THE SCHOOL OF PUBLIC POLICY

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Evaluating the efficiency of renewable energy policy tools to incentivize deployment of renewable energy in Alberta

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Table of Contents

Executive Summary

This report analyzes the efficiency of renewable energy policy as a tool for Albertan policymakers to accelerate the decarbonization of the province's electricity sector. Alberta's electricity system is the most emissions intensive in Canada. Albertans consume only 11% of total electricity generated in Canada but produce 52% of electricity associated emissions. Increasing renewable energy deployment in Alberta could significantly reduce CO2 emissions in the sector and assist in the global fight against climate change.

Policy tools have been used in provinces outside Alberta and in international peer countries to drastically increase the deployment of renewable energy. Proponents of renewable energy policy argue that similar outcomes could be achieved in Alberta. Albertan policymakers have implemented some programs to incentivize renewables development in the past, but more action will be needed to achieve deep decarbonization of the electricity system.

Four policy tools are commonly used in attempts to increase the deployment of renewable energy technologies: carbon pricing, investments in intertie capacity, loan guarantees, and feed-in tariffs (FITs)[1]. These policies address the main barriers to renewables deployment, which are intermittency of variable renewable power generation, lack of financing opportunities, and competition with conventional fossil fuels. This paper evaluates case studies in each of the four policy tools from the Canadian provinces and international comparators to evaluate their ability to increase renewables deployment. The policy tools are then evaluated in the Alberta context to consider regional implications in their implementation. If the stated policy options are capable of efficiently incenting renewables deployment abroad, policymakers may wish to consider implementing or expanding those policy options here in Alberta.

[1] IRENA. 2013 "*Renewable Energy Innovation Policy: Success Criteria and Strategies*" Accessed November 16, 2020. https://www.irena.org/publications/2013/Mar/Renewable-Energy-Innovation-Policy-Success-Criteria-and-Strategies

The report concludes that carbon pricing, intertie capacity investments, loan guarantees, and feed-in tariffs are efficient in increasing renewables penetration in both Canadian and international contexts. If policymakers pursue a comprehensive approach to policy development that considers GHG emissions, electricity prices, intermittency, and impacts on market participants, renewable energy policy can be an efficient tool to accelerate the deployment of renewable power in Alberta.

Introduction

Alberta is home to the most emissions intensive electricity system of all Canadian provinces. In 2018, Alberta made up only 11% of Canadian electricity consumption but 52% of Canadian emissions from electricity generation. In the same year, 91% of electricity in Alberta was produced from either coal or natural gas[2]. Figure 1 visualizes the dominance of fossil fuels in Alberta's electricity system.

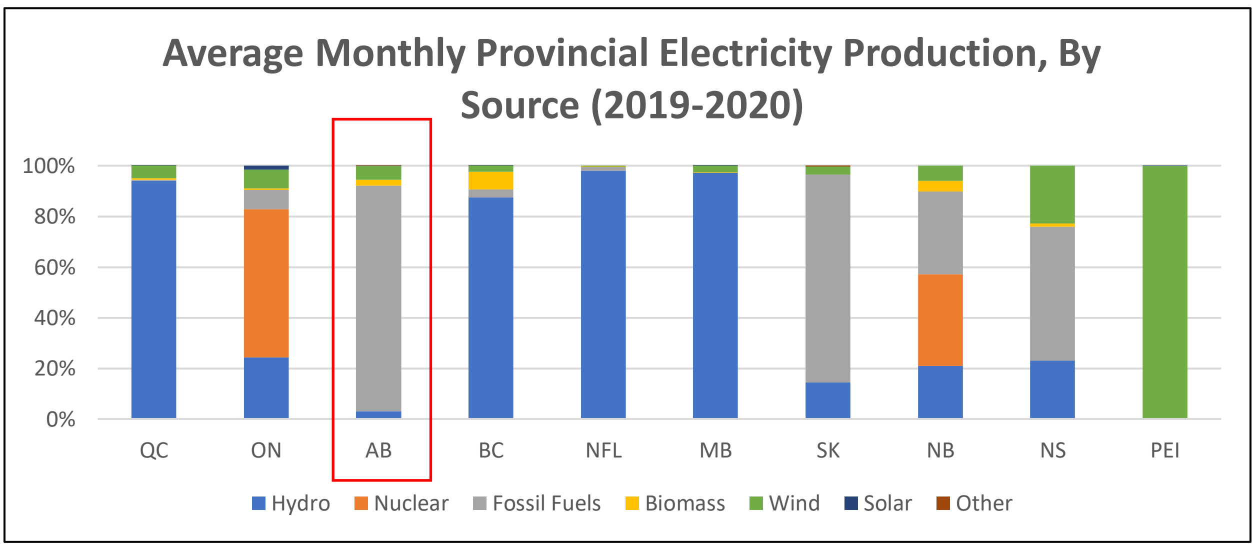

Figure 1: Average monthly provincial electricity production in the Canadian provinces in 2019-2020, by source.

