Case Study
Blackspring Ridge 1 Wind Project

Abstract
This case study is intended to give insight into the feasibility of wind power to provide reliable electricity generation sufficient to meet household and commercial demand in a 2050 NetZero Alberta. During a 2-month period, net generation was 144.1 Mw out of 298.8 Mw of nameplate capacity (48.2%). On a minute-to-minute basis, net generation varied wildly from 0% to 100% and was unable to meet demand without support from fossil fuel generation.

To eliminate the need for fossil fuel support, it would be necessary to install 35,000 Mw of energy storage at an estimated cost of $16.1 Billion.

Based on Canadian averages, the 166 Turbines could result in 2570 Bat deaths and 1360 bird deaths per year.

A NetZero Alberta by 2050
To replace all fossil fuels on the Grid will require the design, consultation, environmental review, approval, and construction of at least 16,340 Mw of Net Capacity (29,710 Mw Nameplate Capacity) of Wind Power.

This is 16,510 Wind Turbines (@ 1.8 Mw) covering 44,565 acres ...or... 11-12 turbines each and every week between 2022 and 2050.

To provide constant and reliable power at constant voltage and frequency will require 4,195,000 Mw of energy storage at a capital cost of $1.93 Trillion. That is $343,600 per Alberta Resident.

Reaching NetZero is neither technically, logistically nor economically feasible.

There is, however, a potential case for adding some level (20-30%) of renewables to the grid with the sole intent of extending Natural Gas reserves into the future.

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Methodology & Notes

To capture typical performance, a two-month period was chosen. Sufficient to identify trends while providing adequate resolution to measure hour-to-hour performance.

The Blackspring Ridge 1 Wind Project was selected because it is located within an area where wind speeds are typical of the rest of Alberta. This recognises that early wind farms were located around Pincher Creek where wind speeds are abnormally high. As additional wind turbines are installed, they will be in areas similar to Blackspring Ridge.

Wind turbines were selected as the preferred choice for adding capacity.

- They have the 2nd lowest LCOE excluding energy storage of any renewable option.
- They have a significantly higher net energy capacity than Solar which is the lowest cost option.
- Existing technology is relatively advanced. Supply, manufacturing, construction and logistics are well understood.

The justification (Climate Change) for the move to NetZero is not addressed as it is irrelevant to the analysis and conclusions. The costs to the consumer and the taxpayer far outweigh any imagined benefit.

Note 1: This case study is a snapshot in time of a specific wind project. The results should be considered a best-case scenario with the understanding that other periods during the year may produce less power and be less reliable.

Note 2: Data collection began without knowledge of the results (i.e., a period with poor performance was not select with foreknowledge of the results).

Note 3: Due to the many uncertainties around future projections of electrical consumption, economic development, population growth and EV adoption, this case-study takes a conservative view and makes no attempt to estimate 2050 electricity consumption precisely, and only considers a reasonable scenario that favors a best-case result. The results therefore are directionally correct but very conservative.
Demand vs. Supply

Electricity Supply must mirror Demand precisely on a 1/60th of a second (60 Hz) basis.

- Voltage must be controlled within a limited range (120V/240 for residential).
- Frequency must be controlled within a limited range (60 Hz).

Therefore, electricity production averaged over minutes, hours and/or days is irrelevant when discussing the capability of a facility to meet demand.

Blackouts (complete loss of electricity supply) and Brownouts (off spec voltage and/or frequency) are unacceptable and to name a few examples may result in:

- Loss of household & Commercial building heat.
- Failure of water supply.
- Business interruption.
- Damage to equipment.
- Unsafe situations such as being stuck in an elevator, interruption to health care services, failure of traffic control, etc.

Blackspring Ridge Net Generation

Hourly generation data was collected between Dec 1, 2020 and Jan 31, 2021.

Average net power generated was 144.1 Mw or 48.2% of nameplate capacity. This would supply 175,300 typical households IF it was a constant regulated supply.

Of critical importance is that while the average net generation was 144.1 Mw/hr, the minute to minute net generation varied widely from 0% to 100% with absolutely no ability to control the rate to meet Grid demand.

Approximately 40% of the period, net generation was below the average. The following histogram illustrates how unreliable Wind power is in Alberta.
As a direct result of the unpredictable, unreliable, and erratic energy generation, it cannot in isolation meet grid demand which requires responsive and controllable output at a specific rate.

Currently, thermal generation (Fossil Fuels) provides adequate support to enable the project to supply a small portion of the total grid demand without affecting voltage and/or frequency.

Bat and Bird deaths are an increasing concern with wind turbines.

- A 2016 study found that approximately 15.5 ± 3.8 bats were killed per turbine per year in Canada.
- A separate study found that approximately 8.2 ± 1.4 birds were killed per turbine per year in Canada.

