





Acknowledgements

Solas Energy Consulting would like to extend gratitude to the following industry associations and organizations for their support on the development of this report:

- Solar Energy Society of Alberta
- Canadian Solar Industry Association
- This project was funded by Alberta Economic Development and Trade

Prepared by: Jackie Gallagher

Caitlin Lopez, P.Eng, Go Productivity

Jason Mah, E.I.T.

Adrienne McGarrigle, B.A. Paula McGarrigle P.Eng. MBA

Leonard Olien, M.Sc.

Graphic Designer: Western Sky Creative

Delivered to: Mr. Rob Harlan

Solar Energy Society of Alberta





Document Purpose

This study provides a concise description of the solar PV industry in Alberta to date, and it highlights opportunities for investment and training that would enable the industry to fulfill requirements for 30 percent renewable energy, including solar PV, by 2030.

Document History

Alberta Solar PV Value Chain Opportunities

Version	Date	Comments
1.0	26 August 2018	Draft for Peer Review
2.0	31 October 2018	Final Draft to Client
3.0	30 November 2018	Updated final Draft to Client

Disclaimer

While this document is believed to contain correct information, Solas Energy Consulting Inc. ("SOLAS") does not make any warranty, either expressed or implied, nor assumes any legal liability or responsibility for accuracy, completeness, methodology, usefulness, reliability, or current status of any material contained in this document ("Report"), nor shall SOLAS assume any liability with respect to any matter or information referred to or contained in the Report, nor shall any person relying on the Report ("Recipient") or any party to whom the Recipient provides the Report or information have any claim against SOLAS arising out of such Report. The interpretation of this or any other data or report related to this project is solely the responsibility of the client.

Executive Summary

Alberta's iconic blue skies provide a solar resource similar to that of Rio de Janeiro, Brazil¹. According to the International Energy Agency, from 1990 to 2016, solar photovoltaic (PV) had an annual growth rate of 43 percent².

43%

Global solar PV's growth rate is projected to be 20 percent compound annual growth from 2016 to 2022³. While the Oil and Gas sector is significantly larger than solar PV, the global growth rate forecast for solar PV is over four times the growth rate predicted for western Canada's oil production over the same time frame.



This study examines the solar PV value chain for both rooftop and ground-mount applications, Alberta's current strengths in the solar PV sector, and the opportunities for Alberta to capture new business from its growing PV market through to 2030. This study also identifies predicted employment opportunities and existing training capabilities for Albertans. This study builds on Solas' 2017 report, *Alberta Solar Market Outlook* — A View to 2030⁴, which estimated Alberta's potential for deploying behind-the-meter, distribution-connected, and transmission-connected solar PV.

This study identifies opportunities in the Alberta solar PV value chain to provide government, investors, and job seekers with the information necessary to prepare for long-term opportunities created by the move to cleaner electricity generation.

This analysis captures purely conventional applications of solar PV (rooftop and ground-mount PV) and does not include the opportunity value from other applications of technologies, such as energy storage, building-integrated solar PV, nanotechnology, and other emerging solar PV technologies. Although there are potential export market opportunities, Solas did not evaluate the export opportunity to the rest of Canada or the USA as part of this study. Today, 32 percent of wind power ownership in Canada is by Alberta-based companies⁵. Solar PV could follow suit.

¹ https://www.nrcan.gc.ca/18366

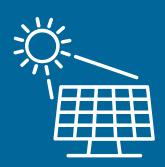
² www.iea.org/publications/freepublications/publication/RenewablesInformation2017Overview.pdf, Page 7.

³ International Energy Agency, "Renewables 2017 Executive Summary" (report, France, 2017), 5.

⁴ P. McGarrigle, L. Olien, C. Chiu, Alberta Solar Market Outlook — A View to 2030, Version 5.0, November 25, 2017.

 $^{^{5}\} https://www.calgaryeconomicdevelopment.com/dmsdocument/135$

Today, Alberta has a small but growing solar PV industry









with 42.7 MW_{DC} deployed,

50% of which is on rooftops.



The Solas 2017 study identified an increasing role for solar power in the future Alberta energy mix.

The Alberta Electric System Operator (AESO) in its Long-Term Outlook also has identified an increasing role for utility-scale solar PV by 2030^7 . The solar PV value chain is a global industry in the manufacturing and deployment of solar PV systems.

The technology, while commercially deployed, continues to enjoy rapid evolutionary changes. Solar PV costs have decreased, and the average levelized cost of energy is expected to decrease by 25 percent by 2022 from 2018 costs⁸. The Lazard study indicated that the levelized cost of energy for solar PV today is on par with natural gas power in many US states⁸.

⁶ Based on Solas analysis of existing deployment in 2018.

⁷https://www.aeso.ca/grid/forecasting/

⁸https://www.iea.org/renewables2018

⁹ https://www.lazard.com/media/450436/rehcd3.ing

Historically in Canada, Ontario attracted solar module assembly through enforced local content requirements and a high internal demand. Alberta's local demand is unlikely to attract investment in polysilicon manufacturing, silicon cells, or solar PV module assembly.

Some manufacturing facilities left Ontario after its policy ended. Racking and electrical components may offer some potential investment opportunities for manufacturers to service both the oil and gas market and the solar PV market. Further research is required to identify specific opportunities.

There are many Alberta-based companies that are contributing to the solar PV value chain. As of June 2018, the Solar Energy Society of Alberta (SESA) has more than 305 companies listed, of which 278 are Alberta-based. Most of these companies (83 percent) are focused on rooftop installation of solar PV. A review of both the Canadian Solar Industry Association and SESA directories demonstrates that the remaining companies are either Canadian or international companies that are headquartered in Ontario, Canada.

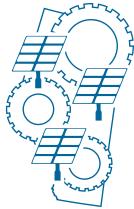
Solas based its analysis of market size for each component of the value chain on the Sustainable Energy Authority of Ireland's report, *Ireland Solar Value Chain Opportunity* (2017) (SEAI 2017 Study). The SEAI 2017 Study provides detailed allocation of value in the solar PV value chain.

By assessing the Alberta solar PV investment from 2019 to 2030 that is distributed across the life cycle and services within the value chain, it is possible to estimate the market value proposition for Alberta businesses in each area.

The Alberta Solar PV Market Value was calculated using the deployment scenario from the Solas 2017 report (3,261 MWpc between 2019 and 2030). The Alberta Solar PV Market Value is comprised of three aspects: Alberta's Current Capacity based on current strengths; Alberta's Growth Opportunity Value where Alberta could grow its capacity and resources to access more of the solar PV value chain; and External Value, which is made of up goods and services that are unlikely to be sourced in Alberta.

Solas identified
the Alberta Solar PV
Market Value at
\$4.1 billion with
3,261 MW_{DC} between
2019 and
2030.

The Alberta Solar PV Market Value accounts for the forecasted decline in the solar PV module cost.



The three aspects of the solar PV market are valued as follows:

- Alberta's Current Capacity (\$0.63 billion) accounts for 15 percent of the Alberta Solar PV Market Value;
- Growth Opportunity Value (\$2.47 billion) accounts for 60 percent; and
- External Value (\$1.04 billion) accounts for 25 percent of Alberta's Solar PV Market Value.

Solas identified the life stage breakdown of the Alberta Solar PV Market Value. (See Table 1.) The six life stages are development, design, manufacturing, installation, operations and maintenance, and decommissioning. The life stages are valued as follows:

- Almost 60 percent of the Alberta Solar PV Market Value is focused on manufacturing (\$2.30 billion).
- Together, the development and design life stages account for 20 percent of the value (\$0.81 billion).
- Installation life stage accounts for 17 percent of the value (\$0.70 billion).
- Operations and maintenance accounts for seven percent of the value (\$0.28 billion).
- By 2030, the decommissioning life stage does not have any value since none of the solar PV deployed in Alberta will be decommissioned at that time.

The manufacturing life stage includes solar cell manufacturing, solar module unit assembly, mounting system manufacturing, and balance of system. Solas identified solar cell manufacturing and solar module unit assembly as unlikely to be produced in Alberta. This External Value was assessed at \$1.0 billion from 2019 to 2030.

Life Stage	Alberta's Current Capacity (\$M)	Alberta's Growth Opportunity Value (\$M)	External Value (\$M)	Alberta Solar PV Market Value (\$M)	Key Areas of Alberta's Growth Opportunity
Development	\$113	\$406	\$ 0	\$519	Finance and commercial, technical advisory, legal
Design	\$162	\$131	\$0	\$294	Site and system design
Manufacturing	\$5	\$1,299	\$1,043	\$2,347	Mounting systems manufacturing and balance-of-system components manufacturing, such as inverters, metering systems, transformers, combiners, optimizers, and conduit
Installation	\$324	\$377	\$0	\$701	Electrical works and project construction management
Operations and maintenance	\$28	\$255	\$0	\$283	Inspections, routine operations and maintenance, component replacement
TOTAL	\$632	\$2,468	\$1,043	\$4,143	

Priority Areas

Solas identified three priority areas where there is significant value and where Alberta is best positioned:

- 1. Increasing capacity in conventional value chain contributions Alberta has the opportunity to provide goods and services in development, design, installation, and maintenance for solar PV. This capacity includes services such as technical advisory, system and site design, legal, and financial services. Increasing Alberta's capacity will allow Albertans to access greater market value rather than these services being imported from other provinces or internationally.
- 2. Diversifying Alberta's manufacturing base Alberta has an opportunity to diversify its existing manufacturing base to support the growing solar PV sector. Higher-value services and equipment such as racking, trackers, combiner boxes, medium-voltage cables, optimizers, inverters, and transformers offer a strong match with Alberta's skill sets and higher labour rates.
- 3. **Focusing on emerging technology** Alberta has an opportunity to continue focusing on emerging innovative and wider solar PV value chain opportunities, such as nanotechnology and energy storage, and ensuring that solar PV and energy storage is part of engineering curriculum options in Alberta.

Solas' analysis identified that the jobs in deployment and operations of almost $3.2~\text{GW}_{DC}$ of solar PV in Alberta will grow to over 8,800 annual full-time equivalent jobs (FTEs) by 2030. Of these positions, 41 percent must be from locally sourced employment.

Types of labour essential for locally sourced employment include permitting, installation, and operation and maintenance. Alberta's talent pool is considerable; however, it is new to the solar PV sector. Additional training is required to transition the workforce.

Alberta has 16 training providers for the solar sector. Several of the training programs focus on designing and installing rooftop solar PV. The remaining programs are more general and pertain to sustainability or introducing solar PV at a basic level. Only one solar PV program is available to train homeowners on solar PV for their residences. There are educational gaps in training for utility-scale renewable energy or utility-scale solar PV and project development. These gaps could be closed through on-the-job training or courses that focus on utility-scale renewable energy development, operations and maintenance, and financial and commercial aspects. Introductory training in these areas can help diversify Alberta's educated labour force.



Next Steps

Alberta has an opportunity to be part of the global solar PV industry. Focusing only on Alberta's potential demand would be a missed opportunity. There are multiple actions required for Alberta to seize its own potential internal demand for solar PV and to play an active role in the growing global market.

Next steps include the following:

- Continuing to foster solar PV forums such as seminars, networking sessions, and conferences in Alberta that integrate industry and research communities on a regular basis.
- Continuing a stable and predictable solar PV market for Alberta businesses to advance their knowledge and experience and to support export opportunities for products and services into the global solar PV market.
- Identifying manufacturing diversification opportunities and maintaining a market that is welcoming to solar PV component manufacturers. Supporting businesses and new entrants that re-train Albertans who have transferable skills.
- Ensuring that Albertans and Alberta's decision-makers and policy-makers have access
 to quality information on solar PV technology to help inform investment decisions,
 given that solar PV is one of the most important energy sources in the next century.
- Providing training that helps leverage experienced personnel with transferable skills to apply their talents in solar PV.
- Ensuring that engineering curricula have options for materials research in energy storage and solar PV in Alberta.
- Reducing and removing barriers to deployment of solar PV within Alberta and
 exploring financing programs for residential, commercial, and industrial customers.
 Barriers were identified in the Solas 2017 study and include commercial/industrial
 roof suitability, project economics, access to low-cost financing, increasing capacity
 and industry capability, and lack of programs for community solar.

