University of Alberta Future Energy Systems

# Alberta Energy Market Profile

Measuring the Costs and Benefits of Energy Transitions

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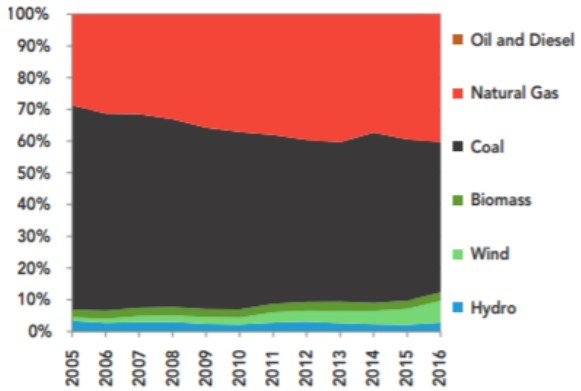
## Context

Alberta's electricity generation predominantly comes from coal and natural gas. In 2016, 47.4% of the total generation was sourced from coal, 40.3% of total generation was from natural gas, and only 12.3% of total generation was from renewable sources. However, there has been significant growth in the wind sector, from 1.1% to 6.9% of total generation since 2005, mostly in the southern portion of the province (National Energy Board (NEB), 2017). In 2016, Alberta was a net importer of energy, trading with BC, Saskatchewan, and Montana (NEB, nd). While Alberta has had hydropower facilities for a long time, with plants built in the 1910s, the construction of these facilities has not kept pace with the energy demand or the production of coal and natural gas facilities.




Electricity Generation by Source 2005 – 2016
Image from: NEB, 2017

Relative to the electric generation mix of other Canadian provinces, Alberta is significantly behind in utilising renewable sources. A possible reason for this is due to the importance of the oil and gas sector and extraction activity for the Albertan economy. Additionally, for 44 years, the provincial government was under the leadership of the Progressive Conservative party, for whom renewable energy was not a priority.

## Alberta Demographics

- **Population**: 4,067,175 (11.6% increase from 2011-2016)
- **Average Age**: 37.8
- **Working Age** (15-64): 2,787,805
- **Private dwellings**: 1,654,129
- **Private dwellings occupied by usual residents**: 1,527,678

Source: Statistics Canada (2016)

## Alberta's Average Consumption

In 2015, the annual consumption of electricity per capita was 19.8 MWh, ranking Alberta as the second highest province in Canada for electricity consumption (36% higher than the national average of 14.5 MWh) (NEB, nd). Calgary has an average cost per $104 per 1,000 kWh, significantly lower than the Canadian mean of approximately $121 per 1,000 kWh (NEB, 2017). The majority of electricity is consumed by industrial users (51% of consumption), followed by commercial users (27% of consumption), residential users (18% of consumption), and farm users (4% of consumption) (Hastings-Simons et al., 2018).

## Regulations

Since 2001, Alberta has a deregulated energy market, with the Alberta Energy System Operator (AESO) acting as the independent system operator and the *Electric Utilities Act* outlining the rules for a competitive power pool (AESO, nd). Various agencies are responsible for managing specific parts of the energy market; the Balancing Pool manages the auction of Power Purchase Arrangements; the Alberta Utilities Commission (AUC) acts as a regulator of utility providers; and the Market Surveillance Administration monitors the market and recommends penalties and fines for the AUC. The Alberta grid connects 235 generating stations with consumers. Any generating station can connect to the grid, subject to the approval of the Alberta Utilities Commission and any relevant permits, laws, and bylaws (AESO, nd). Using Power Purchase Arrangements, buyers purchase electricity from a generator to sell to consumers (Hastings-Simons et al., 2018).