Reliance on fossil fuels for electricity generation in Alberta is a large barrier to achieving Canada's emissions reductions targets as set out in the Paris Climate Agreement. If Alberta wishes to generate meaningful emissions reductions in accordance with Paris, it will need to rapidly transition away from fossil fuels and into renewable energy. Furthermore, decarbonization of the electricity sector may

[2] Canada Energy Regulator. N.d. "*Provincial and Territorial Energy Profiles*" Accessed November 16, 2020. cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles.

encourage the electrification of other sectors that could take advantage of low-carbon power to meet their own decarbonization goals.

Recent policy directives initiated the transition towards low-carbon electricity in Alberta. In 2015, the phase-out of coal power was legislated in the *Climate Leadership Plan*[3]. This will see the retirement of 40% of Alberta's current electricity generation by 2030. The generation technology that is used to replace coal-fired power will likely remain in Alberta's system for up to 40 years, given the long lifespan of utility scale electricity projects. Therefore, the policy choices made between 2015 and 2030 will have long lasting economic and climate impacts. If coal power is primarily replaced by natural gas, the province will miss out on a big opportunity for decarbonization. Therefore, if Albertan policymakers wish to seize this opportunity for emissions reduction, they should consider implementing policy tools that encourage rapid deployments of renewable energy.

Renewable energy policy has been used to increase renewables penetration in similar Canadian provinces like British Columbia and Ontario. They have also been used in international peer countries like Germany, Sweden, and the United States. Proponents of renewable energy policy argue that it could also be used to encourage electricity sector decarbonization in Alberta. Despite the promises of renewable energy policy, opponents suggest that propping up renewables development in the province would have negative impacts on electricity prices, supply stability, and employment in the electricity sector. To analyze the efficiency of renewable energy policy as a tool to increase renewables deployment and reduce GHG emissions, this study evaluates case studies from Canadian provinces and international peer countries. It also discusses the regional implications of these policy options if they were to be implemented in Alberta. If renewable energy policies can be used to efficiently incent renewables

[3] Alberta. 2015. "*Climate Leadership Plan: Progressive Climate Policy*" Accessed August 21, 2020. https://open.alberta.ca/publications/alberta-s-climate-leadership-plan-progressive-climate-policy

deployment in Alberta, policymakers may wish to adopt them to assist in the decarbonization of the provinces electricity sector and aid in the global fight against climate change.

Background:

Scientists and policymakers have emphasized that decarbonization of electricity generation will be important for mitigating the worst impacts of climate change[4]. Electricity generation is the second largest producer of GHG emissions in Alberta[5]. 16% of emissions in Alberta come from the electricity sector. As a result, policymakers have begun to focus on developing and deploying renewable energy to reduce the emissions intensity of emissions systems. Numerous policies have been implemented in attempts to deploy more renewable energy; this suite of policy tools is referred to as renewable energy policy.

Overview of the Alberta Renewable Electricity Market

Before discussing the prospective and historical policies intended to accelerate renewables deployment, it is important to develop an understanding of the market for electricity in Alberta. In particular, the uniqueness of Alberta's deregulated market model and its diversified resource endowment require special consideration.

The Deregulated Market Model:

Unlike most provinces, the Alberta government does not own or operate its own utility company. The province runs a deregulated market that dispatches electricity through a real time energy market[6]. The wholesale electricity market operates under an "energy-only" model, that pays generators only for the electricity they produce. Generators enter offers one week in advance of the settlement interval for their anticipated generation at a desired price that can be changed up to two hours before delivery. Based on

[4] Patel, P. and V., Gunderson. "*Deep decarbonization faces deep challenges"* MRS Bulletin 42(9): 632-33. https://doi-org.ezproxy.lib.ucalgary.ca/10.1557/mrs.2017.191

[5] https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-alberta.html#:~:text=The%20largest%20emitting%20sectors%20in,11%25%20(Figure%208).