Table of Contents

1	Introduction	12
2	Solar PV Value Chain Assessment	15
3	Economic Impact	22
3.1	Market Value for Each Value Chain Component	26
3.2	Alberta's Current Solar Value Chain and Capacity to Capture Potential Market Value	27
3.3	The Value of Increased Market Share of Solar PV with Alberta's Existing Solar PV Capabilities	30
3.4	Alberta's Growth Opportunity Value	31
4	Job Opportunities	33
4.1	Potential Solar PV Jobs	35
4.2	Minimum Required Alberta-Based Solar PV Jobs	
4.3	Existing Alberta-Based Solar PV Talent	38
5	Training Assessment	39
6	Priorities	42
7	Conclusion	44
8	Appendices	45

Table of Contents

Figures	
Figure 1: Rooftop Solar PV Value Chain	18
Figure 2: Ground-mount Solar PV Value Chain	19
Figure 3: Rooftop Solar PV Expenditure by Life Stage (%)	20
Figure 4: Ground-mount Solar PV Expenditure by Life Stage (%)	20
Figure 5: Cumulative Alberta Solar PV Deployment by 2030 — Solas 2017 Study — Scenario E (MWDC)	23
Figure 6: Cumulative Alberta Solar PV Market Value (\$4.1 billion) Identified by Life Stage (\$M)	26
Figure 7: Alberta Solar PV Value Chain Market Value — Rooftop (\$M)	28
Figure 8: Alberta Solar PV Value Chain Market Value — Ground-mount (\$M)	29
Figure 9: Alberta's Current Capacity to Access the Solar PV Market Value \$632M	
(Rooftop and Ground-mount) from 2019 to 2030 (\$M)	30
Figure 10: Alberta Solar PV Market Value (\$4.1 Billion) Based on Scenario E	
Deployment of 3,261 MWDC by 2030 (\$M, %)	31
Figure 11: Alberta Solar PV Market Value Breakdown	32
Tables	
Table 1: Alberta Solar PV Market Value between 2019–2030 and Opportunities for Growth	6
Table 2: Cumulative Estimated Solar PV Market Value in Alberta by 2030	25
Table 3: Estimated Alberta Solar PV Market Value in 2030 (Single Year)	25
Table 4: Examples of the Solar PV Specific Jobs	35
Table 5: 2030 Full-Time Equivalent Jobs Generated for Developing,	
Designing, Manufacturing, and Installing Solar PV Rooftop and Ground-mount (Source: JEDI)	36
Table 6: 2030 Full-Time Equivalent Jobs in Operations and Maintenance (Source: JEDI)	37
Table 7: Full-Time Equivalent Job and Minimum Local Job Requirements in 2030	37
Table 8: Rooftop Solar PV Courses — Design, Installation, and Commissioning	40
Table 9: Alberta-based Courses on Renewable Energy and Sustainability	41
Table 10: Cumulative Installed Capacity Outlook — Scenario E (MWDC)	46
Table 11: Alberta Solar PV Training Programs List	52
Table 12: Statistics Canada — Alberta Companies per NAICS Code	57
Table 13: Statistics Canada — Alberta Jobs by NOC Code	62
Appendices	
Appendix A Study Methodology	
Appendix B Alberta Solar Value Chain Participants	
Appendix C Alberta Solar PV Training Programs List	
Appendix D Solar PV Job Categories and NAICS Code where Relevant	
Appendix E Statistics Canada — Alberta Companies by NAICS Code	

Appendix F Statistics Canada — Alberta Employees by National Occupation Classification Code

Glossary

Abbreviation	Term
AC	Alternating Current
AESO	Alberta Electric System Operator
Balance of System (BOS)	Balance of system (BOS) solar PV systems include components and equipment that move DC energy produced by the solar modules through a conversion system to AC electricity. Most often, BOS refers to components of a PV system other than modules.
CanSIA	Canadian Solar Industries Association
Capex	Capital Expenditure
Collector system	Electrical cabling that connects the inverter/transformers to the point of interconnection
CSA	Canadian Standards Association
DC	Direct Current
FTE	Full-Time Equivalent
JEDI	Jobs and Economic Development Impact model
kWdc	Kilowatts direct current
Module	Solar modules are designed to absorb the sun's rays as a source of energy for generating electricity. These are used as a component of a larger PV system when connected with other modules. Sometimes this is referred to as a solar panel.
MWdc	Megawatts direct current
NABCEP	North American Board of Certified Energy Practitioners
NAICS	North American Industry Classification System
NAIT	Northern Alberta Institute of Technology
NOCS	National Occupation Classification System
NREL	National Renewable Energy Laboratory
Meter	Equipment that measures the amount of electric energy flowing.
Piling	Used to anchor ground-mounted solar arrays and includes drilled shaft piles, driven piles and helical piers or ground screws.
Power inverter	An electronic device that changes direct current to alternating current.
Power optimizer	Electronics that are DC/DC converters used to increase energy output from PV systems by tracking the maximum power point of each module individually.
PV	Photovoltaic
Racking	Photovoltaic mounting system used to fix solar modules to various surfaces such as roofs, building facades, or the ground.
SAIT	Southern Alberta Institute of Technology
SEAI	Sustainable Energy Authority of Ireland
SEI	Solar Energy Institute
SESA	Solar Energy Society of Alberta
SIC	Solar Installers Canada
Switch	Equipment used to interrupt the flow of electrons in a circuit.
Transformer	Equipment that increases or decreases the voltage of the electricity within the solar PV facility
Tracker	Mechanical equipment used to rotate the solar modules to follow the sun's arc using either one axis (single axis tracker) or two axes (dual axis trackers)



Introduction

Solar energy has a profound opportunity in Alberta and worldwide. Alberta's iconic blue skies translate to tremendous solar resource.

Globally, solar photovoltaic (PV) technology has had rapid deployment and plummeting costs. De-carbonization policies, energy security policies, impressive improvements in the efficiency of technology, and cost declines for manufacturing have driven this global growth. The modular deployment ability for solar PV with short development timelines is attractive to investors. Between 2009 and 2017, the levelized cost of energy for utility-scale solar PV fell by 86 percent¹⁰. Solar PV has ranked first or second in new electric capacity additions in the US in each of the last 5 years¹¹. In 2016, the cumulative capacity for solar PV worldwide reached almost 300 GW. Globally, utility-scale projects account for 55 percent of total PV installed capacity, and the remainder is residential, commercial, and off-grid¹².

Worldwide, solar PV deployment is expected to grow to 740 GW by 2022¹³. This growth represents a staggering compound annual growth rate of 19.8 percent. For comparison, the Canadian Association of Petroleum Producers expects Western Canada's oil production to have a compound annual growth rate of 5.5 percent between 2016 and 2022¹⁴. While the Oil and Gas sector is large compared to solar PV, global solar PV deployment is expected to grow at four times the rate of Western Canada's oil production in the same time frame.

The levelized cost of solar energy is also expected to continue to decrease by 25 percent between 2017 and 2022¹⁵. Factors that affect solar PV costs include manufacturing cost declines, supply and demand, and tariffs affecting the price of aluminum, steel, and solar modules.

Alberta's solar resource is similar to Miami, Florida, or Rio De Janeiro, Brazil. Geographically, the solar resource is slightly better in southern Alberta than in northern Alberta. Compared to warmer climates with similar solar resource, Alberta's cooler temperatures are optimal for producing electricity from solar modules.

¹⁰ Lazard, "Lazard's Levelized Cost of Energy Analysis — Version 11.0" (report, 2017), 10.

¹¹ https://www.seia.org/solar-industry-research-data

¹²www.iea.org/topics/renewables/solar — Page referenced on July 17, 2018.

¹³ Ibid

¹⁴ Canadian Association of Petroleum Producers, "June 2018 Crude Oil Forecast, Markets and Transportation" (report, Canada, 2018), Appendix A.1. https://www.capp.ca/publications-and-statistics/crude-oil-forecast extracted on August 16, 2018.

¹⁵ International Energy Agency, "Renewables 2017 Executive Summary" (report, France, 2017), 5.

While Alberta's solar resource is exemplary, Alberta's solar market is in its infancy, with 42.7 MW $_{DC}$ deployed as of June 2018. Of the installed capacity, 25.7 MW 16 was installed under the micro-generation regulation in 2,481 locations behind the meter. Brooks Solar (17 MW $_{DC}$) was recently commissioned as the first distribution-connected solar PV facility. As of August 2018, the Alberta Electric System Operator (AESO) project list had 86 solar PV projects, with a capacity of 4,547 MW. In September 2018, Alberta Infrastructure launched a request for proposals for solar PV for 135,000 MWh per year.

Alberta's government has issued the Climate Leadership Plan (CLP), which is designed to reduce greenhouse gas emissions. The *Renewable Energy Act*, a component of the CLP, established a target for the end of 2030 to produce at least 30 percent of its annual electricity from renewable energy resources within the province. This equates to over 5,000 MW of new renewable energy capacity deployed by 2030. To meet this requirement, the Minister of Energy has directed the AESO to procure large-scale renewable electricity generation. This procurement is done through a competitive process called the Renewable Electricity Program (REP).

In addition, the government revamped the micro-generation regulation where installations of up to 5 MW can be built behind-the-fence. Micro-generation applications reduce the power delivered from the grid and reduce some of the non-energy charges from the electricity retailer. Micro-generation solar PV applications include residential, commercial, industrial, and farm. Solar PV that is outside of the micro-generation sector and not part of the REP can be sold through the Alberta Power Pool on a merchant basis or through bilateral contracts.

Solar PV can be installed through rooftop or ground-mount applications. Rooftop applications are typically installed on residential, farm, commercial, and industrial sites and are used for supplying on-site load. Ground-mount solar PV can be distribution-connected (community generation) or transmission-connected (utility-scale).

This report examines, in detail, the solar PV value chain for rooftop and ground-mount applications, Alberta's strengths within it, and opportunities for Alberta businesses to capture value from a growing Alberta market. The study uses similar methodology to Sustainable Energy Authority of Ireland's *Ireland Solar Value Chain Opportunity Study* (2017) (SEAI 2017 Study); the *US Photovoltaic Prices and Cost Breakdowns: Benchmarks for Residential, Commercial and Utility-Scale Systems* (2017) (NREL 2017 Study); and the National Renewable Energy Laboratory's Jobs and Economic Development Impact (JEDI) Model. This study builds on another Solas study (Solas 2017)¹⁷ on the potential deployment of solar PV market in Alberta issued for the Canadian Solar Industries Association (CanSIA). Alberta companies have the potential to occupy parts of the wider value chain. The qualitative element of this report identifies the value chain needs that Alberta businesses are not meeting. The quantitative element of this report examines the value of the solar PV value chain and the number of jobs, types of jobs, and the training opportunities.

This report is structured as follows:

- Section 2 maps out the conventional solar PV value chain for both rooftop and ground-mount solar PV applications.
- Section 3 identifies Alberta's potential market size and to what extent Alberta can capture this value with its current capacity.
- Alberta Electric System Operator, "Micro-generation in Alberta May 2018" (report, 2017), 1.
 P. McGarrigle, L. Olien, C. Chiu, Alberta Solar Market Outlook A view to 2030, Version 5.0, November 25, 2017.

- **Section 4** presents the number and types of employment positions that are available within the growing Alberta solar PV market.
- Section 5 identifies training opportunities in Alberta and gaps where additional training is required.
- Section 6 identifies the priorities and next steps for increasing Alberta's involvement in the solar PV sector.





Solar PV Value Chain Assessment

Solas developed the solar PV value chain model from the perspective of the developer or owner of a solar PV system.

This report focuses on the components and services that form the conventional value chain: raw materials, interim products, and end products, including silicon wafers, modules, mounting equipment, and system electronics, as well as the remaining balance of plant. The value chains presented do not include research and development, overhead, or profit.

The life stages of a solar PV project are described below:

- Development This stage includes acquiring land, permitting, financing, initial feasibility studies, and all activities completed prior to the project's detailed design.
- **Design** This stage includes constraints analyses, layout design and optimization, engineering, glare studies, cost estimation, and procurement.
- Manufacturing This stage includes solar cell manufacturing, module components manufacturing, module unit assembly, and balance-of-system technology such as inverters, optimizers, racking, trackers, transformers, combiner boxes, etc.
- Installation and Commission This stage includes project and construction
 management, construction labour, mounting and piling equipment, electrical work,
 raw materials such as aggregate and cement, and commissioning and testing.
 Installation and commissioning vary significantly between rooftop and ground-mount
 applications.
- Operations and Maintenance This stage includes metering and communications, maintenance, insurance, warranty, and aggregation of output and sales.
- Decommissioning This stage includes activities to dismantle and remove the solar PV facility, either on rooftop or ground-mount, and includes waste management and project management. Decommissioning costs were assumed to be 10 percent of annual operations costs and based them on a publicly available study on decommissioning costs¹⁸ that is consistent with the SEAI study.

¹⁸ D. Raimi, Decommissioning US Power Plant, Decisions Costs and Key Issues, October 2017, Table 1 — Decommissioning Cost Estimates per MW of Capacity (Mean), Page 3.

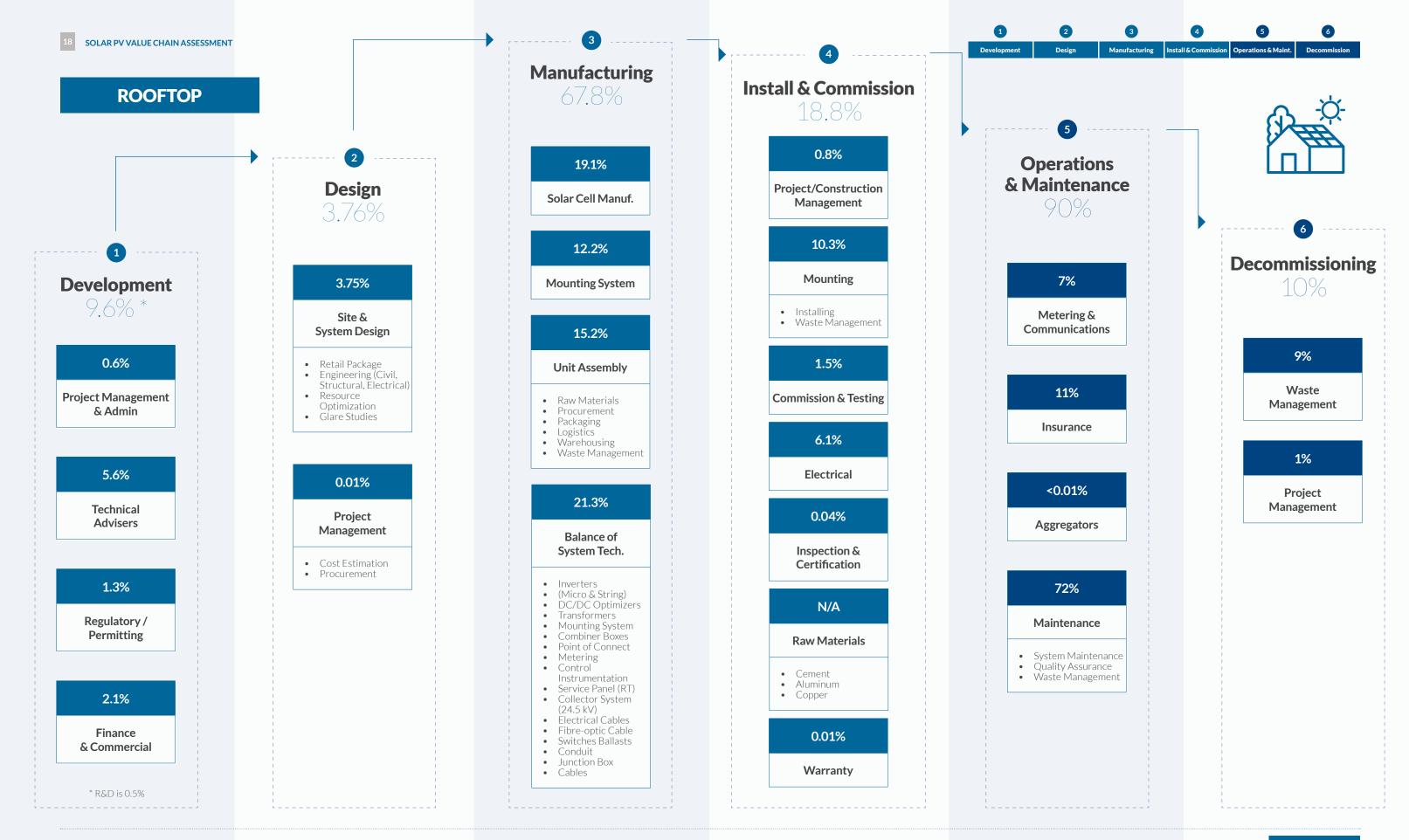
Within each life stage of a solar PV project, Solas has identified the value chain components and the details pertaining to specific skills and technologies.

