scenario is based on meeting the LTEP's targets for generation from solar PV (i.e. 10,700 MW of renewables by 2018 and 1.5% of total electricity generation by 2030)

- This will require a reduced level of contract offers for solar PV generation compared to the current rate
- Our expected case scenario assumes a continuance of the FIT program
- It also assumes a moderate attrition rate amongst existing contracts

Low Case Scenario

In the low case scenario, Ontario will install approximately 2,000 MW dc of solar PV by 2018.

The low case scenario is based on solar PV becoming a less significant part of the province's electricity mix than is currently targeted in the Long-Term Energy Plan (LTEP).

- This could occur if solar PV were to make up a smaller than expected share of the 10,700 MW of renewables targeted in the LTEP or if Ontario's overall target for renewables were to decrease compared to the current LTEP
- Our low case scenario assumes a steeper than expected reduction to the rate of contract offers for solar PV generation
- It also assumes a higher than expected attrition rate amongst existing contracts

Appendix C - Cost of the Long-Term Energy Plan

Ontario's Long-Term Energy Plan charts a course for our electricity supply mix through 2030. The plan requires substantial investment in new and refurbished sources of electricity generation.

Proposed changes to Ontario's supply mix include:

- the refurbishment of aging generation assets (i.e. 10,000 MW of nuclear generation capacity)
- the construction of 2,000 MW of new nuclear generation capacity
- the installation of 10,700 MW of renewable energy generation
- the closing of all coal-fired power plants in the province
- an increased reliance on both hydroelectric power and natural gas for electricity.

All of these changes will have impacts on the cost of electricity in the Ontario.

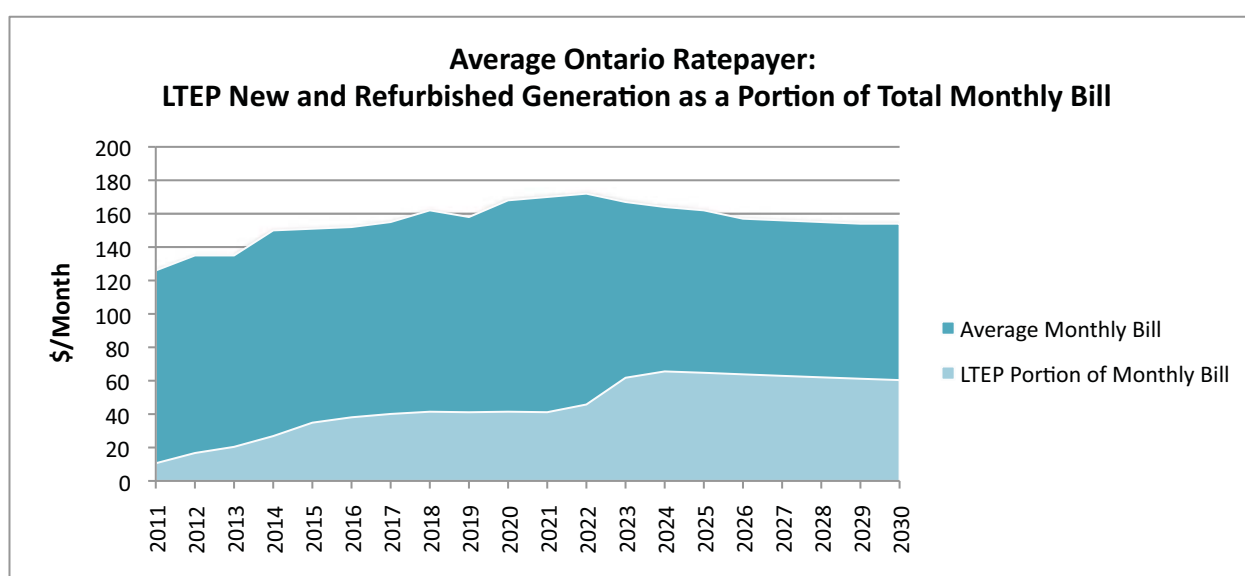


Figure 18 - Average Ontario Electricity Customer: LTEP New and Refurbished Generation as a Portion of Total Monthly Bill