## Micro-Generation

Under *Micro-Generation Regulation* (2008), residents can generate electricity using renewable sources as long as the capacity is under 5 MW. Any excess energy can be sold back to the grid in exchange for energy credits. Small microgenerators (under 150 kilowatts) are credited at the retail rate for electricity, whereas any larger microgenerators are credited at the wholesale market price (Government of Alberta, nd*a*). As of May 2018, microgeneration capacity is as follows (AESO, 2018*a*):

- Solar: 2,481 sites with 25.654 MW total installed capacity
- Solar/Wind: 29 sites with 0.195 MW total installed capacity
- Wind: 63 sites with 0.912 MW total installed capacity
- Other: 8 sites with 0.253 MW total installed capacity
- Natural Gas: 1 site with 0.305 MW total installed capacity
- Natural Gas Cogeneration: 1 site with 0.847 MW installed capacity

## Goals

Since the election of the NDP government, the Albertan government has established a goal of procuring 30% renewable electricity by 2030, under the *Renewable Electricity Act* (2016). Additionally, the government is planning to phase out coal generation by 2030, primarily by transitioning or replacing these facilities with natural gas generators. The Province has introduced a number of programs to encourage renewable energy generation, some of which are listed below:

- **Renewable Energy Program**: This program is intended to procure 5,000 MW of renewable energy by 2030. Last year, the first round of the project supported 600 MW of renewable capacity currently under construction. This program provides financing for renewable projects and is funded through the Alberta Climate Leadership Plan (Government of Alberta, 2018).

- **Carbon Competitiveness Incentives Regulation:** This regulation applies to large scale greenhouse gas emitters (greater than 100,000 tonnes per year). Operating as a cap and trade

system, generators are allocated emission performance credits that allow a maximum amount of emissions. Generators who exceed their allowance are allowed to purchase credits from other generators and offsets. Renewable projects can sell offsets or opt into the system and receive emission performance credits they can sell (Hastings-Simon et al., 2018).

- **Alberta Municipal Solar Program:** This program provides a rebate per watt to municipalities to install solar modules on municipal facilities or land (Municipal Climate Change Action Centre, nd). In April of 2017, $2 million had been provided to 28 projects across 18 municipalities through this program (CBC, 2017).

- **Alberta Indigenous Solar Program** and **Alberta Indigenous Green Energy Development Program:** These programs help fund programs in First Nation Communities and Metis Settlements (Government of Alberta, nd*b* and Government of Alberta, nd*c*).

- **On-Farm Solar Photovoltaics Program:** This program provides financial support for farms to install photovoltaics (Government of Alberta, nd*d*).

- **The Residential and Commercial Solar Program:** This program provides financial incentives for private building owners to install photovoltaics (Energy Efficiency Alberta, nd).

- **Community Generation Capacity Building Program:** This program, the result of a partnership between Energy Efficiency Alberta and the Municipal Climate Change Action Centre, provides funding for pre-development activities for community-owned renewable energy projects (Energy Efficiency Alberta, nd*a*).

- **Community Generation Program:** The Government of Alberta has provided $200 million dollars over 20 years to this program to provide community projects with price guarantees for the energy produced. By providing revenue certainty, the Government of Alberta intends to encourage investment in community renewable generation. This program is expected to launch in fall of 2019 (Energy Efficiency Alberta, nd*b*).

## Transitioning Market

The Government of Alberta has endorsed a recommendation by the AESO to transition from an energy market to a capacity market. This transition is recommended to ensure the reliability of the electricity system, provide more stable prices, provide revenue certainty for generators, maintain a competitive market force, drive innovation and cost discipline, and be adaptable to policy decisions (AESO, 2016).

The existing Energy-Only Market Structure suffers from a lack of interest in investment due to revenue uncertainty. Thus, it is unlikely that there would be sufficient uptake to meet future demand (AESO, 2016). Additionally, the energy-only market structure also makes it difficult to support renewable energy. As intermittent energy sources are added to the grid, the revenue to all generators will be reduced, thereby reducing investment in energy generators. Both wind and solar reduce the pool price because the cost of operation is comparatively low. As firm generators lose revenue when wind and