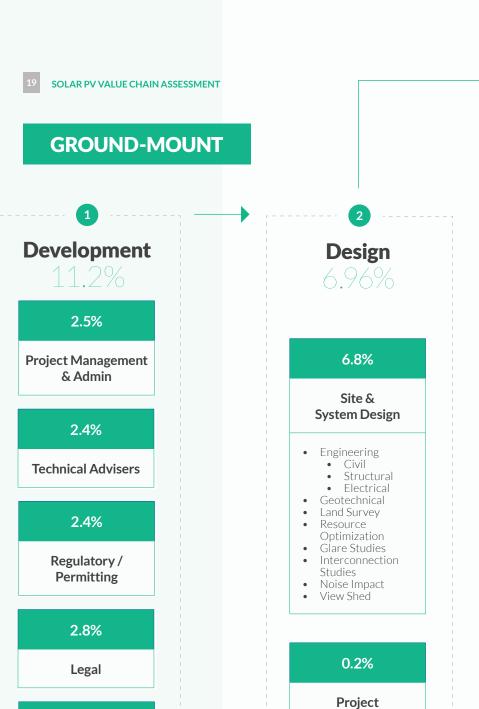
For this analysis, Solas developed two value chain models: rooftop and ground-mount. This analysis was not extended to research and development, electricity storage technologies, or to building-integrated solar PV. This section identifies the components of the rooftop and ground-mount solar value chains (**Figure 1** and **Figure 2**). The figures summarize the breakdown by life stage for each type of solar PV installation.

The rooftop solar value chain applies to residential, commercial, industrial, and farm applications. Solas' model assumes an average system size of 8 kW_{DC} using crystalline silicon PV arrays. In Alberta, rooftop solar is part of the micro-generation regulation and, therefore, it is considered behind-the-fence. This size was chosen to align with the SEAI 2017 Study and the NREL 2017 Study.

Ground-mount solar PV applies to distribution- and transmission-connected solar PV facilities. Solas' model assumes a ground-mount system of 100 MWpc size using fixed-tilt crystalline silicon PV arrays. This size was chosen to align with the deployment for utility-scale solar used in the Solas 2017 study. The ground-mount value chain model includes the high-voltage side of the transformer as the point of interconnection for both distribution and transmission-connected projects.



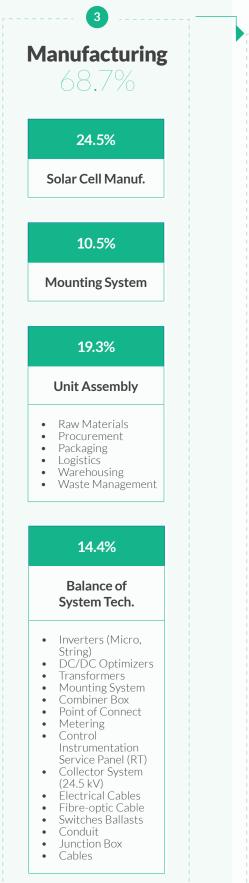




Management

Cost Estimation

Procurement





2.6%

8.0%

Electrical

1.8%

Civil Works/Install

0.7%

Commission & Testing

0.03%

Owner Rep.

0.03%

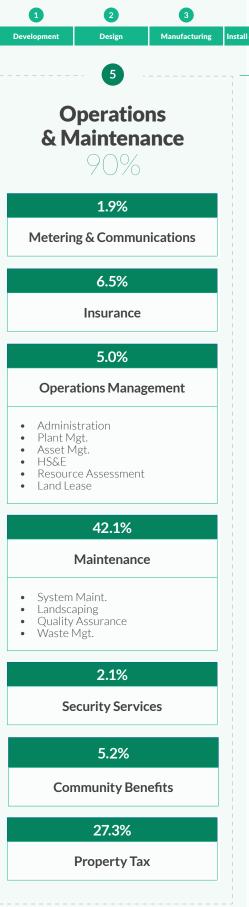
Mechanical & HVAC

<0.01%

Warranty

<0.01%

Inspection & Certification





6



2.9%

Finance

& Commercial

0.5%

Land

Land Acquisition

Land Subdivision

Solas conducted a literature review to quantify the allocation of investment over each component and life cycle stage¹⁹. The SEAI study was chosen as the basis for the models because it has significant detail that allows for customizing those aspects that are more suited for Alberta. The generic value chain models illustrate how investment in solar PV systems is distributed between their components.

Solas has extensive experience in estimating costs for solar PV projects and has compared the three reports to internal models to determine the appropriate calibration of the model to 2018 values. This resulting composite allocation is important for identifying the scale of the opportunity for Alberta's industry within each of these areas. The generic value chain models identify the average percentage of capital costs or annual operating and maintenance costs incurred in each value chain component.

Figure 3 and **Figure 4** below provide the capital expenditure and operations and maintenance expenditure by life cycle stage for rooftop and ground-mount solar.

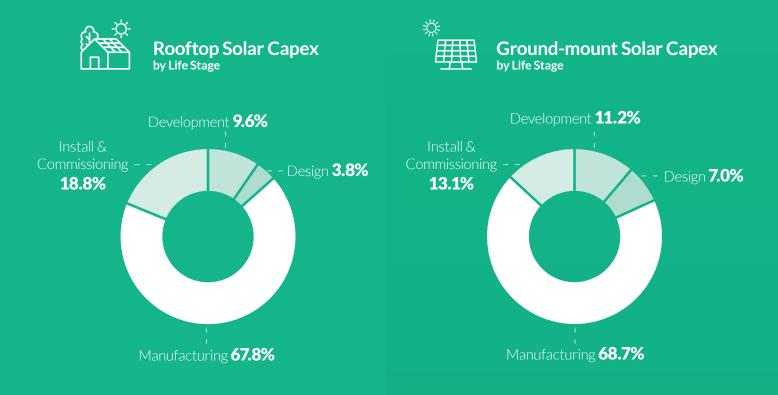


Figure 3: Rooftop Solar PV Expenditure by Life Stage (%)

Figure 4: Ground-mount Solar PV Expenditure by Life Stage (%)

The manufacturing life stage value dominates the solar PV value chain for both rooftop and ground-mount solar types (69 percent). Manufacturing is divided into four cost centres, two of which are specific to the solar module: solar cell manufacturing and solar module unit assembly.

Solar cell manufacturing (19–24 percent) has the largest single share of the capital investment in a solar PV system, along with solar module unit assembly (15–19 percent). Electrical equipment can account for 14–21 percent of the capital investment in PV systems. The largest electrical component is inverters and transformers.

Businesses involved in the solar cell manufacturing, mounting system manufacturing, unit assembly, and electrical equipment and balance-of-system technology stand to capture most of the value in the solar PV value chain, either in rooftop or ground-mount solar PV applications. Because the relative size of this part of the value chain is so large, even smaller component suppliers in module manufacturing (such as sealant, back sheet, frame, etc.) can capture significant value.

Installation costs account for 19 percent of the costs for rooftop and 13 percent of the costs for ground-mount solar PV systems. For ground-mount installation, electrical costs are the largest component at eight percent of the total expenditure. For rooftop installation, mounting is the largest component at 10 percent of the total expenditure.

Development and design account for between 13 percent and 18 percent of total expenditure for rooftop and ground-mount solar PV, respectively.









Operations & maintenance costs are low for solar PV compared to other power generation that uses rotating equipment, such as thermal power generation.

Operations and maintenance for rooftop solar PV applications have lower costs compared to ground-mount solar because little day-to-day attention is required. Rooftop maintenance focuses on replacement parts at the end of the equipment warranty.







Economic Impact

To evaluate the potential size of the Alberta solar business, this section leverages Solas' previous study, *Alberta Solar Market Outlook — A view to 2030*° (Solas 2017).

This report uses Scenario E from the Solas 2017 study for solar deployment. Scenario E uses solar deployment growth rates observed and forecast for the USA solar market, consistent with the *U.S. Solar Market Insight Full Report 2016 Year in Review*²¹. The results presented in this report do not estimate the economic impacts from the construction of transmission and distribution infrastructure. The results also do not include the economic impacts from the potential export of manufactured components from Alberta to other jurisdictions. Therefore, the economic impacts are conservative.

The Solas 2017 study forecasts the potential deployment of 3,261 MW_{DC} of installed solar PV capacity in Alberta by 2030. Of the 3,261 MW_{DC}, 24 percent is rooftop and 76 percent is ground-mount. For rooftop solar PV installations, Scenario E identifies a total of 791 MW_{DC} by 2030, applied on 12 percent of all residences, seven percent of all commercial or industrial buildings, and one percent of all farms. For ground-mount solar PV installations, Scenario E forecasts 389 MW_{DC} as distribution-connected solar PV and 2,081 MW_{DC} as transmission-connected by 2030. (See **Figure 5** below.)



Figure 5: Cumulative Alberta Solar PV Deployment by 2030 — Solas 2017 Study — Scenario E (MWpc)

²⁰ P. McGarrigle, L. Olien, C. Chiu, Alberta Solar Market Outlook — A view to 2030, Version 5.0, November 25, 2017.

²¹ U.S. Solar Market Insight Full Report 2016 Year in Review, GTM Research and Solar Energy Industries Association.

Solas estimated the value of the Alberta market by combining its 2017 study Scenario E deployment with its internal cost estimates²² for rooftop and ground-mount solar PV and by using solar PV module decline cost curves from GTM^{23} . The results of this market value analysis are an order-of-magnitude assessment only.

The resulting solar capacity (3,261 MW_{DC})



represents about 12% of Alberta's installed generating capacity in 2030.



For comparison, in 2016

Solar PV comprised 19% of California's generating capacity



Solas estimates the Alberta solar PV market value from 2019 to 2030 at \$4.1 billion.

Table 2 below demonstrates the cumulative solar PV market value in Alberta by 2030 and identifies rooftop solar as having a value of approximately one-third that of the ground-mount solar PV. By 2030, the number of installations for rooftop solar are significantly higher than that of ground-mount applications.





²² 2018 rooftop cost assumption: \$ 1.82 /Watt | 2018 ground-mount cost assumptions: \$1.41/Watt — excluding profit and marketing costs.

²³ Solar Summit Breakfast Briefing: PV Systems and Technology Trends, GTM Research, May 2018.

Cumulative market value by 2030	Rooftop (791 MW _{DC})	Ground-mount (2,470 MW _{DC})	Total (3,261 MW _{DC})
Non-operations expenditures (\$M)	\$1,099	\$2,761	\$3,860
Operations and maintenance expenditures ²⁴ (\$M)	\$63	\$220	\$283
Total solar PV market (\$M)	\$1,162	\$2,981	\$4,143
Number of Installations by 2030	96,576	99	96,675

Table 2: Cumulative Estimated Solar PV Market Value in Alberta by 2030²⁵

Market Size in 2030	Rooftop		Ground-mount		Total	
Non-operations expenditures (\$M)	\$216.2M	2030 single year installing 155 MW _{DC}	\$527.0M	2030 single year installing 503 MW _{DC}	\$743.2	2030 single year installing 658 MW _{DC}
Operations and maintenance expenditures (\$M)	\$16.3M	2030 maintaining 791 MW _{DC}	\$51.7M ²⁶	2030 maintaining 2,470 MW _{DC}	\$68.0	2030 maintaining 3,261 MW _{DC}
Total solar PV market value	\$232.5M		\$578.7M		\$811.2M	
Number of Installations in the year 2030	Installations in the 21,426		15		21,441	

Table 3: Estimated Alberta Solar PV Market Value in 2030 (Single Year)²⁷

Table 3 above identifies the potential market for the single year 2030 at \$811.2 million for solar PV, assuming the Solas 2017 study deployment rate.

²⁴ Operations and Maintenance (O&M) costs were determined through review of the SEIA 2017 Study, Lazard's Levelized cost of Energy, NREL 2017 Study, confidential client data and Solas internal estimates. For residential rooftop solar PV, O&M costs were assumed to be a replacement of inverters once over the project's lifetime. The inverter cost was taken from the NREL capital cost study, and it assumed inverter installation comprises 10 percent of residential rooftop installation costs. Commercial rooftop O&M costs include replacement of inverters, additional insurance, and inspection costs. The economic evaluation was based on a weighted average of residential and commercial O&M costs.

O&M costs for ground-mount solar were based on averaging available data and its own experience. Labour and materials costs were assumed to be 60 percent labour and 40 percent materials. Property taxes are not part of the value chain value study; however, they contribute to local economic value and, therefore, Solas has reported the estimate of property tax value separately.

²⁵ All values presented in the chart are measured in 2018 dollars. Technology cost decline costs are integrated into the values presented.

²⁶ \$24.6 million in property taxes not included.

²⁷ All values presented in the chart are measured in 2018 dollars. Technology cost decline costs are integrated into the values presented.

For rooftop solar, the geographic distribution of the deployment will focus on urban centres. Rooftop solar applications can be applied anywhere in Alberta and will have the greatest number of installations. The resource difference between northern and southern Alberta (10 percent) will have little effect compared to micro-siting-specific applications. The deployment by location was identified in the Solas 2017 study.

Solas estimated residential rooftop solar opportunities at 34,238 and 38,428 applications in Edmonton and Calgary, respectively, and 3,642 and 4,433 applications in Lethbridge and Red Deer, respectively.

The Solas 2017 study forecast ground-mount applications in areas within 10 kilometres of a distribution system, transmission line, and existing substations. Therefore, most solar PV ground-mount facilities will be located near existing distribution and utility corridors.

3.1 Market Value for Each Value Chain Component

The life stage breakdown of the Alberta Solar PV Market Value was identified. The six life stages are development, design, manufacturing, installation, operations and maintenance, and decommissioning. Figure 6 below identifies the breakdown of the Alberta Solar PV Market Value by life stage from 2019–2030.