[6] Alberta Electricity System Operator. N.d. "*Guide to understanding Alberta's electricity market*" Accessed November 24, 2020. https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/

the offers made by generators, a merit order is sorted that determines which generators are dispatched based on real-time demand for electricity. The system encourages competition among producers to generate the lowest cost electricity. For renewables to be profitable in this deregulated electricity system, they must generate electricity at a levelized cost below the average pool price. The average pool price in 2019 was $54.88[7]. There are some renewable resources that can produce electricity below this average pool price, namely solar PV and onshore wind, but many renewables sit just outside this marginal price.

Alberta's Renewable Resource Endowment

Alberta is best known for its abundant fossil fuel reserves, but Alberta also has a strong endowment of renewable energy resources. Alberta has access to ample variable renewable resources, like wind and solar, as well as numerous firm low-carbon resources, like hydrogen, geothermal, and biomass. A summary of Alberta's renewables potential in each of these resources is provided below.

Wind

Wind is Alberta's most developed renewable resource. There are ample wind resources in the province, particularly in Southern Alberta and along the Rocky Mountains[8]. Wind turbines begin spinning at wind speeds between 12-14km/h and reach full capacity at 50-60km/h. Most areas in Alberta are capable of operating wind turbines at full capacity. Much of the province has average wind speeds of 50-70km/h[9]. Average wind speeds in Pincher Creek, where most new and existing wind power is built, can exceed 100km/h. Wind power is also the lowest-cost option for electricity in Canada. In December 2017, a competitive supply auction in Alberta produced the lowest average rate paid for wind power in the

[7] Alberta Electricity System Operator. N.d. "*Reports – Pool Price*" Accessed November 25, 2020. http://ets.aeso.ca/
[8] Canada. 2016. "*Wind Atlas*" Accessed Nov 11, 2020. http://www.windatlas.ca/maps-en.php?field=E1&height=50&season=ANU
[9] Transportation Alberta. N.d. "*Analysis of Hourly Wind Data*" Accessed November 9, 2020. http://www.transportation.alberta.ca/Content/docType30/Production/hrwinddata.pdf

country at $37/MWh[10]. As a result of these high wind speeds and low project costs, wind power is viable across most of the province.

Solar

One common misconception about Alberta is that it has limited solar potential. In reality, Alberta has the second-best average lifetime expected electricity production from solar PV in Canada, trailing only Saskatchewan[11]. Alberta also benefits from the most sunny days of any province in Canada[12]. Resultantly, the breakeven price for residential solar in Alberta is below any other province[13]. Alberta's sunniest municipality, Wildhorse, has a solar potential of 1373kWh/kW. Calgary also has commendable solar potential, at 1292kWh/kw. For comparison, one of the world's largest solar hotspots, Los Angeles, has a solar potential of 1485kWh/kW. Indeed, there is ample potential for buildout of cost-competitive solar power in Alberta.

Geothermal

Amongst the Canadian provinces, Alberta is uniquely positioned to buildout geothermal capacity. Given the provinces existing oil and gas infrastructure and skilled workforce, the transition to geothermal energy would be relatively smooth. A recent study estimated that there approximately 500 wells in Alberta that could be repurposed for geothermal energy production[14]. Cumulatively, the technical potential of proven and inferred geothermal energy in Alberta – total possible production given structural, ecological, and regulatory constraints – is between 139,000MW and 555,800MW[15] assuming 5% and 20% recovery rates, respectively. This generating capacity is substantial, Alberta currently has 16,332MW of installed

[10] Canadian Wind Energy Association. 2019. "*Wind Facts: Affordable Power*" Accessed October 29, 2020. https://canwea.ca/wind-facts/affordable-power/#:~:text=Wind%20energy%20is%20now%20the,of%20%2437%20per%20megawatt%20hour.m

[11] Natural Resources Canada. 2020. "*Photovoltaic potential and solar resource maps of Canada*" Accessed November 17, 2020. https://canwea.ca/wind-facts/affordable-power/#:~:text=Wind%20energy%20is%20now%20the,of%20%2437%20per%20megawatt%20hour.m

[12] Gridworks Energy. N.d. "*Myth: Alberta is not a good place for solar power*" Accessed November 12. 2020. https://gridworksenergy.com/myth-alberta-is-not-a-good-place-for-solar-power/

[13] Canada Energy Regulator. 2020. "*Economics of Solar Power in Canada – Results*" Accessed October 20, 2020. https://gridworksenergy.com/myth-alberta-is-not-a-good-place-for-solar-power/