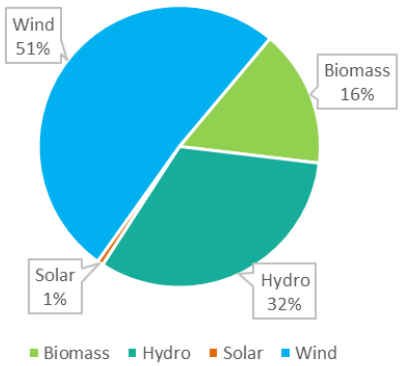
solar are producing, they must charge higher prices when wind and solar are not producing. Back up generating plants will be required and the firm generation capacity will not be reduced through the use of renewable technology. As coal is a firm generator and is being phased out, the market needs to able to incent firm generators to replace coal (AESO, 2016).

The Capacity Market System is intended to provide revenue certainty to investors, increasing the likelihood of investing in renewable generators and natural gas facilities to replace coal power plants (AESO, 2016). While the capacity market is recommended, a number of disadvantages were discussed. These include having an increased complexity. Additionally, forecasting error may lead to procuring more capacity than necessary, resulting in higher costs than necessary to consumers for short periods of time (AESO, 2016). While the AESO has recommended this transition, some consumer groups have expressed concern over high prices (Varcoe, 2018).

## Renewable Projects

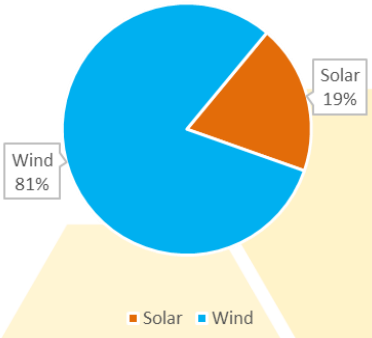
The majority of renewable projects in Alberta are privately owned and operated and sell to the power pool. Renewable energy projects in operation have a capacity of approximately 2,897 MW, out of the provinces total capacity of 16,390 MW (AESO, 2018*b*). Renewable energy represents approximately 17.7% of the total capacity. However, there are several projects in development, either seeking AUC approval or funding, that are anticipated to bring an additional 4,104.2 MW of renewable energy into the market. These planned or proposed projects include the four projects funded under the Renewable Energy Program.

Renewable Projects in Operation by Type




Of operational projects, the largest renewable source in Alberta is wind, likely due to the significant potential in southern Alberta. The next largest renewable source is hydroelectricity followed by biomass. Solar represents the smallest number of commercial producers but is the most significant renewable used for microgeneration, which has a capacity of 25.7 MW (AESO, 2018*a*).

Renewable Projects in Development by Type

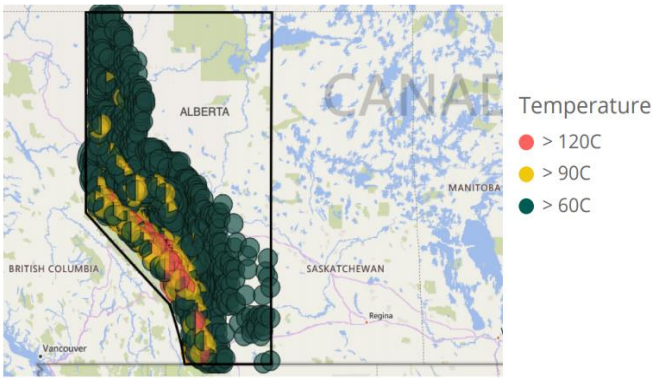



Examining proposed renewable projects, the majority of proposed projects are wind farms. No biomass or hydroelectric projects are currently proposed, although there are multiple commercial solar farms in development, including the 400 MW Travers Solar Project in Vulcan.

# Renewable Energy Potential

## Geothermal

Geothermal electricity is produced when geothermal fluid (heated water) is drawn from the ground and used to generate electrical energy (Leitch, Hastings-Simon, & Haley, 2017). Utility-scale electricity may be produced at water temperatures greater than 100° C (Banks, 2017). Alberta has significant potential for geothermal energy production, estimated to be as much as 389 MW of geothermal capacity, and is well-poised to incorporate geothermal energy due to the transferability of skills, workforce, and policy with the oil and gas industry (Leitch, Hastings-Simon, & Haley, 2017).