- Almost 60 percent of the Alberta Solar PV Market Value is focused on manufacturing (\$2.3 billion).
- Together, the development and design life stages account for 20 percent of the value (\$0.81 billion).
- Installation life stage accounts for 17 percent of the value (\$0.70 billion).
- Operations and maintenance accounts for seven percent of the value (\$0.28 billion).
- By 2030, decommissioning does not have any value since none of the solar PV deployed will be decommissioned.

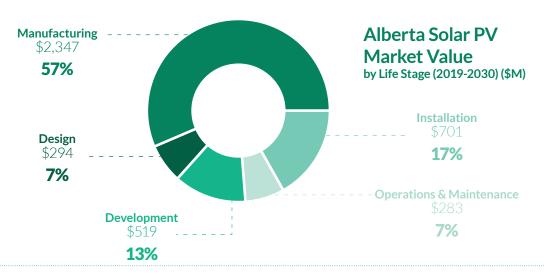


Figure 6: Cumulative Alberta Solar PV Market Value (\$4.1 billion) Identified by Life Stage (\$M)²⁸

Figure 7 and **Figure 8** in Section 3.2 show the cumulative expenditure (\$4.1 billion) distributed across the value chain.

²⁸ All values presented in the chart are measured in 2018 dollars. Technology cost decline costs are integrated into the values presented. Property tax has not been included in this evaluation and would add an additional \$0.11 billion to the assessment.

3.2 Alberta's Current Solar Value Chain & Capacity to Capture Potential Market Value

Solas created a database of Alberta's current solar PV value chain using its familiarity with the industry, SESA's membership list, and CanSIA's membership list. The Alberta-based companies were categorized into developers, contractors, service suppliers, equipment suppliers, materials suppliers, etc., to match the categories in the solar PV value chain model.

Each component of the value chain was assessed to determine Alberta businesses' current capacity to capture market value. The assessment was based on a review of the Alberta-based industry participant database and the North American Industry Classification System (NAICS) information from Statistics Canada²⁹. Alberta-based companies were defined as those that have an Alberta business address and excluded those that are in Canada but do not have an office in Alberta.

The solar PV value chain includes more than 70 industries (at the six-digit NAICS code level) and a very broad range of skill sets, from project development to construction, operations and maintenance, and equipment manufacturing. Table 12 in Appendix E of this report identifies the number of companies with employees in Alberta that have skill sets that could be transferrable to the solar PV industry.

Alberta has no shortage of expertise related to project development, construction, operations and maintenance, and decommissioning. This talent pool is experienced in utilities and oil and gas; however, expertise in solar PV is limited. Solas also pulled from the National Occupation Classification (NOC) codes to identify the talent pool that the solar PV industry could draw from in Alberta. Table 13 in Appendix F of this report identifies the number of jobs and median salary for solar PV applicable skills.

Alberta's current ability to capture market value was evaluated using a rating system that looked at the number of companies, the company size, and their experience levels in solar PV. This work was completed through a qualitative assessment. A colour-coding system was used to represent the ability to capture market value, with red being the lowest and green being the highest.

Figure 7 and **Figure 8** below indicate the market value for each component of the value chain and Alberta's current capabilities, which are colour-coded.

Ability to Capture Market Value

Very well positioned

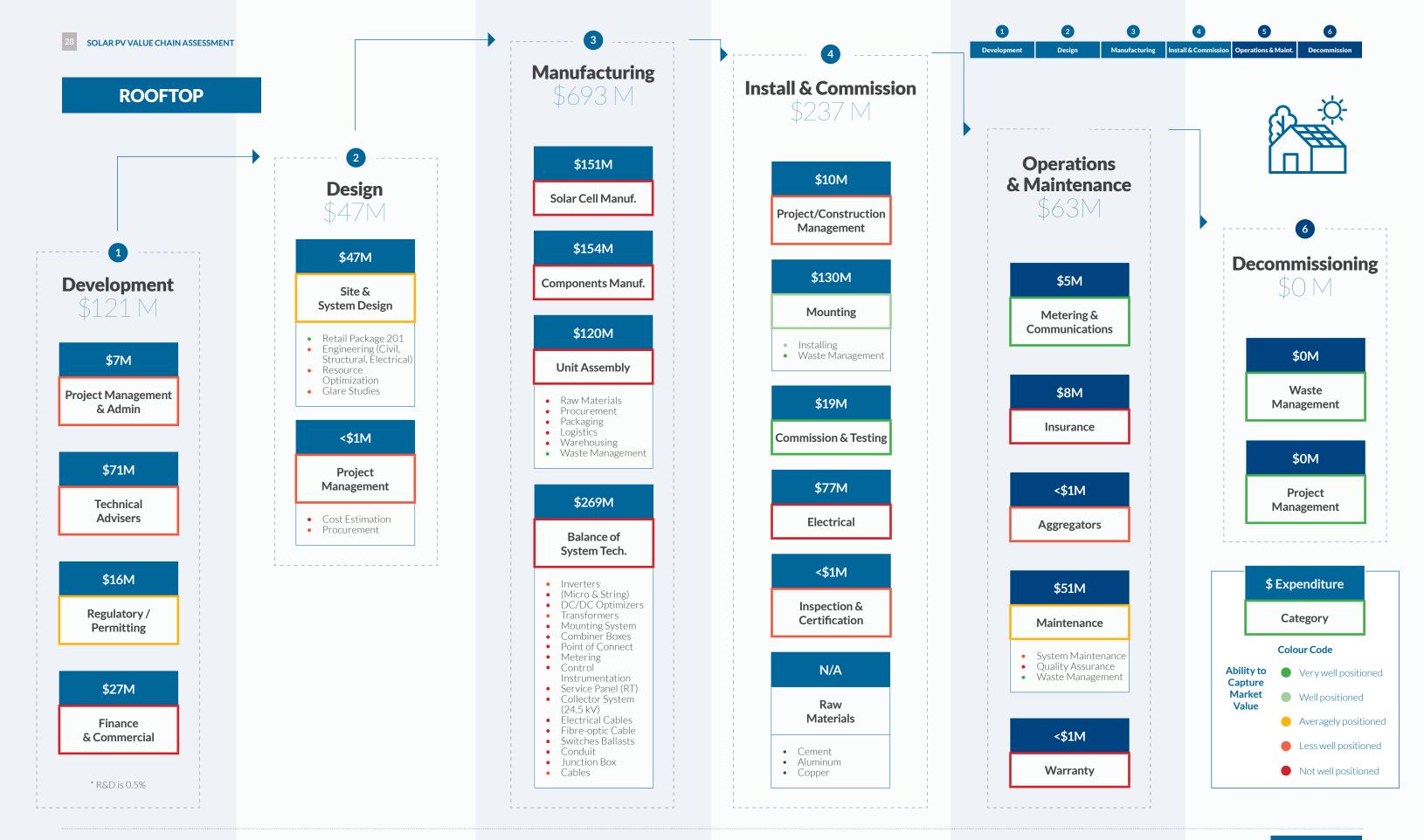
Well positioned

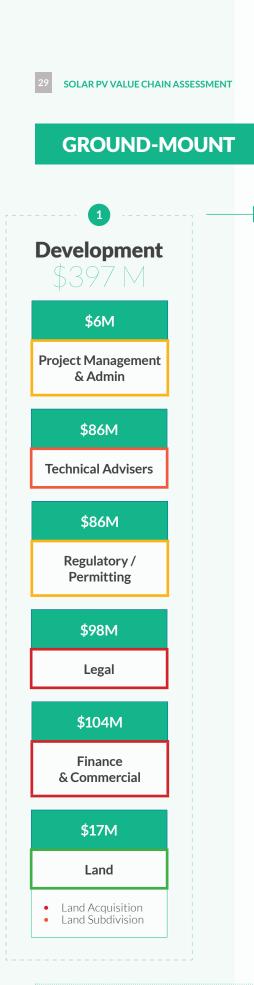
Averagely positioned

Less well positioned

Not well positioned

²⁹ https://www.statcan.gc.ca/eng/subjects/standard/naics/2017/index











\$464 M

\$91M

\$284M

Electrical

\$63M

Civil Works/Install

\$24M

Commission & Testing

\$1M

Owner Rep.

\$1M

Mechanical & HVAC

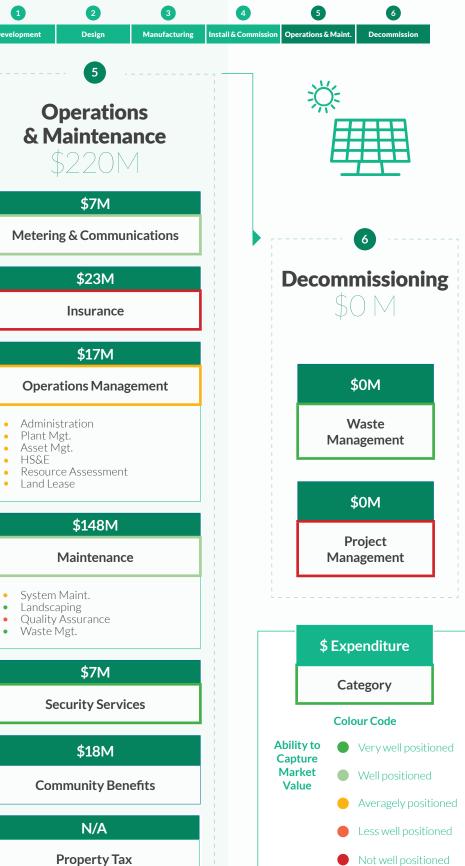
<\$1M

Warranty

<\$1M

Inspection & Certification





GROUND-MOUNT

3.3 Alberta's Current Capacity for Solar PV Market Value

In 2018, there are Alberta-based businesses that have the ability to capture some of Alberta's Solar PV Market Value. Some of these Alberta-based solar PV businesses have historically served other, more mature solar markets or the off-grid solar PV market.

Solas determined the value of Alberta's Current Capacity by combining the ability to capture market value with the value of each market component. Combining these estimates with the market size estimates set out in **Figure 7** and **Figure 8** gives a sense of the potential size of the market for an Alberta business if it pursued opportunities in the solar PV industry.

Based on this method of estimation, the total value that Alberta businesses are poised to capture is estimated at \$632 million by 2030 (Alberta's Current Capacity) out of the total \$4.1 billion (Alberta Solar PV Market Value) as shown in **Figure 9**. The largest component of Alberta's Current Capacity is installation, followed by design, development, and operations. Alberta's Current Capacity for operations and maintenance is estimated at 10 percent of the total operations market value because the market is at the early stages in Alberta, particularly the utility-scale solar PV market.

Today, Alberta-based manufacturing capabilities in solar PV are limited. The manufacturing life stage includes solar cell manufacturing, solar module unit assembly, mounting system manufacturing, and balance of system. In July 2017, Alberta welcomed its first solar manufacturer, CyboInverter Canada, a solar PV mini-inverter manufacturer, to Calgary. When in full production in Alberta, the only component from the US will be the circuit board, with all other internal and external components produced, procured, assembled, programmed, tested, and supported in Alberta or Canada³⁰. The US Pacific Northwest is home to some of the largest manufacturers at each step of the supply chain for polysilicon, wafers, cells, and modules. In Washington state, REC Silicon maintains 20,000 tons of polysilicon production capacity. In Oregon, Panasonic has 50 MW of solar capacity in wafers, and Solar World has approximately 500 MW of capacity in modules and cells³¹. Solas identified solar cell manufacturing and solar module unit assembly as unlikely to be produced in Alberta. This External Value was assessed at \$1 billion from 2019 to 2030.

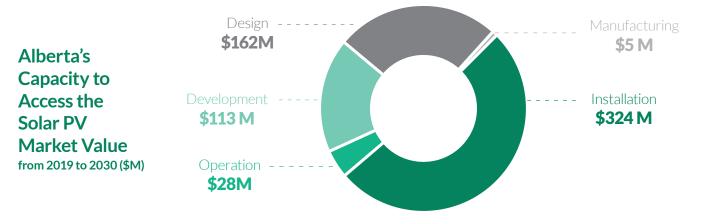


Figure 9: Alberta's Current Capacity to Access the Solar PV Market Value \$632M (Rooftop and Ground-mount) from 2019 to 2030 (\$M)

³⁰ http://cybocan.com/uploads/1/0/8/2/108255657/alberta_solar_press_release.pdf retrieved October 27, 2018

³¹ http://www.manufacturingcleanenergy.org/blog-20170327.html retrieved October 26, 2018.

3.4 Alberta's Growth Opportunity Value

The Alberta Solar PV Market Value is comprised of three aspects: Alberta's Current Capacity based on current strengths; Alberta's Growth Opportunity Value, where Alberta could grow its capacity and resources to access more of the solar PV value chain; and External Value, which is made up of goods and services that are unlikely to be sourced in Alberta.

Figure 10 below identifies Alberta's Current Capacity, Alberta's Growth Opportunity Value, and External Value.

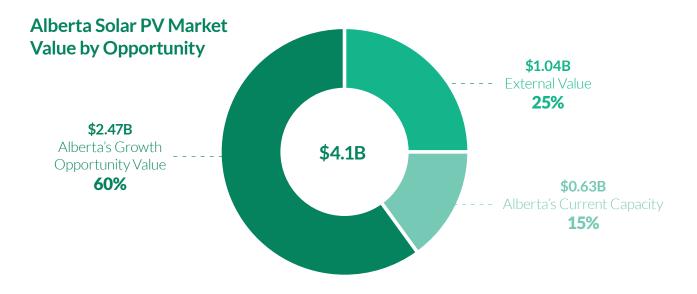


Figure 10: Alberta Solar PV Market Value (\$4.1 Billion) Based on Scenario E Deployment of 3,261 MWpc by 2030 (\$,%)

A detailed evaluation was completed for each value component to understand the opportunities for Alberta specifically. The sunburst diagram (**Figure 11**) below illustrates the Alberta Solar PV Market Value breakdown for Alberta's Current Capacity, Alberta's Growth Opportunity Value, External Value by life stage and specific value component. This figure represents the relative size of the market value for each value chain component. Alberta's Growth Opportunity Value exists in the following life stages:

- Development and Design The Alberta growth opportunity value for development and design is \$537 million³².
 Within development and design, four components have growth opportunity value of over \$100 million each:
 Legal, Finance and Commercial, Technical Advisers, as well as Site and System Design.
- Manufacturing This is the largest growth opportunity for Alberta in the Solar PV industry, with a total growth opportunity value of \$1.3 billion. The Alberta growth opportunity value is in balance-of-system electronics manufacturing (\$0.77 billion) and mounting system manufacturing (\$0.52 billion).
- Installation Alberta growth opportunity value is \$377 million for installation. The largest component of installation is electrical works at \$218 million.