[14] Canadian Geothermal Association. N.d. "*Alberta well filtering study overview, wellhead analysis, methodology, and dashboards*" Accessed November 17, 2020. https://www.cangea.ca/reportanddashboards.html#:~:text=Over%2060%2C000%20oil%20and%20gas,C)%3A%20about%207%2C200%20wells

capacity. Despite this vast potential, very little geothermal energy has been built in Alberta. Geothermal projects are still relatively expensive; LCOE for geothermal projects range between $59-$101/MWh. If project costs for geothermal energy fell, through renewable energy policy or otherwise, Alberta would be well positioned to adopt huge amounts of firm low carbon geothermal energy.

<u>Hydrogen</u>

Alberta also has the opportunity to leverage oil and gas expertise for the development of hydrogen power. Canada is ranked as the second-lowest cost producer of "blue" hydrogen[15]. Blue hydrogen is formed by steam methane reforming of natural gas coupled with carbon capture and storage. The main appeal of hydrogen in Alberta is that it would repurpose existing reserves of oil and gas for hydrogen production. Rather than lying dormant, these suspended or orphaned wells could produce hydrogen. Alberta could also generate green hydrogen, or hydrogen produced from renewable energy powered electrolysis of water. Both of these production methods have potential in Alberta. Despite the broad appeal of hydrogen-fired electricity, it is still relatively expensive. The LCOE for hydrogen is approximately $100/MWh to $200/MWh, well above the LCOE for natural gas. If policy was successful in reducing the LCOE for hydrogen-fired electricity production, Alberta could position itself as a world leader.

<u>Biomass</u>

Alberta also has the opportunity to leverage existing agricultural and landfill infrastructure for the development of biomass energy. Alberta's prairie and forested lands host vast agricultural and forestry development; byproducts from these processes can be used to produce biomass energy. Furthermore, sequestered methane emissions from landfills can be used to generate biogas energy. There is currently 428MW[16] of installed biomass/biogas capacity in Alberta, with potential for much more. Biomass energy

[15] Canadian Energy Systems Analysis Research. 2020. "*Alberta can lead the Transition to a Net-Zero Canada – While Re-Energising its Economy*" Accessed October 1, 2020. https://www.cesarnet.ca/blog/alberta-can-lead-transition-net-zero-canada-while-re-energising-its-economy
[16] Green Alberta Energy. N.d. "*Energy in Alberta – Statistics*" Accessed November 3, 2020. https://www.greenalbertaenergy.ca/statistics.html#:~:text=In%20Alberta%2C%20there%20is%20a,and%20other%20eco%2Dfriendly%20resources.

can be produced at rates that are nearly competitive with fossil fuel fired generation, at $49/MWh[17]. Biomass is the least expensive form of firm low-carbon power in Alberta. If LCOE for biomass is reduced to levels competitive with natural gas, Alberta could produce a large portion of its energy needs from biomass.

Economics of Renewable Power:

It is clear that Alberta has the potential to develop each of the above renewable resources, but the economics for these resources vary greatly. For renewables to compete in Alberta's market, they need to be able to produce electricity near or below the LCOE of natural gas. Wind, solar, and biomass energy are all cost-competitive, but geothermal and hydrogen are not. Figure 2 summarizes the cost competitiveness of these different generation technologies.