Wells with Repurposing Capacity
Source: Fuzeium Innovations,
https://fuzeium.com/geothermal-co-production-study-3/

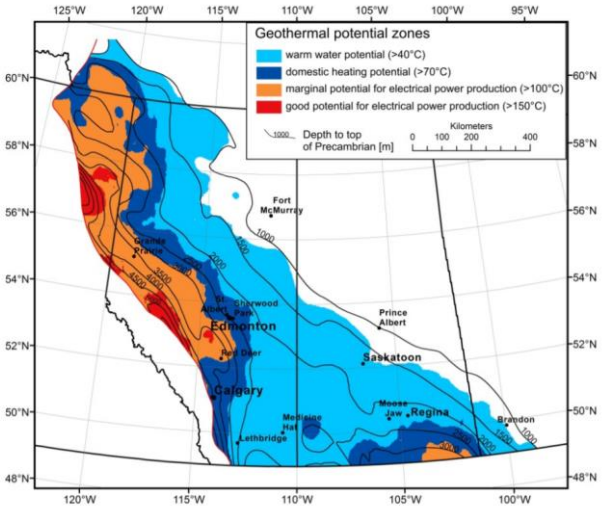
The Pembina Institute has completed a report evaluating the transferability of knowledge and infrastructure between the oil and gas sector and geothermal energy. There are a number of tools in the oil and gas sector that may be repurposed to support geothermal development (Leitch, Hastings-Simon, & Haley, 2017):

- Skills: Both the oil and gas and geothermal industry rely upon an understanding of geological exploration, drilling, subsurface thermodynamics, and heat transfer. These similarities would allow employees in the oil and gas sector to be easily transferred to the geothermal sector.
- Regulatory Framework: Alberta has a regulatory framework that guides the development and operations of oil and gas sites that can be adapted to the development and operations of geothermal wells. Some regulatory elements that can transfer include permitting, site safety standards, project management elements, and requirements for environmental assessments.
- Sub-Surface Data: geothermal energy requires an understanding of sub-surface processes which can be determined or estimated from oil and gas data.
- Use of Wells: Geothermal energy extraction can repurpose abandoned wells or produce alongside active wells through co-generation. The Canadian Geothermal Energy Association estimates there are 60,935 wells that may be suitable for geothermal energy. Repurposing wells significantly enhances the financial viability of geothermal projects; drilling costs are around 30-40% of a project cost.

Alberta's capacity for geothermal energy is not evenly geographically distributed, and some areas have significantly more potential than others. The map adjacent displays possible geothermal application based on temperature at the top of the Precambrian basement. From this report, potential areas for

geothermal electrical generators include the hamlet of Winfield and the Town of Hinton (Weides & Majorowicz, 2014).

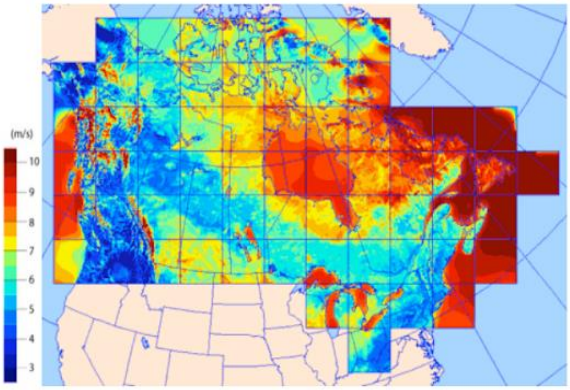
The University of Alberta has produced a report examining the geothermal potential in western Alberta (Banks, 2017). The project found a capacity of 1,150 MW in the project area over a 30 year timeline. In the County of Grande Prairie, the is a capacity for 185 MW, enough energy to meet all the domestic needs. The Municipal District of Greenview had a capacity of 175 MW. The Town of Hinton has a capacity of 630 MW, sufficiently high to replace the existing 450 MW coal plant. Clearwater County has a capacity of 160 MW (Banks, 2017).