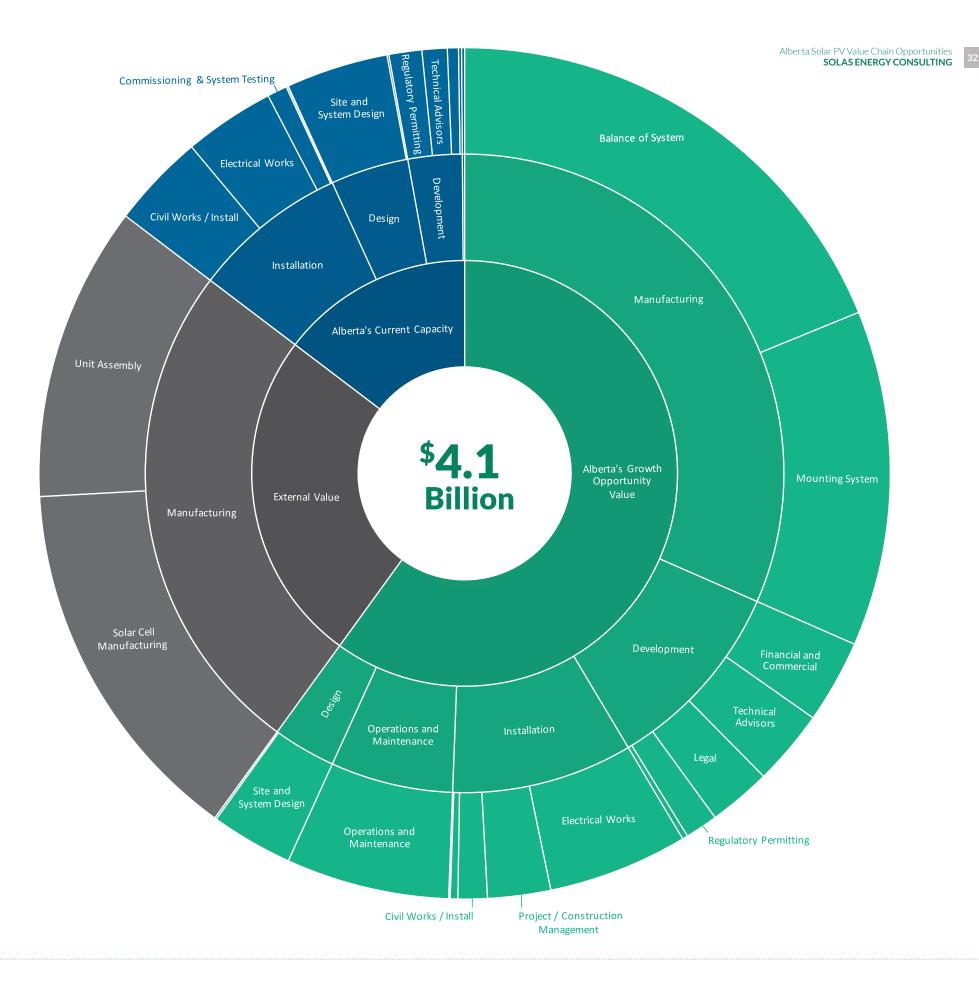
³² Growth Opportunity Value for Development is \$406M and Design is \$131M for a total value of \$537M.

Alberta has a manufacturing base that primarily services the oil and gas sector; however, it has the opportunity to also serve the solar PV sector. With the global expected growth rate of solar PV, Albertabased businesses can look to export opportunities in addition to Alberta's own domestic demand for solar PV products.

Higher-value products offer a potentially stronger match with Alberta's skill sets and higher labour rates. These products include mounting systems manufacturing and balance-of-system manufacturing such as inverters, metering systems, transformers, combiners, optimizers, and conduits. Additional studies are required to identify Alberta's capacity to provide these higher-value products.

Research and development have potential opportunities in Alberta; however, additional study is required to evaluate the opportunities and Alberta's capabilities. Materials sciences and nanotechnology may have opportunities in the solar PV sector. While this report does not include energy storage, it is important to be aware of the opportunities in energy storage and to be aware of the current research and development that is ongoing at the University of Calgary and the University of Alberta.

Energy storage deployment is expected to grow significantly and may be deployed with residential, commercial, and utility-scale solar applications.







Job Opportunities

Solar energy jobs are diverse. In the USA in 2017, there were more than 1.9 million jobs in the energy-related sector, with the biggest share in the oil and gas industry at 26.7 percent. According to the Solar Foundation³³, solar-related jobs come in at second place, with a share of 19.4 percent.

Since 2010, USA employment in solar grew 168 percent. While solar in the USA made up just under two percent of overall energy generation, it employed twice as many workers as the coal industry and five times as many as nuclear power, and it had as many workers as the natural gas industry.

In the USA in 2017, solar energy jobs were mostly in installation (52.7 percent), manufacturing (14.6 percent), project development (13.2 percent), and sales & distribution (12.3 percent)³⁴.



 $^{^{\}rm 33}$ www.thesolar foundation.org/national retrieved August 25, 2018

³⁴ www.statista.com/chart/12672/solar-energy-jobs-in-the-united-states/retrieved August 25, 2018

4.1 Potential Solar PV Jobs

The Solar Career Map³⁵ identifies 40 job types that are involved in solar PV for manufacturing, system design, project development, and installation and operations. Table 4 provides an example of the types of jobs in the solar PV industry.

Manufacturing	 Computer Numerical Control Operator Advanced Manufacturing Technician Instrumentation and Electronics Technician Process Control Technician Instrumentation and Electronics Technician 	 Quality Assurance Specialist Electrical Engineer Industrial Engineer Mechanical Engineer Environmental Engineer Materials Scientist
System Design	 IT Specialist Residential PV System Designer Engineering Technician Utility Interconnection Engineer Civil Structural Engineer Power Systems Engineer 	 Solar Energy Systems Designer Software Engineer Project Engineer with Solar Expertise Geotechnical expert with Solar Expertise Land Survey Experts Acoustic Practitioner
Project Development	 Solar Site Assessor Solar Marketing Specialist Solar Sales Representative Code official with Solar Expertise Electrical Inspector with Solar Expertise Building Inspector with Solar Expertise Solar Utility Procurement Specialist Lawyer with Solar Expertise Solar Project Developer Environmental Scientist Land Acquisition Specialist with Solar Expertise Civil Engineer with Solar Expertise 	 Resource Scientist with Solar Expertise Geotechnical specialist with Solar Expertise Meteorologist Finance Specialist with Solar Expertise Stakeholder Consultation Specialist with Solar Expertise Permitting Expert with Solar Expertise Power Marketing Expert with Solar Expertise Geographic Information System Specialist (GIS) with Solar Expertise
Installation and Operations	 Solar Assembler/Basic Installer Roofer with Solar Expertise Solar Crew Chief Solar PV Installer Solar Service Technician (residential) Solar PV Technician (commercial/utility) Electrician with Solar Expertise Solar Project Manager Solar Installation Contractor Solar Fleet Manager Solar Instructor 	 Electrical Engineer with Solar Expertise Solar Asset Manager Construction Manager with Solar Expertise Solar contract administrator Solar System Commissioners Pile Driver Operator Safety Manager Landscaper Environmental Scientist



The JEDI model provided by NREL was used to estimate the economic impacts of constructing and operating solar power at the local and provincial levels. The jobs, earnings, and output are distributed across three categories: project development and onsite labour impacts; local revenue and supply chain impacts; and induced impacts³⁶.

The JEDI model results are intended to be estimates and not precise predictions. In the estimates, the construction jobs are defined as full-time equivalents (FTE) or 2,080 hours of labour. While the JEDI model is not designed specifically for Canadian deployment, in the authors' experience, the JEDI model is representative for this analysis. Solas used the JEDI model and updated the model inputs for construction, equipment, annual operating and maintenance, financing parameters, and other costs.

Deploying 3,261 MW_{DC} will require direct and indirect employment in Alberta. The JEDI model identified the number of jobs required for eight job categories. For 2030 alone, the following table (Table 5) identifies the number of FTE jobs that solar PV creates for each job category.

In 2030, over 8,800 FTE jobs will be required to develop, design, manufacture, and install 155 MW $_{DC}$ for rooftop and 503 MW $_{DC}$ for ground-mount solar PV. Seventy percent of these jobs are in ground-mount solar PV, and 30 percent are in rooftop solar PV applications.

Job Type — Project Development, Design, Manufacturing, Installation, and Construction	Jobs for Rooftop 2030 (FTE)	Jobs for Ground-mount 2030 (FTE)	TOTAL (FTE)
Construction and installation labour	886	2,427	3,313
Construction and installation services	181	328	509
Manufacturing	387	916	1,303
Trade (wholesale and retail)	172	376	548
Professional services	31	63	94
Other services	72	122	194
Other sectors	298	689	987
Induced impacts	546	1,317	1,863
TOTAL	2,573	6,238	8,811

Table 5: 2030 Full-Time Equivalent Jobs Generated for Developing, Designing, Manufacturing, and Installing Solar PV Rooftop and Ground-mount (Source: JEDI)

³⁶ Induced impacts are jobs that result from the spending of earnings or savings by those directly or indirectly employed or affected by the project. These include jobs at retailers, schools, hospitals, and restaurants.

Installing 3,261 MWDC solar PV will also require employment in the operations and maintenance of the installed systems. Table 6 below identifies an additional 945 FTE jobs required for operations and maintenance in the year 2030. The majority (over 80 percent) of the operations and maintenance jobs are for ground-mount applications, and the remainder are for rooftop solar PV applications.

Job Type — Annual O&M	Jobs for Rooftop 2030 (FTE)	Jobs for Ground-mount 2030 (FTE)	Total O&M Employment (FTE)	
Labour	52	402	454	
Supply chain impact	70	204	274	
Induced impact	37	180	217	
TOTAL	159	786	945	

Table 6: 2030 Full-Time Equivalent Jobs in Operations and Maintenance (Source: JEDI)

Total employment to support the solar electricity sector in Alberta,

including development, design, manufacturing, installation, operations and maintenance,

could amount to 9,756 FTEs.

4.2 Minimum Required Alberta-Based Solar PV Jobs

While not all jobs will be located in Alberta, at a minimum, deploying solar PV will require local skills and labour for the permitting and construction and operations and maintenance of the solar PV facilities. The JEDI model analyzes the portion of expenditures spent locally and the number of locally required jobs.

Multiple factors influence the construction and operating costs that are spent locally. The availability of local resources (including skilled labour and

materials) and the availability of locally manufactured power plant components significantly affect the economic benefits that accrue to Alberta. Table 7 identifies the total and minimum local job requirements for deployment and operations and maintenance for the year 2030.

	Development, Design, Manufacturing, and Installation Jobs (FTE)	Operations and Maintenance Jobs (FTE)	Total Jobs (FTE)
Total FTE jobs required	8,811	945	9,756
Minimum local FTE jobs required	4,951	671	5,622
Percentage of total jobs that must be local	56%	71%	58%

Table 7: Full-Time Equivalent Job and Minimum Local Job Requirements in 2030

Depending on the manufacturing base established in Alberta, not all of the 9,756 FTE jobs will be local. The JEDI model as shown in Table 7 above indicates that local permitting and installation will require a total of 4,951 FTE jobs in deployment (non-operations). Operations and maintenance will require 671 FTE jobs. The minimum local employment requirements are 5,622 FTE jobs or 58 percent of the total jobs required for deployment of 3,261 MW_{DC} solar PV by 2030. The minimum FTE required represents 27 percent of the current utility sector jobs in Alberta³⁷.

4.3 Existing Alberta-Based Solar PV Talent

According to Calgary Economic Development, "Calgary is an established 'talent hub' of high-value-added, service-oriented workers that are experienced in the energy industry³⁸." "Transferrable occupations that exist in high capacity in Alberta include: engineers (mechanical, electrical, civil, chemical, structural, systems, and environmental), geologists and geotechnical specialists, biologists, computer and ICT specialists, construction specialists, land management specialists, lawyers, and contract administrators³⁹." These transferrable occupations apply to the solar PV industry growth opportunities in Alberta.

The data available for information on the current talent in Alberta is high-level and general in nature. Statistics Canada does not track employment within the solar PV sector nor within the renewable energy industry.

A review of both the existing CanSIA and SESA solar directories and the National Occupation Classification System (NOCS) information reveals that Alberta's current talent pool is considerable; however, it will need to grow to match the pace of solar PV development. Alberta's talent pool has the ability to complete project development, design, installation, and operations and maintenance. Alberta has talent and transferable skills. However, additional training may be required to transition into the solar energy sector. In addition, western Canada has the capacity to manufacture racking and mounting systems, and it potentially has the capacity to manufacture electrical components.



Training Assessment



Training Assessment

Solas assessed the training opportunities relevant to the solar PV sector that are available to Albertans. This database was compiled based on secondary research through publicly available data sources. Sixteen training providers were identified, including post-secondary institutions and industry organizations (see Table 8).

The majority of courses focus on designing, installing, and commissioning residential rooftop solar. Typically, the programs either align with the Canadian Standards Association (CSA) or the North American Board of Certified Energy Practitioners (NABCEP). The Northern Alberta Institute of Technology (NAIT) has a program that focuses on renewable and alternative energy. The Southern Alberta Institute of Technology (SAIT) has integrated renewable energy into its curriculum by adding a module to its electrician program. Site and system design courses are available for sales roles, and installation courses are available for electricians. The list of design, installation, and commissioning courses is provided below.