- By 2018, LTEP targets for new and refurbished generation will cost the average Ontario electricity customer \$41.90 per month or 26% of their monthly electricity bill
- By 2030, LTEP targets for new and refurbished generation will cost the average Ontario electricity customer \$60.65 per month or 39% of their monthly electricity bill

Cost of Solar PV Within the Long-Term Energy Plan

Clearly, meeting LTEP targets for electricity generation by 2030 will require substantial investment. Largely, the costs of new and refurbished generation will be passed on to Ontario electricity customers. Solar PV will account for a relatively small portion of those costs.

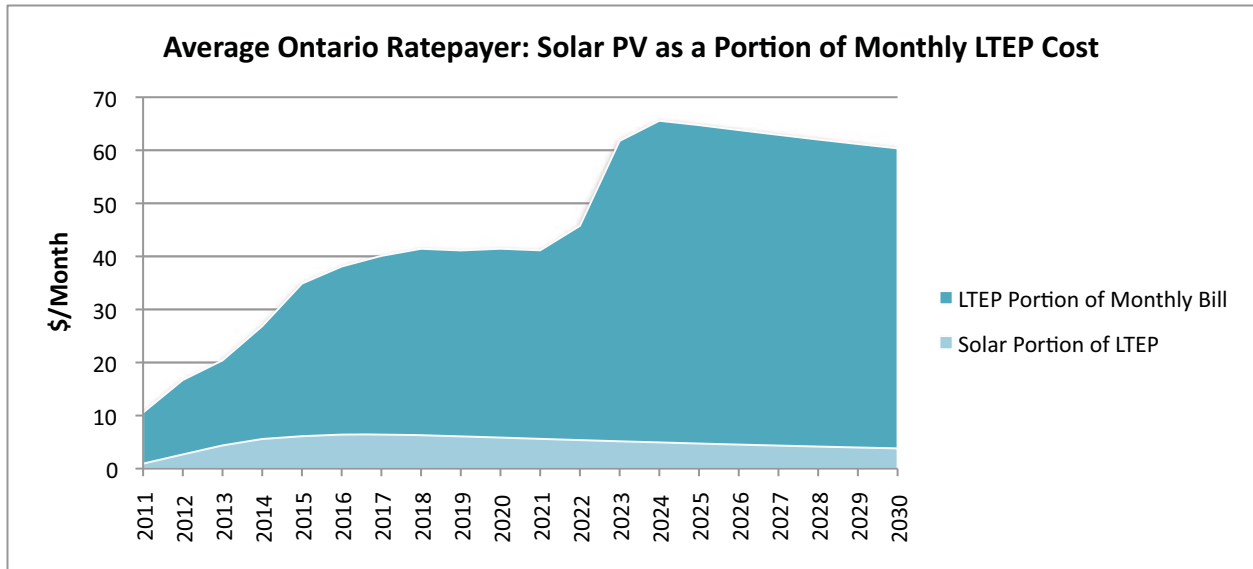


Figure 19 - Average Ontario Electricity Customer: Solar PV as a Portion of Monthly LTEP Cost

- Between 2011-2030, the average monthly cost of the LTEP to the average Ontario electricity customer is expected to be \$45.05
- Over that same period, the total average monthly cost of solar PV to the average Ontario electricity customer is expected to be \$4.87
- For the average Ontario electricity customer, solar PV is expected to account for 10.8% of the cost of the LTEP

Appendix D – Assumptions

Assumption	Value
Long-term target for generation from solar PV in Ontario	2.97 TWh by 2030 (Or 1.5% of Ontario's electricity supply ¹²)
Weighted average capacity factor in Ontario (relative to MW dc)	11.5%
Module performance degradation	1% annually
Expected installed capacity by 2018	Approximately 3,000 MW dc
Weighted average solar FIT tariff rate decrease	7% annually
Average annual inflation rate	2% ¹³
Average cost of solar PV generation 2011-2018	46.7 cents/kWh
Average cost of new natural gas generation (excluding externalities)	13 cents/kWh 2010-2030 ¹⁴
Externalities associated with natural gas	2 cents/kWh ¹⁵
Average cost of coal-fired generation	3.7 cents/kWh ¹⁶
Externalities associated with coal	12.7 cents/kWh ¹⁷
Local spending on construction phase of solar PV projects in Ontario	36%-48% of total investment depending on type of project (e.g. residential or commercial rooftop) and level of Domestic Content