Geothermal Potential Areas
Source: Weides & Majorowicz, 2014

## Wind

Wind energy has an estimated potential of 150 GW, more than enough to meet Alberta's demand for energy (Solas Energy Consulting, 2013). The adjacent map shows average annual wind speeds in the nation, with speeds of more than 7 m/s (yellow) being considered potentially economically viable (Bell & Weis, 2009). Southern Alberta has significantly higher potential than Northern Alberta, which is reflected in the current and proposed locations of wind projects.




Average Annual Wind Speed at 80 m
Source: Environment Canada, as depicted in Bell & Weis, 2009

In a 2015 national study by Barrington-Leigh & Ouliaris, wind potentials across the nation were measured to determine the feasible generation. Using GIS, high wind potentials were identified using wind speeds of 7 m/s at a height of 80 m. The study excluded protected lands, inland water bodies, First Nations land, and a 5 km buffer around population centres. The remaining lands were then amended to only include lands near transmission lines (Barrington-Leigh & Ouliaris, 2015). Assuming that 25% of the remaining high potential areas are utilised, which accounts for competing land uses, Alberta could generate 169 TWh per year. Of Alberta's total 2015 energy demand of 699 TWh per year, wind energy could account for 24% of Alberta's total energy generation (Barrington-Leigh & Ouliaris, 2015).

## Hydroelectric

The Canadian Hydro Association estimates that Alberta has more than 11,500 MW of economic hydro potential that can be captured, through both reservoirs and run of river projects (EEM, 2006). However, feasibility is challenged by reservoir projects that cause significant ecological harm and are therefore unlikely to be approved.

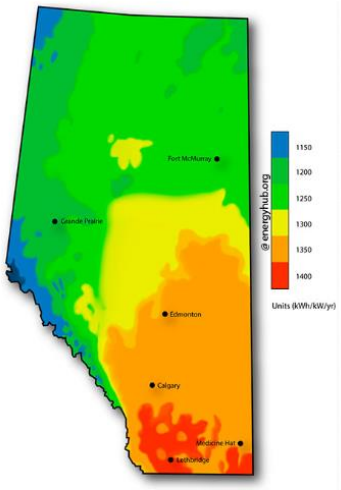
A Hatch Ltd. 2010 report evaluates potential by drainage basin. The following values provide the ultimate developable hydroelectric energy potential, or the maximum practically developable generation accounting for river characteristics, lack of suitable sites, social or environmental restrictions, and others (Hatch Ltd., 2010).

- Athabasca River Basin: 13,050 GWh
- Churchill River Basin: No hydroelectric potential
- Hay River Basin: 100 GWh
- Milk River Basin: No hydroelectric potential
- North Saskatchewan River Basin: 8,270 GWh
- Peace River Basin: 19,720 GWh
- Red Deer River: 340 GWh
- Slave River Basin: 7,640 GWh
- South Saskatchewan River Basin: 3,930 GWh

Barrington-Leigh & Ouliaris (2015) used the technical feasibility of hydroelectric resources and assumed a 60% capacity to generation ratio and 60% of feasible sites are developed to determine the feasibility of energy generation from hydroelectric sources. Alberta could produce 101 TWh per year, which could meet 14% of the total 699 TWh per year demand.

## Solar

Alberta has the second highest potential of the provinces as a solar producer, in terms of energy generating ability per kilowatt of installed capacity (Solar Panel Power Canada, nd), benefiting from receiving lots of sunlight and having cold temperatures. It is estimated it would require 1,746 $km^2$ of solar panels to meet all of Alberta's energy needs (Glave and Thibault, 2014). Southern Alberta has significantly more potential than northern parts of the province. Potential will also vary daily and seasonally. Using the most feasible areas in the nation and excluding the lands most feasible for wind development, Alberta could produce 63 TWh per year, accounting for 9% of the total demand of 699 TWh per year (Barrington-Leigh & Ouliaris, 2015).