Blackspring Ridge can therefore be expected to kill on average **2570 (1940 – 3260) bats** and **1360 (1130 – 1590) birds** each year.

It should be noted that Solar Energy is less reliable and more erratic than Wind.

To reach the 2050 NetZero target, Fossil Fuels must be abandoned. Therefore, all wind (or Solar) generation requires Energy Storage to provide a dispatchable (controllable) supply at correct voltage and frequency.
Energy Storage – How Much and at what Cost?

Current technology offers several Energy Storage Options:

- Batteries – Li-ion, liquid metal, salt water, etc.
- Compressed and Liquified Air Storage
- Hydrogen
- Pumped Hydro
- Gravity Battery (Stacked Block or fixed weight)

For this case study, Li-ion batteries are selected. They are proven technology with well documented costs that are generally lower than other technologies at this time.

Using the net generation of 144.1 Mw for the facility, the required storage capacity for the period can be assessed. This is a best-case that does not include allowances for inverter efficiency, line loses, battery efficiency, temperature effects, battery deterioration and other factors that will increase the required storage capacity.

During the period, battery storage would be needed for more than 254 hours of continuous and uninterrupted supply @ 144.1 Mw to achieve average net generation. This would require a minimum of 35,000 Mw of total storage capacity.

This can be expressed as 242.4 Mw of storage for every 1 Mw of Net Wind Power Generation.

As of Jan 2021, the largest grid scale battery storage system is 300 Mw / 1200 Mwh, located in Monterey County, California. The facility began operation in December 2020.

According to Lazard, the capital cost of wholesale storage with a capacity 100 Mw, capable of up to 200 Mwh output is $488 US to $980 US per Kw (Avg $734 US/Kw).
Recognizing that the cost of batteries has fallen in recent years, the Lazard capital cost should be adjusted for the purposes of this case-study.

The average cost for 100 Mw / 200 Mwh capable storage is given as $734 US/Kw. Converting to Canadian funds at $1.25 Can/US the cost would be $917.5 Can/Kw. Assuming future costs will drop 50% between 2022 and 2050, the cost of storage will be $458.8/Kw or $458,800/Mw.

Capital cost for 35,000 Mw of storage will therefore be $16.1 Billion to support 144.1 Mw net generation of wind power.

Grid Interconnection as a Replacement for Energy Storage

An option often put forward to avoid Energy Storage is the interconnection of renewable facilities in different areas so that when the production from one drops off, the others ramp up to meet demand. This is not practical because:

- All interconnecting transmission lines would need to be able to carry the combined load of all connected facilities.
  - A transmission line recently installed between Pincher Creek and Calgary (160 kms) cost $2.2 Billion.
- Additional substations would have to be built.
- Wind and Solar are not dispatchable. Their generation rates cannot be increased or decreased except under very limited circumstances.
- Unless located significant distances apart, what affects one, generally affects many to some degree. The following graph shows a snapshot of all renewable energy generation in Alberta over a 48-hour period. Note that the Total Generation is uncontrolled as all facilities are generating maximum potential.
Relying on the import of electricity from other jurisdictions to eliminate or at a minimum reduce energy storage will present challenges as other provinces and states will also be expanding their grids to meet an equivalent level of demand as they strive to eliminate GHG emissions.
Scaling up to meet NetZero by 2050

Generation Capacity in Alberta 2021:

Fossil Fuel

<table>
<thead>
<tr>
<th>Type</th>
<th>Capacity (Mw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (@95% Eff)</td>
<td>5,072</td>
</tr>
<tr>
<td>Cogen (@95% Eff)</td>
<td>5,085</td>
</tr>
<tr>
<td>Simple Cycle (@95% Eff)</td>
<td>1,125</td>
</tr>
<tr>
<td>Combined Cycle (@95% Eff)</td>
<td>1,753</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>13,035</strong></td>
</tr>
</tbody>
</table>

Current Peak Demand: 12,000 Mw

Renewables

<table>
<thead>
<tr>
<th>Type</th>
<th>Capacity (Mw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass (@95% Eff)</td>
<td>430</td>
</tr>
<tr>
<td>Wind (@55% Eff)</td>
<td>980</td>
</tr>
<tr>
<td>Hydro (@95% Eff)</td>
<td>849</td>
</tr>
<tr>
<td>Solar (@15% Eff)</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>2,275</strong></td>
</tr>
</tbody>
</table>

Note: Although net generation capacity during the period was only 48.2%, it is assumed that future wind projects would be able to optimize locations to increase net generation. For this reason, 55% is used for future projections.