¹² Ontario Ministry of Energy. (2010). *Ontario's Long-Term Energy Plan: Building our Clean Energy Future*. Government of Ontario.

¹³ Bank of Canada target

¹⁴ Ontario Power Authority. (2007). *Methodology and Assumptions for the Cost to Consumer Model*. http://www.powerauthority.on.ca/ipsp/Storage/53/4886_G-2-1_Att_1_corrected_071019.pdf; and Ontario Power Authority. (2008). *Integrated Power System Plan for the Period 2008-2027*. <http://www.powerauthority.on.ca/integrated-power-system-plan/g-plan-outcomes>.

¹⁵ DSS Management Consultants Inc. (2005). *Cost Benefit Analysis: Replacing Ontario's Coal Fired Electricity Generation*. Toronto: Ontario Ministry of Energy.

¹⁶ *ibid*

¹⁷ *ibid*

Local spending on O&M phase of solar PV projects in Ontario (Including labour and equipment)	69%-76% of total investment depending on type of investment
Average total solar PV installation cost decrease 2011-2018	6.4%
O&M spending	< 1% of capital costs annually (For all market segments: residential, commercial rooftop, etc.)
Conversion from MW ac to MW dc	115%
Increase to the average Ontario electricity customer's average monthly bill 2011-2030	\$28
New or refurbished generation by 2030 (Relative to 2011)	70% ¹⁹
Average monthly consumption of electricity by the average Ontario electricity customer	800 kWh ²⁰

¹⁹ Ontario Power Authority. (2011). *Integrated Power System Plan (IPSP) Planning and Consultation Overview*. OPA.; Ontario Ministry of Energy. (2010). *Ontario's Long-Term Energy Plan: Building our Clean Energy Future*. Government of Ontario.

²⁰ Ontario Ministry of Energy. (2010). *Ontario's Long-Term Energy Plan: Building our Clean Energy Future*. Government of Ontario.

Table of Figures

Figure 1 - Ontario's Solar PV Market: Total Investment.....	10
Figure 2 - Ontario's Solar PV Market: Spending in Ontario.....	11
Figure 3 - Spending in Ontario as Portion of Total Investment	11
Figure 4 - Total Investment Over Time	12
Figure 5 - Spending in Ontario Over Time.....	13
Figure 6 – Solar PV Industry Spending in Ontario (With and Without Module Exports)	14
Figure 7 - Job Creation per GWh Produced.....	15
Figure 8 - Cost per Job Created by Technology	16
Figure 9 - Solar PV Sector Employment in Ontario	17
Figure 10 - Solar PV Sector Employment in Ontario by Job Year	18
Figure 11 - Solar PV Sector Job Creation in Ontario (With and Without Exports)	19
Figure 12 - Direct and Indirect Job Creation in Ontario's Solar PV Sector	20
Figure 13 - Ontario Solar PV Employment by Type of Job	20
Figure 14 - Average Cost/kWh for Peaking Power in Ontario (Including Externalities).....	22
Figure 15 - Expected Average Monthly Household Electricity Bill: Solar PV vs. Alternatives	23
Figure 16 - Expected Average Monthly Household Electricity Bill: Solar PV vs. Alternatives (Excluding Externalities)	24
Figure 17 – Electricity Generation and Job Creation per \$1,000,000 Cost to Electricity Ratepayers	25
Figure 20 - Average Ontario Electricity Customer: LTEP New and Refurbished Generation as a Portion of Total Monthly Bill	32
Figure 21 - Average Ontario Electricity Customer: Solar PV as a Portion of Monthly LTEP Cost	33

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