Average Annual Solar Generation Capacity per kW installed
Source: https://solarpanelpower.ca/solar-power-maps-

## Bioenergy

Barrington-Leigh & Ouliaris (2015) summarised the potential biomass energy provided by James (2009), which found Alberta could produce 90.4 TWh per year, accounting for 12.9% of the total energy demand in 2015.

## Environmental Considerations

All renewable projects, when applying for their AUC permit, must abide by Alberta Environment and Parks designed considerations of ecological impacts. This includes a list of ecologically sensitive areas to avoid situating renewable projects, which is comprised of grasslands, old growth forest stands, named water bodies, valley breaks, valleys of large permanent water courses, and wildlife sensitivity areas.

# Key Definitions

**Capacity:** maximum electric output a facility can produces, and is measured in MW (National Energy Board, 2017)

**Generation:** process of producing electric energy by transforming other forms of energy using this capacity. Generation describes the amount of energy produced, and can be measured in gigawatt hours (National Energy Board, 2017).

**Renewable:** any energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate at which they are consumed. Hydro, tidal, wind, biomass, and solar electricity are considered renewable (National Energy Board, 2017).

## References


AEP (2018). Wildlife Land Use Guidelines. Retrieved from: http://aep.alberta.ca/fish-wildlife/wildlife-land-use-guidelines/default.aspx

AESO (2018*a*). Micro-Generation in Alberta. Micro-Generation Reporting.

AESO (2018*b*). Current Supply Demand Report. Retrieved 3:02 pm, May 29, 2018.

AESO (2016). Alberta's Wholesale Electricity Market Transition Recommendation. Retrieved from: https://www.aeso.ca/assets/Uploads/Albertas-Wholesale-Electricity-Market-Transition.pdf

AESO (nd). Guide to Understanding Alberta's Electricity Market. Retrieved from: https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/

ATCOPower (nd). Oldman River Hydroelectric Dam. Retrieved from: http://www.atcopower.com/Our-Facilities/Our-Power-Technologies/Hydroelectric/Oldman_River

Banks J. (2017). Deep-Dive Analysis of the Best Geothermal Reservoirs for Commercial Development in Alberta: Fina Report. *University of Alberta Earth and Atmospheric Services.*

Barrington-Leigh, C. & Ouliaris, M. (2015). The Renewable Energy Landscape in Canada: A Spatial Analysis. Retrieved from: http://wellbeing.ihsp.mcgill.ca/publications/Barrington-Leigh-Ouliaris-IAEE2015.pdf

Bell, J. & Weis, T. (2009). Greening the Grid: Powering Alberta's Future with Renewable Energy. *Pembina Institute*.

CBC (2017). Alberta Touts Success of Solar Power Program for Municipalities. Retrieved from:http://www.cbc.ca/news/canada/calgary/municipal-solar-program-alberta-didsbury-panels-rebates-electricity-greenhouse-gas-1.4058691

Chalcroft, D. (1988) The Engineering Background to the Oldman River Dam and Reservoir , Canadian Water Resources Journal, 13:3, 6-14

City of Medicine Hat (nd). Box Springs Wind Farm. Retrieved from: https://www.medicinehat.ca/government/departments/utility-sustainability/hat-smart/city-initiatives/box-springs

Daschuk, J. & Marchildon, G.(1993). Historical Chronology of the Oldman River Dam Conflict. Retrieved from: http://www.parc.ca/mcri/pdfs/HistoricalChronologyoftheOldmanRiverDamConflict.pdf

Dodge, D. & Thompson, D. (2015). Green Acres, the Largest Solar Farm in Western Canada. *Green Energy Futures.* Retrieved from: http://www.greenenergyfutures.ca/episode/hutterite-solar-western-canada-biggest

EEM (2006). Study of the Hydropower Potential in Canada.