Looking at 2021 Peak Demand it is evident that there is sufficient thermal generation capacity (13,035 Mw) without the need for any renewables. Subsidies, RECs and capital costs for renewables only serve to add an unnecessary burden on consumers and taxpayers.

Adding Wind capacity to meet NetZero in 2050

It is reasonable to expect that generation from Cogen facilities will still be a viable source in 2050. Net capacity may be reduced somewhat as the economy shrinks due to punitive carbon taxes and increased costs for goods and services. For this case-study however, it is assumed that it will remain at 2021 levels.

It is also assumed that the number of Electric Vehicles will continue to grow. As of 2016 with a total population of 4.07 Million, there were 3,589,302 vehicles registered in Alberta. Extrapolating to 2050 with a projected population of 6.8 Million, there will be 5,997,000 registered vehicles. Of those, approximately 5,515,000 (92%) weigh less than 4500 kg and would be replaced by an EV. If we assume a conservative 85% will be EVs in 2050, that equates to at least 4,685,000 EVs.

EVs create a unique problem for the grid. The majority of drivers work during the day so most recharging will occur in the early evening and overnight. People will generally prefer to recharge as soon as possible and will tend to plug in their cars as soon as they get home. This would create a very high demand that will have to be mitigated by constraining when people can recharge their vehicles.

This will invariably lead to “Smart Meters” being mandated which have the capability to adjust the price of power during different times of day and even shut off power to customers to maintain Grid Integrity. This
will not result in cheaper power during off-peak periods, but rather more expensive power during peak periods. This will increase the cost of operating an EV for many people.

Assuming that average EV usage is 15,000 km/year, at 15 Kwh/100 km total consumption will be:

\[(15,000 \text{ km/year} \times 15 \text{ Kwh/100 km}) / 8760 \text{ hrs/year} = 0.256 \text{ Kw capacity}\]

**Projected Demand 2050**

<table>
<thead>
<tr>
<th>Population of 6.8 Million:</th>
<th>22,500 Mw</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,685,000 EVs @ 0.256 Kw</td>
<td>1,200 Mw</td>
</tr>
<tr>
<td>Total</td>
<td>23,700 Mw</td>
</tr>
</tbody>
</table>

**Existing Sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cogen (@95% Eff):</td>
<td>5,085 Mw</td>
</tr>
<tr>
<td>Biomass (@95% Eff):</td>
<td>430 Mw</td>
</tr>
<tr>
<td>Hydro (@95% Eff):</td>
<td>849 Mw</td>
</tr>
<tr>
<td>Solar (@15% Eff):</td>
<td>16 Mw</td>
</tr>
<tr>
<td>Wind (@55% Eff):</td>
<td>980 Mw</td>
</tr>
</tbody>
</table>

| Total | 7360 Mw |

**Additional Renewable Energy Req'd:**

| Nameplate Capacity @ 55%: | 29,710 Mw |
| Turbines @ 1.8 Mw: | 16,510 Units |
| Land Area @ 1.5 acres/Mw: | 44,565 Acres |

Includes pad, substations, access roads, etc.

To install 16,510 new wind turbines beginning in 2022 with completion by 2050 will require 11 - 12 turbines to be installed each and every week for 28 years (1456 weeks) without downtime due to weather, supply, personnel or logistic issues. An enormous undertaking that has never been achieved.

While new wind turbines are being installed, substations and transmission lines must be installed to tie the new turbines into the grid.

During the 28-year period, many of the existing wind turbines will reach the end of their useful life and require major upgrades and/or replacement. This will include new installations that were completed between 2022 and 2030.
Adding energy storage to meet NetZero in 2050

Using the above projections, total wind generation will be the existing 980 Mw plus an additional 16,340 Mw for a total of 17,320 Mw.

Using a factor of 242.2 Mw of storage for every Mw of net generation capacity, total storage required will be 4,195,000 Mw of energy storage.

At an estimated capital cost of $458,800/Mw, the total cost would be $1.93 Trillion

Nuclear Power – A Viable Alternative?

The average nameplate capacity of all nuclear units in Canada is 720 Mw. Net generation is 706 Mw (98% Efficiency). Typically, 4 Units are combined for a net generation capacity of 2824 Mw per facility.

To add the required 16,340 Mw capacity to replace fossil fuels and meet 2050 demand, it would take 23 units. This would require almost 4 units to be built and commissioned every 5 years until 2050. This is technically possible but would pose almost insurmountable logistical and economic hurdles.

A major obstacle will be the public perception of nuclear power as being unsafe. This is untrue, but accidents if they do occur can be spectacular. To obtain approval to build the first nuclear plant would take at least 10 years to go through the entire process including consultation, environmental impact reviews and other major hurdles. It would not be unreasonable to expect significant legal action by groups opposed to nuclear. That means at best that there will be only 19 years to commission 23 units or one every 10 – 11 months.