Name	Location	Duration	Certification		
Everblue	Online and USA	Online and 2 days in-person	NABCEP		
Grid Works Energy	Edmonton	5-day course	CSA		
Light up the World	Edmonton	40 hours training	N/A		
NAIT	Edmonton	2-year program	N/A		
Solar Energy International	Online and Colorado, USA	5-day course	NABCEP		
Solar Installers Canada	Calgary	35 hours	CSA		
SAIT	Calgary	40-hour course for certified journeyman electricians	N/A		
Solar Energy Society of Alberta	- Edmonton		N/A		
Northern Lakes College	Slave Lake		CSA		

Table 8: Rooftop Solar PV Courses — Design, Installation, and Commissioning

Additional courses (Table 9) are available that are more general to sustainable energy and renewable energy. Solas found construction management courses at SAIT, NAIT, University of Calgary, and the University of Alberta; however, none of these programs have a specialization in renewable energy.

Institution	Location	Course
MacEwan University	Edmonton	Business 201 — Introduction to Sustainable Business
Lakeland College	Vermillion & Lloydminster	Renewable Energy and Conservation (Certificate/Diploma)
Lethbridge College	Lethbridge	Solar 101 for homeowners
Medicine Hat College	Medicine Hat	Introduction to Solar
Mount Royal	Calgary	Strategic Sustainability and the Energy Industry
Red Deer College	Red Deer	Alternative Energy Lab 40
University of Alberta	Edmonton	Faculty of Engineering — Energy and Environment Graduate courses — MEC E 643 Renewable Energy Engineering and Sustainability
University of Calgary	Calgary	Continuing Education — BMC 252 — Renewable Energy Technologies Faculty of Engineering — ENG 355 Introduction to Energy and the Environment Faculty of Engineering — ENG 507 Introduction to Sustainable Development Faculty of Engineering — ENG 575 Alternative Energy Systems Faculty of Business — Energy Management 301 — Electricity Management Faculty of Business — FNCE 559 Renewable Power Generation Finance Graduate degree — Masters in Sustainable Energy Development

Table 9: Alberta-based Courses on Renewable Energy and Sustainability

To ensure that Alberta can meet the opportunity of large-scale solar deployment, it is key that workers with transferable skills are informed about the opportunities in renewable energy and about how their skills can be transferred. Introductory solar or renewable energy courses aimed at the professional may help to ease the transition from traditional energy employment to the renewable energy sector.

Solas' search revealed that no training is directed towards utility-scale renewable energy or utility-scale solar PV or project development. These gaps could be closed through on-the-job training or courses that focus on providing training on utility-scale renewable energy development, regulation and permitting, as well as on financial and commercial aspects. Introductory training in these areas can help the transition to renewable energy.

Some engineering programs at the University of Alberta offer undergraduate courses in materials science and nanotechnology. Energy storage research is available through the University of Calgary. Continued access to engineering in the areas of energy storage and solar PV materials science is important for Alberta's engineers to be relevant in this new and growing industry.

⁴⁰ Solas did not identify specific programs related to renewable energy; however, the Alternative Energy Lab includes solar and was identified to assist in other programs.





Priorities

Based on the evaluation completed in this study, Solas identified several priority areas where there is significant value to be captured and where Alberta could be well positioned:

- 1. Increasing capacity in conventional value chain contributions Increasing capacity in the development, design, installation, and maintenance for both rooftop and ground-mount solar PV. This capacity includes services such as technical advisory, system and site design, legal, and financial services. Alberta requires additional talent in these areas to meet the future demand for solar PV. Alberta can also use this expertise to service the global solar PV market.
- 2. **Diversifying Alberta's manufacturing base** Identifying opportunities for diversifying Alberta's manufacturing base to support the growing solar PV sector. Higher-value products offer a stronger match with Alberta's skill sets and higher labour rates. Given the expected size of the global solar PV market, this could be a potentially attractive market for Alberta's manufacturing base such as manufacturing inverters, metering systems, transformers, combiners, optimizers, and conduits, and subsequently helping to diversify Alberta's economy.
- 3. **Focusing on emerging technology** Continuing work on materials research through Alberta's institutions to access the global opportunity for application in the solar PV sector, including nanotechnology and energy storage. Ensuring that solar PV and energy storage is part of engineering curriculum options in Alberta.

Conclusion

Worldwide, the global solar PV market is one of the fastest growing technologies for power generation. The analysis in this report indicates that Alberta Solar PV Market Value could be over \$4 billion by 2030, with over \$3 billion accessible to Alberta-based businesses⁴¹. Value Chain Growth opportunities for Alberta businesses include the following:

Design & development \$537M

Manufacturing \$1,299M

Installation \$377M

The market opportunity can be increased by Alberta-based companies accessing export opportunities beyond Alberta's own demand. To access the global opportunity for applications in the solar PV sector, the highest priority areas are increasing Alberta's capacity in the conventional solar PV market, identifying opportunities for diversifying Alberta's manufacturing base, and continuing research and development on materials research for nanotechnology and energy storage through Alberta's institutions.

There are several steps that policy-makers, the solar industry, educators, and the research community can take to access the priority areas. **These steps include the following:**

- Continuing to foster solar PV forums in Alberta that integrate industry and research communities on a regular basis.
- Continuing to advance a strong and stable domestic solar PV market for Alberta businesses to increase their knowledge and experience and to support export opportunities in the global solar PV market.
- Identifying opportunities and further funding and supporting the diversification of the manufacturing base for Alberta-based businesses; supporting businesses and new entrants that retrain Albertans with transferable skills.
- Ensuring that Albertans and Alberta decision-makers and policy-makers have access to quality information on solar PV technology to help inform investment decisions, given that solar PV is one of the most important energy sources in this next century. Provide training that helps to leverage experienced personnel with transferable skills and apply their talents in solar PV.

The solar PV market is forecast to be significant and to have double-digit growth rates. Alberta has an opportunity to be part of this growing industry. Taking key steps now will ensure that Alberta has a place on the global stage for this industry sector that complements its current energy base.

⁴¹ This includes Alberta's Current Capacity of \$632M and Alberta's Growth Opportunity Value of \$2,468M for a total of \$3,100M.

Appendix A

Study Methodology

To generate the results of this study, Solas compiled several data sources and used various methods to forecast to 2030. For historical cost breakdowns, which generate the percentages of the cost centres for capital expenditure and operational expenditure, this study references three main sources: the *Ireland Solar Value Chain Opportunity*, issued by Sustainable Energy Authority of Ireland (2017) (SEAI Study), the *US Photovoltaic Prices and Cost Breakdowns: Benchmarks for Residential, Commercial and Utility-Scale Systems* (2017) (NREL 2017), and the Solas Energy Consulting Inc. (Solas 2017) study on the potential deployment of solar PV market in Alberta issued for the Canadian Solar Industries Association.

To calculate the economic impact, the Jobs and Economic Development Impact (JEDI) model was used, which the National Renewable Energy Laboratory developed to understand the economic benefits of power generation development. The JEDI model specifically designed for the solar PV industry was used. JEDI does not provide a forecast, but it calculates the economic benefits of the outlook that Solas developed for solar PV deployment in Alberta. The JEDI model was used to evaluate the economic benefits of utility-scale development and residential-scale development. NREL factors were compiled from a database of regional economic data to calculate local economic benefit to different sectors of power system investment.

Internal cost data were used to determine the total costs for each stage of a solar PV project (both rooftop and ground-mount), and the SEAI study's percent breakdown was used to determine the more detailed cost breakdown for smaller sub-activities that match the Alberta Solar value chain model. Several assumptions in the SEAI Study categories were modified to relate them to the Alberta model.

In Alberta, the outlook scenario for 2030 constitutes 3,261 MW total installed capacity, starting in 2016 with 16 MW and growing, according to Table 10 below.

	5	Scenario E — Cur	mulative Installe	ed Capacity MW	D C		
YEAR	Total Solar Capacity	Residential — Rooftop	Commercial — Rooftop	Farm — Ground-mount	Community Generation (Distribution Connected — Ground-mount)	Utility – Ground-mount	
2016	16.0	7.0	7.0	2.0	-	-	
2017	47.3	15.0	15.0	2.3	15.0	-	
2018	178.7	23.0	23.0	2.7	30.0	100.0	
2019	210.0	31.0	31.0	3.0	45.0	100.0	
2020	288.6	41.3	39.9	3.4	61.8	142.2	
2021	384.6	54.5	50.0	3.8	80.5	195.8	
2022	502.0	71.5	61.1	4.3	101.5	263.6	
2023	646.4	93.4	73.7	4.8	125.0	349.6	
2024	824.2	121.5	87.7	5.4	151.2	458.5	
2025	1,044.1	157.6	103.3	6.0	180.6	596.6	
2026	1,316.5	204.0	120.8	6.7	213.4	771.5	
2027	1,655.0	263.7	140.4	7.6	250.1	993.2	
2028	2,076.6	340.5	162.3	8.5	291.2	1,274.2	
2029	2,602.7	439.1	186.8	9.5	337.1	1,630.2	
2030	3,260.7	566.0	214.2	10.6	388.5	2,081.4	

Table 10: Cumulative Installed Capacity Outlook − Scenario E (MWDC)

Knowing the typical cost per kilowatt and the percentage breakdown of that cost to the various cost centres, the estimate of spending and jobs is then calculated.

Additional effects on the outlook scenario are the expected reduction in the costs of the solar PV modules and inflation.

Appendix B

Alberta Solar Value Chain Participants

The combined list of value chain participants is made up from the SESA and CanSIA directories, with 100–300 organizations in each directory (with overlap). Solas identified the companies that have an office in Alberta as part of the Alberta value chain. These directories only include companies that are registered members; therefore, it is very likely that there are organizations active in Alberta's solar industry that are not in these directories. The list of companies was further processed by reviewing each organization and determining the services they provide, either internally or externally. The resulting list below is the participants who are part of the solar PV value chain.

Company Directory Listing — Utility-Scale⁴²

Owners

- Bluearth Renewables
- EDF Renewables Canada Inc.
- EDP Renewables Canada Ltd.
- Elemental Energy Renewables Inc.
- Enbridge Inc.
- Enmax
- EPCOR
- Greengate Power Corporation
- GP JOULE
- Hep capital AG
- Invenergy Canada
- NextEra Energy Canada
- Suncor Energy Inc.
- TransAlta

EPCs

- 3G Energy Development Inc.
- Aura Power Renewables Ltd.
- Ellis Don
- Hawk's Aerial and Technical Solutions Inc.
- Mirth and Sight Limited
- PCL Constructors Canada Inc.
- Solas Energy Consulting Inc. (Construction management)
- Stantec Consulting Ltd
- WSP Canada Inc.
- Teshmont
- Tetra Tech Canada Inc.

Electrical, Mechanical, Contractors, and Professional Services

- Logic Control
- Bennett Jones LLP
- Borden Ladner Gervais LLP
- Cassels Brock & Blackwell LLP
- Dillon Consulting Limited
- DNV GL
- Gowling WLG (Canada) LLP
- Hugh Wood Canada Ltd.
- LandSolutions
- Miller Thomson LLP
- Natural Resource Solutions Inc.
- Osler, Hoskin & Harcourt LLP
- Power Advisory
- Renewable Energy Systems (RES) Canada Inc
- Solas Energy Consulting Inc.
- Stikeman Elliott LLP
- Torvs LLP
- Scott Land & Lease
- URICA Energy Real Time Ltd.

Company Directory Listing — Utility-Scale (Cont'd)

Suppliers and Wholesale

- A-1 Ground Screws
- Arrow Arc Solar
- ATCO Group
- Azgard Solar Inc.
- Campbell Scientific (Canada) Corp.
- DC Power Corp.
- EECOL ELECTRIC ULC.
- Gallant & Company
- Graybar Canada
- Aimsio
- Almita Piling
- BAYO.S Canada Ltd.
- Fusetek
- Hellermann Tyton Canada
- Hoskin Scientific
- MR Control Systems International Inc
- Spartan Controls

Utilities

- AltaLink
- Enmax
- EPCOR
- Fortis Alberta Inc.
- Municipalities

Company Directory Listing — Residential⁴³

Owners

- Pathfinder Clean Energy (PACE) Limited
- Solar Brokers Canada
- W Dusk Energy Group, Inc.

• Engineering and Professional Services

- Green Cat Renewables
- Green Light Power Inc.
- SunFrog Solar
- Howell Mayhew Engineering
- Internat Energy Solutions Canada
- Zon Engineering Inc.
- DES Engineering Ltd.
- Dandelion Renewables
- R.J. Burnside & Associates Limited
- TECTONIC ENERGY CONSULTING Inc.
- CIMA+
- Pinchin Ltd.
- Power Advisory LLC
- SULINE
- VRK Solar Inc

- Prime Property Management
- ATB Financial
- Underwriters Laboratories of Canada Inc.
- CoPower Inc
- Jones Brown Inc.

[•] Finance and Commercial

 $^{^{\}rm 43}\,$ Those listed on the CanSIA or SESA directories.