Energy Efficiency Alberta (nd). Renewable Energy - Now More Affordable. Retrieved from: https://www.efficiencyalberta.ca/solar/

Energy Efficiency Alberta (nd*a*). Community Energy Capacity Building Program. Retrieved from: https://www.efficiencyalberta.ca/cgcb/

Energy Efficiency Alberta (nd*b*). Community Generation Online Resource Hub. Retrieved from: https://www.efficiencyalberta.ca/commgen/

Hastings-Simon, S., Kaddoura, S., Klonick, A., Leitch, A., and Porter, M.(2018). Plugging In: Opportunities to procure renewable energy for non-utility companies and institutions in Alberta. *The Pembina Institute, Rocky Mountain Institute and Calgary Economic Development*.

Hatch Ltd. (2010). Final Report for Alberta Utilities Commission Update on Alberta's Hydroelectricity Energy Resources.

Glave, J. & Thibault, B. (2014). Power to Change - How Alberta Can Green Its Grid and Embrace Clean Energy. *Pembina Institute, Clean Energy Canada, and the Pembina Foundation*

Government of Alberta (2018). Renewable Energy to Power New Jobs, Investment. Retrieved from: https://www.alberta.ca/release.cfm?xID=55695ADD3C996-CDCD-89D9-6A025089F93B3584

Government of Alberta (nd*a*). What is Micro-Generation? *Alberta Energy.* Retrieved from: http://www.energy.alberta.ca/AU/electricity/AboutElec/Pages/MicroGen.aspx

Government of Alberta (nd*b*). Alberta Indigenous Solar Program. *Alberta Indigenous Relations.* Retrieved from: http://indigenous.alberta.ca/AISP.cfm

Government of Alberta (nd*c*). Alberta Indigenous Green Energy Development Program. *Alberta Indigenous Relations*. Retrieved from: http://www.indigenous.alberta.ca/AIGEDP.cfm

Government of Alberta (nd*d*). On-Farm Solar Photovoltaics Program. *Alberta Agriculture and Forestry.* Retrieved from: https://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv464

James, D. (2009). Biomass Energy Possibilities for Alberta to 2100. Energy Futures Network.

Learned, K., Kinas, H. & Lee, T. (2017). Survey Report: Large Scale Wind & Solar Decision Support Tools for Rural Municipalities Project. *Miistakis Institute*. Calgary, AB.

Leitch, A., Hastings-Simon, S., & Haley, B. (2017). Heat Seeking: Alberta's Geothermal Industry Potential and Barriers. *Pembina Institute*.

Municipal Climate Change Action Centre (nd). AMSP. Retrieved from: http://www.mccac.ca/programs/AMSP

National Energy Board (nd). Provincial and Territorial Energy Profiles - Alberta. Retrieved from: https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/ab-eng.html#s2

National Energy Board (2017). Canada's Renewable Power Landscape - Energy Market Analysis 2017. Retrieved from: https://www.neb-one.gc.ca/nrg/sttstc/lctrct/rprt/2017cndrnwblpwr/2017cndrnwblpwr-eng.pdf

Solar Panel Power Canada (nd). Canadian Solar Power Resource Maps. Retrieved from: https://solarpanelpower.ca/solar-power-maps-canada/

Solas Energy Consulting (2013). A WindVision for Alberta – Technical Overview Report, Version 2.0, page 9.

Statistics Canada (2016). Census Profile, 2016 Census - Alberta [Province]. Retrieved from: http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=48&Geo2=&Code2=&Data=Count&SearchText=Alberta&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=48

Varcoe, C. (2018). Government Watchdogs Worry Alberta's New Power Market Could Trigger Costs. *Calgary Herald.* Retrieved from: http://calgaryherald.com/business/energy/varcoe-consumer-group-launches-complaint-over-albertas-new-power-market

Weides, S. & Majorowicz, J. (2014): Implications of Spatial Variability in Heat Flow for Geothermal Resource Evaluation in Large Foreland Basins: The Case of the Western Canada Sedimentary Basin. Energies, 7, 4, p. 2573-2594.