Technological advances such as Small Modular Reactors (SMR) which produce up to 300 Mw and reactors that can use spent fuel from other reactors may address some issues, but in general, nuclear is not a practical option to achieve NetZero in 2050

Social Impacts

The push to NetZero will increase the cost of electricity to all consumers.

The required subsidies to install renewables to this magnitude will be enormous adding significant tax increases, punitive carbon taxes and/or increased national debt.

High electricity costs and punitive taxes will increase the costs to all businesses. Net cost will increase at all levels of the supply chain and the cumulative costs will be passed onto the consumer when they purchase goods and services.

As fossil fuel usage is reduced, royalty revenue received by the Alberta government will be lost. Renewables do not pay royalties.

Impacts to all Canadians will include but definitely are not limited to:

- Higher unemployment as businesses move production offshore to countries with lower costs.
- Higher unemployment means less income tax collected. This will have to be replaced by higher taxes for those still employed.
- Loss of royalty revenue from fossil fuels will reduce government revenue resulting in higher taxes.
- Loss of excise and road taxes currently paid at the gas pump. This will have to be replaced by an EV Usage Fee, reducing savings people gained by switching to an EV.
- More than 50% of Canadians who live paycheck to paycheck will be pushed to the breaking point.
- Many will be forced to choose between “Heat or Eat”.

http://www.goinggreencanada.ca/Case_Study_Black_Spring_Ridge.pdf
Case Study
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- Existing homes will have to be retrofitted to heat with electricity. The cost will be paid by the homeowner or landlord (passed onto the tenant). Utility bill's will skyrocket.
- New homes will be more expensive to build & cost more to heat.
- Loss of farmland will result in lost crop and/or livestock production.
- Many will be forced to give up their homes as living close to wind turbines is untenable. They will not be able to sell their homes so will lose all their investment.
- With less disposable income:
  - Many people will find it more difficult or impossible to qualify for a mortgage.
  - Consumers will spend less at local businesses resulting in many having to close their doors.
  - Consumers will be forced to buy less expensive foreign made products at Big Box Stores. This will result in even more local businesses having to close their doors. Foreign products have a larger Carbon Footprint than products made in Canada.

A Case for limited Renewables

There is a case for adding renewables today to extend Natural Gas supplies in the future. For example, at todays rate of consumption, Natural Gas supplies may become scarcer in 40 – 50 years. This of course is dependant on the development of new reserves and/or technology innovation to improve efficiencies of existing equipment. At some point however, it will run out.

By installing renewables to replace 20% to 30% of Combined Cycle Electricity today, the supply of Natural Gas will be extended in the future. The economics should be based on the cost of installing renewables today against the Present Value of Natural Gas in the Future when prices increase due to scarcity. It is a reasonable assumption that there may be a valid case for this.

Project Description

Completion Date: Aug 24, 2014
Nameplate Capacity: 298.8 Mw
Wind Turbines: 166 Vesta V100-1.8 Mw
Design Objective: Provide clean energy to approximately 140,000 households.
Alberta Household Electricity Consumption: Average 600 Kwh/month = 7200 Kwh/year (0.822 Capacity)
Renewable Energy Certificates (RECs): 20-year agreement with PG&E for the sale of all RECs generated by the project.
Subsidies: RECs Only
Lifespan: 25 years
Location: N 50 8.085, W 112 54.969
Case Study
Blackspring Ridge 1 Wind Project

http://www.goinggreencanada.ca/Case_Study_Black_Spring_Ridge.pdf

Project Footprint

Average Wind Speeds
Case Study

Blackspring Ridge 1 Wind Project

Sources:

- Blackspring Ridge 1 Wind Project Final Report
- PSTI Dashboard - Data Source
- Lazard - Authority on LCOE
- Info on Blackouts and Brownouts
- Grid Scale Energy Storage Info
- Utility Scale Battery Information - 2019
- Worlds Largest Battery Storage System
- Provincial Energy Profiles
- Alberta Electricity Generation Factsheet
- Vehicle Registrations Alberta 2012-2016
- Vehicles Registered in Canada 2015 to 2019
- US Energy - Nuclear Power
- Nuclear Power in Canada
- SMR Reactors
- Destroying Alberta's Affordable Power Advantage - Fiends of Science
- Design Considerations of a Real-World Interprovincial Energy Corridor Transmission Line - Kent A Zehr
- Alberta Census Profile 2016
- Bat Deaths from Wind Turbines in Canada 2016
- Bird Deaths in Canada - Avian Conservation & Ecology

Other Opinions

- https://www.linkedin.com/pulse/winds-winter-discontent-curtis-sheptycki/

W.R. Johnson
Feb 1, 2021

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