Small system design, installation, commissioning and testing, and maintenance rooftop services

- @ Home Electric
- 1Sun
- 1tech Green Inc.
- Aeternum Energy & Developments
- AL SOLAR Inc.
- AltaPro Electric
- Ameresco Canada Inc.
- ASI Tech Energy Solutions
- Atlas Solar
- ATUM Energy Services Inc.
- Axis Electric Ltd.
- Blue Chip Electrical Inc.
- Blue Pond Solar
- Bright Earth Electric
- Byrne's Electric
- Calgary Solar
- Canadian Power Pac
- CAP Solar Ltd.
- CBI Solar
- Centre Star Energy Inc.
- CHE Power Structures
- C-It Solar
- Clean Power Electric
- CM SunEra
- Compass Rose Electric Inc.
- Conscious Choice
- Corellian Energy Solutions
- CorSolis Energy
- C-Returns
- CSWS
- Custom Electric
- Deco Management Services Inc.
- DNM Solar Solutions Inc.
- Earthtech Energy Services Inc.
- Eclipse Bio-Science Corp.
- Eco-Smart Energy Solutions Inc.
- Elekt Energy Services Ltd.
- Elementium Energy Corporation
- Empower Energy Corp.
- Eneray Solar
- Energysmart Canada
- Energywise Solar

- Ener-Kruse Solar / A Division of Kruse'n Construction
- Enova Energy
- EnSegs Inc.
- Epoch Electric and Renewable Systems
- Ever Star Renewables
- Evergreen & Gold Renewable Energy Inc.
- EVOLVrenewables Inc.
- Exposure Solar
- Freedom Energy Solar Experts Inc.
- Future Skies Energy Inc.
- G2 Solar
- Generate Energy Ltd.
- Genesis Solar
- Global Point Energy West
- Grace Energy
- Greenergy Renewable Energy Ltd.
- Gridworks Energy Group Inc.
- Hanas Electrical Services Ltd.
- Happy Solar & Renewable Energy
- Horizon North Power Systems
- Horizon Power Solutions 24-7 Inc.
- Houle Country Solar & Security
- Hound Tree Electric
- Ideal Electric & Controls
- Interstellar Energy
- J'S NRG
- Kantra Electric Inc.
- KCP Energy Inc.
- KIERNAN ELECTRIC
- Kumsons Electrical Services
- Kustom Projects Inc.
- Lambda Solar Energy Inc.
- Lean & Green Electrical Ltd.
- LumoSpec Technologies
- Majestic Electric
- Maverick Alternative Energy Inc.
- Megalith Power Alternatives Ltd.
- True North Solar Inc.
- Affordable Green Sun Solar
- GI Electrical
- MiEnergy Solar
- Momentum Solar

- N.A.P.S. Solar Store Northern Alternate Power Systems
- NE Generation
- Neighbour Power
- Net Zero Solar
- Newo Global Energy
- Northern Brea Renewables
- NRG Energy
- OFF GRID HEATING
- Okanagan Solar Ltd.
- Pomphrey Industries Corp.
- PONA Energy Corp.
- Powermax Electric & Solar
- Progressive Concepts Ltd.
- PV Solar Enterprises Ltd.
- Quantum Solar Solutions Inc.
- RDK Electric Ltd.
- Reck's Electric Ltd.
- Redi Fast Fix-It
- Regent Electric Ltd.
- Renewable Solutions
- Renewall Projects
- Rezcom Electric Ltd.
- Riteline Electric Ltd.
- Robinhood Energy
- Rokin' Renewable Ltd.
- Royal Energy & Electric Group Ltd.
- SARSCO Energy Consulting Inc.
- Sine Power Ltd.
- SkyFire Energy
- Sol Power Projects Ltd.
- Solace Electrical Solutions Ltd.
- Solar Base Electric Ltd.
- Solar Country Energy Ltd.
- Solar Den
- Solar Harvest Ltd.
- Solar Optix Energy Services
- Solar People
- Solar Pro Power
- Solar Super Store Inc.
- Solar Technical A Division of Schafer Electric Ltd.
- Solar Waves Energy
- Solar YYC Inc.
- Solaré Distributors Inc.
- Solarchi Canada

- Solarcor Energy Inc.
- SOLARMAX Power Inc.
- SolarNinjas Energy Solutions Ltd.
- Solarwind Renewable Energy Inc.
- Solun Ltd.
- Sun Peak Solar Solutions
- Sun Valley Solar & Electrical Ltd.
- Sunfind Solar
- Sungod Industries Ltd.
- SunMill Solar
- SUPERGREEN Solutions
- Sustainergy
- SYNCSOLAR Inc.
- Tarpon Energy Services Ltd.
- TerraGen Solar
- Terralta Inc.
- Thackos Energy Inc.
- The Force Solar Inc.
- The Solar Guys
- Traditional Electric Inc.
- Ultimate Electric Ltd.
- Ventures Green Inc.
- Verg Enterprises Inc.
- Vibrant Solar Solutions Ltd.
- VIELSOLAR
- VIRTUOSO ENERGY
- Vision Energy Inc.
- WATT Renewable Corporation
- West Coast Visions
- Western Solar
- Windy Sky Enterprises Ltd. O/A Edwards Electric 1988 & WeWentSolar.Ca

• Electrical, Mechanical, and other Contractors

- A-Phase Electrical & Contracting Services Ltd.
- CJ Energy
- Clark Builders
- Crestview Electric Ltd.
- Deane Roofing and Cladding Ltd.
- FUSION Power Systems
- Goose Creek Renewable Energy Inc.
- Great Canadian Solar Ltd.
- GW Electrical Services
- Hilman Electric
- Jayson Global
- Jeffrey Electric
- Juve Solar Ltd.
- Klis Electric
- Knight Plumbing, Heating, Air Conditioning & Electrical
- Kuby Renewable Energy
- Lexand Electric
- Longday Solar
- New Horizon Power and Controls
- North Light Energy
- OUR ELECTRICIAN
- Phase 3 Electric Ponoka Ltd.
- Ridgeline Power Solutions MAX Energy Corp.

Utilities

- ENMAX Energy Corp.
- EPCOR
- Bullfrog Power Inc
- Fortis Alberta Inc.
- Rocky REA

Associations

- Akamihk Community
- Alberta Green Economy Network
- Green Arrow Corp.
- Canadian Solar Industries Association
- DreamCatcher Energy Inc
- Edmonton Public Schools
- Peace Energy A Renewable Energy Cooperative
- Solar Energy Society of Alberta (SESA)

- Sirrom Wiring and Electrical Services Ltd.
- SOLAR CONCEPTS
- Summit Electric & Maintenance Ltd.
- Sunny South Insulators Inc.
- Taurus
- Team Tomic Electric Inc.
- Versatile Electric & Controls Ltd.
- Ward Contracting
- Wave Technical Ltd.
- Solar Homes Inc.
- Ascendant Renewable Energy, Inc.
- DREWS ELECTRIC Inc.
- Earthbound
- Exceed Solar
- REW Electric Inc.
- Simba Solar
- Solar Optix Energy Services
- SolarFlex Energy
- Sweeney Electric Ltd.
- Terralta Inc.
- The Light Idea Inc.
- TKO Electrical Contracting Inc.
- Water Valley Electrical

Technology Providers

- VM Systems
- Eramosa Engineering Inc.

Suppliers

- Ecofitt Corporation
- HFS PV
- Jackson Power & Electric Ltd.
- Kel-Terra Inc.
- Mustang Controls Ltd.
- Pronghorn Controls Ltd.
- Solar Wholesaler Ltd.
- National Solar Distributors Inc.
- EnSolar Energy Inc.
- Hammond Power Solutions
- Hb Solar Canada
- Impulse Technologies Ltd.
- Sentinel Solar
- Viessmann Manufacturing Company Inc
- Cybolnverter Canada
- Solarland Canada

Appendix C

Alberta Solar PV Training Programs List

Table 11: Alberta Solar PV Training Programs List

Training Provider	Course/program name	Course/program description and details
Decentralised Energy Canada (DEC)	Course 1: Technology Performance and Project Feasibility	Analysis of solar, wind, combined heat and power projects
MacEwan University	Business 201	Introduction to Sustainable Business, how a sustainable business is run, and how emerging issues in business can be addressed from a sustainability perspective
Grid Works Energy	1-Day Solar PV Introduction	Know more about tech and industry before purchasing a PV system for home or building
Grid Works Energy	3-Day Solar PV Design Course	Crash course on latest solar technology out there. Go over design theory for both string inverters and micro-inverters with the Canadian Electrical Code. Including solar economics, solar incentive/rebate programs available, solar contractors, business practices
Grid Works Energy	5-Day Hands-On Grid- Connected Solar PV Design and Installation Course	Similar to the 3-day course with an additional two days of hands-on practice in designing and installing string-inverter and micro-inverter PV systems.
Lakeland College	Renewable Energy & Conservation (Certificate/ Diploma)	Design, plan and complete renewable energy projects. Provides basics of types of renewable energy, energy principles, environmental impacts of energy generation and use
Mount Royal University	Strategic Sustainability & the Energy Industry Certificate of Completion	Gain an understanding of fundamentals of sustainability through three pillars, environment, society, and economics.
NAIT	Alternative Energy Technology — Diploma (2 years in-class training)	Students learn about various aspects of renewable energy systems: assembly, design, hybridization, permitting, and project economics. Solar training focuses on-site assessment, system layout and design (on-grid and off-grid), financial analysis, assembly, project management, inspection, testing, and commissioning.
NAIT	Continuing Education Course (30 hours)	Students learn how to successfully install, and troubleshoot solar PV residential systems. NAIT believes in the value of hands-on teaching, and this course is structured to allow you, a journeyman electrician, to become a competent and confident installer, ready to enter the growing renewable energy market with the required skills
NAIT	Bachelor of Technology in Technology Management	Students have the opportunity to choose from up to 15 electives from the sustainability area of interest, such as Environmental Impact Assessment; Issues in Society, Environment, and Sustainability; Environmental Management Systems; Global Citizenship; Global Energy Development and Society.
NAIT	Bachelor of Technology in Construction Management	Provides a degree in construction management including sustainability training.

Training Provider	Course/program name	Course/program description and details
SAIT	Solar PV: Introduction and Applications — ELEC 142	Examines the basics of solar PV installations, including the electrical grid system and how solar PV can help reduce reliance on it. Learn advantages of grid-tie, stand-alone and battery backup solar PV installations.
SAIT	Solar PV: Installation for Electricians — ELEC 141	Topics of permits/restrictions, logistical site considerations, system sizing, factors affecting solar PV output, and aspects involved with the CEC relating to the installation
SAIT	Construction Management Certificate	Certificate program
SESA	The Economics of Grid- Tied Solar Photovoltaics	Explore the economic advantages of grid-tied solar PV microgeneration systems with Alberta-specific examples
SESA	Photovoltaic System Design and Modelling	How to design and evaluate the performance of solar electric systems
SESA	Battery Based Photovoltaic Systems	How to design and evaluate the performance of battery based solar electric systems
SESA	Contracts for the Solar Industry — Summer 2018 (and continued)	How to create contracts for your solar installation business
SESA	Commissioning Solar PV Systems	Training on commissioning and testing photovoltaic systems
University of Alberta	MBA Natural Resources, Energy, and Environment	The 2-year MBA program will help develop analytical skills, industry understanding, and communications experience.
University of Alberta	Certificate Construction Management and Administration	250-hour certificate program
University of Calgary	Masters in Sustainable Energy Development	The interdisciplinary graduate program provides a balanced education related to energy and environmental management.
University of Calgary	Certificate in Professional Management — Construction	300-hour certificate program
Women Building Futures & Grid Works Energy	Electrical and Solar Energy Basics	5-week classroom and hands-on skills development training for employment in the electrical industry and solar energy industry
Women in Renewable Energy (WIRE)	Speed Mentoring	Helps students and professionals entering the energy field to receive mentorship and feedback
SEI	RE100: Introduction to Renewable Energy	Free course that covers the basics of renewable energy
SEI	PV101: Solar Training — Solar Electric Design and Installation	5-day course. Fundamentals give a solid understanding of various components, system architectures, and applications for PV systems. This focuses on grid-direct PV systems.
SEI	PV110: Solar Training — Solar Water Pumping	3-day course that combines presentations with hands-on experience. Learn how to select the proper pump for the job, sizing the PV array, selecting equipment such as controllers and linear current boosters and installation methods.

Training Provider	Course/program name	Course/program description and details
SEI	PV201L: Solar Training — Solar Electric Lab Week	Work in small groups and use what was learned in PV 101 to the test by installing and commissioning a wide variety of system types, then decommissioning and breaking down.
SEI	PV202: Solar Training: Advanced PV System Design and the NEC (Grid-Direct)	5-day course. Focus on residential and commercial-scale systems code requirements, design parameters, and best practices are applicable to all types and sizes of PV installations. Address requirements for disconnects, overcurrent protection, and wire sizing; interconnection requirements and calculations; grounding, ground faults, and surge protection; calculations for system sizing, inverter selection, and electrical configuration; ground and roof mount details; and commissioning performance analysis procedures.
SEI	PV 203: Solar Training — PV System Fundamentals (Battery-Based)	Fundamentals of battery-based systems. The applications and configurations and components such as batteries, charge controllers, and battery-based inverters.
SEI	PVOL206: Solar Training — Solar Business and Technical Sales	Focuses on technical details for sales professionals, financial analysis, and system financing.
SEI	PV303: Solar Training — Advanced PV Multimode and Microgrid Design (Battery-Based)	Detailed design considerations for AC and DC coupled systems, along with an in-depth presentation on designing a stand-alone micro grid.
SEI	PV204: Solar Training — Advanced PV Stand-Alone System Design (Battery- Based)	Detailed analysis of load considerations, charge controller sizing, and specifying stand-alone inverters with design examples that address the specifics of different off-grid applications.
SEI	PVOL350: Solar Training — PV Systems — Tools and Techniques for Operations and Maintenance	A 6-week course. Train technicians to safely and effectively perform operations and maintenance tasks including inspections, commissioning, performance verification, and troubleshooting
Northern Lakes College	Grid-Tie Solar Electric System Design and Modelling	A 3-week course designed to develop the skills needed to design and model solar electric systems for both residential and commercial installations. The course uses RETScreen and System Advisor Model software to teach how to construct feasibility reports and showcase performance of proposed systems and installations.
Northern Lakes College	Canadian Standards Association (CSA) Photovoltaic (PV) Exam Preparation	5-day course. The course is designed to appeal to those wanting to install solar electric systems with a home owner's permit, or those wishing to have an in-depth understanding of solar electric installations.
Northern Lakes College	Grid-Tie System Installation	The course will utilize the skills and knowledge from the 5-day CSA exam prep course to perform hands-on rooftop installation and commissioning of a 3 to 5 kW grid-tie PC system using a micro-inverter.

Training Provider	Course/program name	Course/program description and details
Solar Installers Canada (SIC)	Bronze SIC Certification Course	Shows proficiency in the fundamental basics of solar technology. The course includes a 1-day course to learn basics of solar and determine if solar is right for your home or RV and a 2-day course to introduce system sizing and size solar systems for yourself and clients
Solar Installers Canada (SIC)	Silver SIC Certification Course	Gain the ability to professionally size and maintain solar energy systems. Includes all course from Bronze certification plus 1-day solar workshop to explore concepts of angles, shading and series/parallel, learn to hook up batteries and battery workshop to learn how to properly connect and charge your batteries, and working with different types of batteries
Solar Installers Canada (SIC)	Gold SIC Certification Course	Includes all courses in Silver and Bronze certification. Additionally, full hands-on grid-tie installation in the facility, with both string and microinverters and install on an elevated roof as well as hands-on off-grid, including the required maintenance
Solar Installers Canada (SIC)	Introduction to Solar	6-hour course to begin photovoltaic understanding, including types of panels, how solar works in Alberta, types of systems, how many solar panels required for average home, etc.
Solar Installers Canada (SIC)	System Sizing Course	Introduction to simple solar theories, including grid-tied, offgrid, and hybrid systems.
Solar Installers Canada (SIC)	Solar Workshop Course	Workshop compounds the ideas of production capabilities, learn how to hook up panels in both series and parallel and monitor the outputs.
Solar Installers Canada (SIC)	Battery Workshop	Learn the fundamentals of battery storage, including hands- on workshop to design and install a battery system
Solar Installers Canada (SIC)	Hands-On Grid-Tie Course	Learn to fully install a grid tie photovoltaic system. Include safety parameters, tool inspection, and electrical wiring.
Solar Installers Canada (SIC)	Hands-On Off-Grid Course	Learn to fully install an off-grid photovoltaic system. Including compliance OH&S standards, ground-mount racking system, wiring, battery storage systems
Light Up the World	Introduction to Solar Technology	3-hour course to learn the basics of solar technology, electricity principles, solar PV system components, and how to do basic calculations to meet power needs
Light Up the World	Off-Grid Install One-Day Workshop	Understand how to install small-scale off-grid solar PV systems. Includes theory and practical hands-on workshops.

Appendix D

Solar PV Job Categories and NAICS Code where Relevant

The Alberta solar value chain model has considerable detail in the skills and professions needed for each stage of a project and operations. However, the JEDI model's output for the jobs created by a solar project is in higher-level categories. Therefore, it is important for this study to map the main categories of jobs from the JEDI model to the types of jobs seen throughout the project's lifecycle. For industry areas that have a relevant NAICS code, the number is listed:

Construction and installation labour

- Construction labourers
- Building trades
- Construction site assemblers and disassemblers
- O&M individuals

Construction and installation-related services

- Construction site managers
- Construction project managers
- Electricians
- Certified solar PV installers
- System commissioners
- Inspectors
- Drivers
- Heavy equipment operator

Manufacturing impacts

- Machine operators
- Assemblers
- Welders
- Robotic engineers
- Solar cell manufacturing semi-conductor and related devices 334413
- Electrical components manufacturing — 335999
- Wiring device manufacturing 33593

• Trade (wholesale & retail) 42,453 (miscellaneous)

Professional services

- Project managers
- Financial advisers
- Administration team
- Safety managers
- Legal 5411
- Management, scientific, and technical consulting 54161, 5613*
- Environmental other technical consulting 54162, 54169

- Scientific research and development 5417
 - Meteorologist
 - Environmentalist
 - Biologist
- Management 55**
- Architectural, engineering, and related 5413
 - Engineering disciplines
 Specialized design services 5414

Other services (directly related to solar industry)

- Transportation
- Couriers
- Warehousing and storage
- Publishers
- Communications
- Automotive
- Machinery
- Advertising
- Employment services
- Facilities support
- Security
- Waste management
- Educational services
- Health care services
- Family services
- Recreation
- Food services
- Repair and maintenance
- Civic, social, professional organizations

• Other sectors (not directly related to solar industry)

- Induced impacts (jobs created as a result of solar projects)
- Operations and Maintenance
 - Labour technicians
 - Supply chain impact Materials & equipment services
 - Induced Impact

Appendix E

Statistics Canada — Alberta Companies by NAICS Code

There is a general standard for industry codes for companies called NAICS: North American Industry Classification System. This study has collected all the NAICS codes that may be relevant to the tasks in the solar PV project. Secondly, Statistics Canada compiles the number of companies for each of the NAICS codes and reports on how many employees each company had. The following charts depict the talent pool for key elements for the phases of a solar PV project: development, design, manufacturing, and installation and commissioning, operations and maintenance, and decommissioning⁴⁴.

Table 12: Statistics Canada — Alberta Companies per NAICS Code

		Number of companies of different sizes by Number of employees									
Development		No. employees	Total	1-4	5-9	10-19	20-49	50-99	100- 199	200- 499	500+
561110	Office administrative services	2,221	1,081	785	116	68	57	28	11	6	10
541611	Administrative management and general management consulting services	5,765	1,765	1,603	101	36	19	5	0	1	0
541690	Other scientific and technical consulting services	5,707	2,249	2,064	96	58	20	6	3	2	0
541110	Lawyers' offices	2,106	2532	1,984	296	148	78	21	4	1	0
541360	Geophysical surveying and mapping services	724	257	209	18	7	12	5	4	2	0
541370	Surveying and mapping services (except geophysical)	184	202	93	28	25	33	18	5	0	0
541690	Environmental consulting services	5,707	2249	2,064	96	58	20	6	3	2	0
541620	Administrative management and general management consulting services	1,444	691	551	58	44	24	12	1	1	0

⁴⁴ Canada, S. (2016). Table 552-0007. Retrieved MAY 30, 2018, from http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=5520007 Canada, S. (2016). Table 553-0006. Retrieved MAY 30, 2018, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=5530006

		Number of companies of different sizes by Number of employees									
	Design		Total	1-4	5-9	10-19	20-49	50-99	100- 199	200- 499	500+
238210	Electrical contractors and other wiring installation contractors	2,360	2,200	1,291	404	206	184	77	19	13	6
541330	Engineering services	6,423	3,342	2,614	246	189	175	53	42	20	3
541360	Geophysical surveying and mapping services	724	257	209	18	7	12	5	4	2	0
541370	Surveying and mapping services (except geophysical)	184	202	93	28	25	33	18	5	0	0
541420	Industrial design services	222	117	110	5	2	0	0	0	0	0
541490	Other specialized design services	222	43	36	4	2	1	0	0	0	0
541690	Other scientific and technical consulting services	5,707	2,249	2,064	96	58	20	6	3	2	О
551114	Head offices	61	587	121	88	102	123	52	39	36	26
561110	Office administrative services	2,221	1,081	785	116	68	57	28	11	6	10

Ma	Manufacturing		Number of companies of different sizes by Number of employees										
- General		No. employees	Total	1-4	5-9	10-19	20-49	50-99	100- 199	200- 499	500+		
334410	Semiconductor and other electronic component manufacturing	15	24	8	3	5	2	5	1	0	0		
331110	Iron and steel mills and ferro-alloy manufacturing	6	6	2	0	3	0	0	0	1	0		
335920	Communication and energy wire and cable manufacturing	7	10	3	1	2	4	0	0	0	0		
335990	All other electrical equipment and component manufacturing	52	27	16	8	1	1	1	0	0	0		

Electrical Components		Number of companies of different sizes by Number of employees												
		No. employees	Total	1-4	5-9	10-19	20-49	50-99	100- 199	200- 499	500+			
238210	Electrical contractors and other wiring installation contractors	2,360	2,200	1,291	404	206	184	77	19	13	6			
335311	Power, distribution, and specialty transformers manufacturing	5	4	1	2	1	0	0	0	0	0			
335312	Motor and generator manufacturing	10	11	4	1	0	2	3	0	1	0			
335315	Switchgear and switchboard and relay and industrial control apparatus manufacturing	8	31	4	9	8	7	3	0	0	0			
335920	Communication and energy wire and cable manufacturing	7	10	3	1	2	4	0	0	0	0			
335930	Wiring device manufacturing	3	1	0	0	0	1	0	0	0	0			
335990	All other electrical equipment and component manufacturing	52	27	16	8	1	1	1	0	0	0			
541330	Engineering services	6,423	3,342	2,614	246	189	175	53	42	20	3			

Raw Materials		Number of companies of different sizes by Number of employees												
		No. employees	Total	1-4	5-9	10-19	20-49	50-99	100- 199	200- 499	500+			
326130	Laminated plastic plate, sheet (except packaging), and shape manufacturing	7	4	4	0	0	0	0	0	0	0			
327214	Glass manufacturing	1	9	4	3	1	0	1	0	0	О			
331110	Iron and steel mills and ferro-alloy manufacturing	6	6	2	0	3	0	0	0	1	0			
335930	Wiring device manufacturing	3	1	0	0	0	1	0	0	0	0			

Installation & Commissioning		Number of companies of different sizes by Number of employees												
		No. employees	Total	1-4	5-9	10-19	20- 49	50-99	100- 199	200- 499	500+			
237130	Power and communication line and related structures construction	111	143	55	24	25	21	8	4	3	3			
237990	Other heavy and civil engineering construction	253	196	79	33	28	35	11	7	3	0			
482113	Mainline freight rail transportation	8	29	6	6	7	4	1	1	1	3			
484110	General freight trucking, local	3,835	1,825	1,544	159	68	43	7	4	0	0			
484229	Other specialized freight trucking (except used goods), local	785	565	392	79	48	37	7	1	1	0			
484239	Other specialized freight trucking (except used goods), long distance	546	404	247	44	27	54	15	15	1	1			
488210	Support activities for rail transportation	20	54	14	12	12	10	3	1	2	0			
541330	Engineering services	6,423	3,342	2,614	246	189	175	53	42	20	3			
541690	Other scientific and technical consulting services	5,707	2,249	2,064	96	58	20	6	3	2	0			
561110	Office administrative services	2,221	1,081	785	116	68	57	28	11	6	10			
562110	Waste collection	159	195	98	38	26	28	2	3	0	0			
238210	Electrical contractors and other wiring installation contractors	2,360	2,200	1,291	404	206	184	77	19	13	6			
237310	Highway, street, and bridge construction	307	393	148	69	58	57	26	21	11	3			
238910	Site preparation contractors	1,669	1,354	796	220	137	123	35	29	10	4			
238990	All other specialty trade contractors	3,397	1,326	896	208	110	65	19	23	3	2			
551114	Head offices	61	587	121	88	102	123	52	39	36	26			
236210	Industrial building and structure construction	555	394	240	52	31	27	23	6	10	5			
237130	Power and communication line and related structures construction	111	143	55	24	25	21	8	4	3	3			
236210	Industrial building and structure construction	555	394	240	52	31	27	23	6	10	5			
238220	Plumbing, heating, and air-conditioning contractors	1,928	2,119	1,277	357	238	162	51	29	4	1			

Installation & Commissioning		Number of companies of different sizes by Number of employees											
		No. employees	Total	1-4	5-9	10- 19	20- 49	50- 99	100- 199	200- 499	500+		
238110	Poured concrete foundation and structure contractors	543	721	354	206	78	59	18	5	1	0		
331110	Iron and steel mills and ferro- alloy manufacturing	6	6	2	0	3	0	0	0	1	0		
331317	Aluminum rolling, drawing, extruding, and alloying	4	3	0	1	0	2	0	0	0	О		
331420	Copper rolling, drawing, extruding, and alloying	4	0	0	0	0	0	0	0	0	0		

Operations & Maintenance, Decommissioning		Number of companies of different sizes by Number of employees											
		No. employees	Total	1-4	5-9	10- 19	20- 49	50- 99	100- 199	200- 499	500+		
221119	Other electric power generation	72	30	12	8	2	7	0	1	0	0		
221121	Electric bulk power transmission and control	6	9	2	2	0	0	0	1	2	2		
541620	Environmental consulting services	1,444	691	551	58	44	24	12	1	1	0		
541690	Other scientific and technical consulting services	5,707	2,249	2,064	96	58	20	6	3	2	0		
551114	Head offices	61	587	121	88	102	123	52	39	36	26		
561110	Office administrative services	2,221	1,081	785	116	68	57	28	11	6	10		
561730	Landscaping services	1,566	1,414	743	376	163	93	26	10	3	0		
562110	Waste collection	159	195	98	38	26	28	2	3	0	0		
811310	Commercial and industrial machinery and equipment repair (except automotive and electronic) and maintenance	3,697	2,918	2,176	363	237	100	23	9	9	1		
811210	Electronic and precision equipment repair and maintenance	466	362	250	55	31	18	6	2	0	0		
419120	Wholesale trade agents and brokers	521	460	307	74	46	21	9	2	1	0		
913910	Other local, municipal, and regional public administration	68	330	70	49	58	39	47	39	19	9		
561612	Security guard and patrol services	127	111	27	14	15	29	6	3	12	5		
221122	Electric power distribution	61	63	17	7	17	9	4	3	4	2		
484110	General freight trucking, local	3,835	1,825	1,544	159	68	43	7	4	0	0		
238210	Electrical contractors and other wiring installation contractors	2,360	2,200	1,291	404	206	184	77	19	13	6		

Appendix F

Statistics Canada — Alberta Employees by NOCS Code

To explore the talent pool that the solar PV industry could draw from in Alberta, Solas queried the Statistics Canada Census from 2016 for the number of jobs by National Occupation Classification (NOC) code.

The relevant NOC codes were pulled for the value chain model and sorted by life stage of a project. The table below (Table 13) outlines the results. Please note that NOC codes are limited in detail, and some jobs were not distinguishable, such as lawyers.

Area	Position Title	2016 NOC	Median Salary	Number jobs
	Land acquisition specialist	1225	\$ 80,000	6,155
	Business administration — Renewables planning	1122	\$89,133	5,010
	Environmental scientist	4161	\$ 97,820	2,450
Development	Resource scientist	2115	\$ 98,073	100
	Meteorologist	2114	\$ 83,229	140
	Financial adviser	111	\$ 100,354	6,025
	Project engineer/ Project manager	211	\$ 162,008	2,335
5 .	Civil engineer	2131	\$ 109,348	6,450
Design	Electrical engineer (including power engineer)	2133	\$ 118,700	4,795
	Industrial and manufacturing (includes quality engineer)	2141	\$ 134,624	1,555
Manufacturing	Assembler and fabricator	9525	\$ 54,598	90
	Logistician/Supply chain supervisor	1215	\$ 64,436	4,105
	Construction manager	711	\$ 101,121	10,045
In an all	Electrician technician	2242	\$ 59,592	4,015
Install	Construction labourer	7611	\$ 55,241	10,180
	Construction Inspector	2263	\$ 88,639	1,480
	Asset manager	125	\$ 74,235	1,930
O&M,	Site manager (facility O&M)	714	\$81,737	6,035
Decommissioning	Environmental science technician (civil technical)	2231	\$ 85,678	1,840
	Meteorological technician	2255	\$ 80,565	1,115

Table 13: Statistics Canada — Alberta Jobs by NOC code