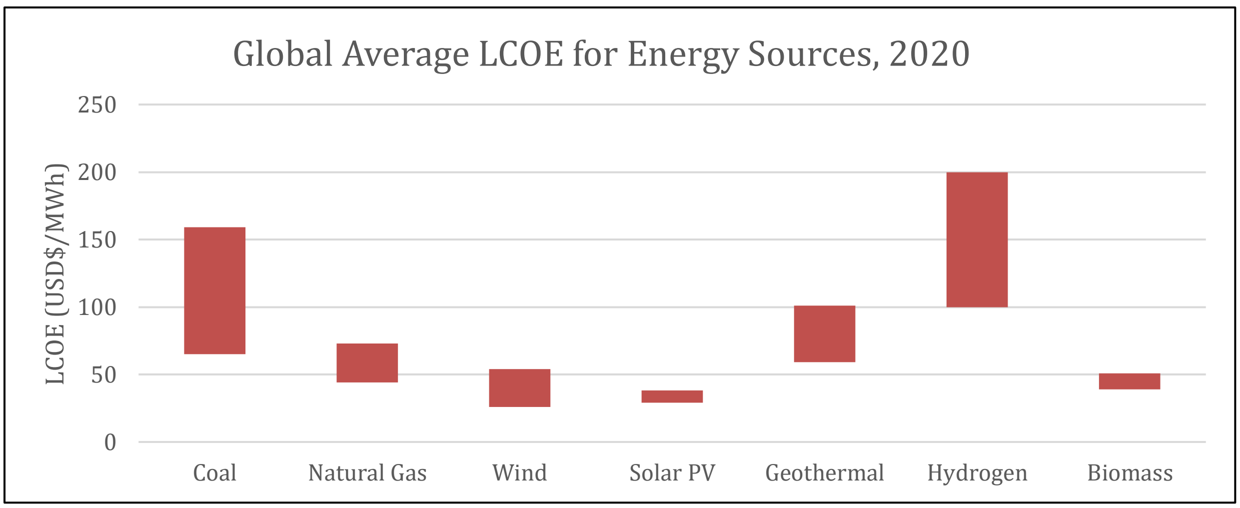

Figure 2: Global average levelized cost of electricity (USD$/MWh) for renewable and conventional sources of electricity. Adapted from Lazard[18] and CERI[17].

The Renewable Energy Program:

Alberta has implemented a few key renewable energy policies aimed at accelerating the deployment of the above renewable resources; the most noteworthy of which is the Renewable Energy Program (REP).

[17] Canadian Energy Research Institute. 2018. "*A comprehensive guide to electricity generation options in Canada*" Accessed November 6, 2020. https://ceri.ca/assets/files/Study_168_Full_Report.pdf

The REP is Alberta's most ambitious renewable energy policy to date. The REP was implemented in 2016 via the *Renewable Electricity Act*[18] with the objective of achieving 30% renewable electricity generation by 2030. The REPs three phases utilized an Indexed Renewable Energy Credit (REC) that were secured through competitive bidding processes. Winners of the REC bidding process secured long term contracts that set guaranteed prices ($/MWh) for renewable power generation. 12 contracts totaling 1359.3MW were offered over the programs three phases (Table 1)[19]. The REP process relied on competitive bidding processes. Competition for long term-contracts puts downward pressure on the fixed rate, incentivizing cost-reductions in renewable power. The REP process was less likely to raise electricity prices since the long-term rates were closer to market rates. Additionally, REP contracts were financed by revenues from the carbon tax and not by ratepayers; this ensured that the contracts did not have distortionary impacts on prices.

Proponent	Project	Capacity (MW)	Nearest City
EDP Renewables Canada	Sharp Hills Wind Farm	248.4	Oyen
Enel Green Power Canada	Riverview Wind Farm	115	Pincher Creek
Enel Green Power Canada	Phase 2 of Castle Rock Ridge Wind Power Plant	30.6	Pincher Creek
Capital Power	Whitla Wind	201.6	Medicine Hat
EDF Renewables Canada	Cypress Wind	201.6	Medicine Hat
Potentia Renewables	Stirling Wind	113	Lethbridge
Capstone Infrastructure	Buffalo Atlee Wind 1	17.25	Brooks
Capstone Infrastructure	Buffalo Atlee Wind 2	13.8	Brooks
Capstone Infrastructure	Buffalo Atlee Wind 3	17.25	Brooks
Transalta Corporation	Windrise Wind	207	Pincher Creek
Potentia Renewables	Jenner Wind	122.4	Brooks
Potentia Renewables	Jenner Wind 2	71.4	Brooks

Figure 3: Contracts secured through the REP in Alberta. Green = Phase 1, Blue = Phase 2, Red = Phase 3.

[18] Renewable Electricity Act. 2016. Bill 27. S.2 29th Legislature.
[19] Alberta Electricity System Operator. N.d. "*Renewable Electricity Program*" Accessed Nov 11, 2020. https://www.aeso.ca/market/renewable-electricity-program/

During its tenure, the REP was responsible for most wind power installations in Alberta. By providing financial security for these capital-intensive projects, proponents were able to build out vastly more wind power than ever before. In 2015, there was 1,463MW of installed wind capacity in the province. In 2017, Round 1 of the REP procured nearly 600MW of wind power; and an additional 700MW of wind capacity was added in Rounds 2 and 3. Despite being largely successful at accelerating renewables deployment in Alberta, the REP program was discontinued in 2019 following a change in government, but the program had served its purpose. It is now clear that wind power projects are profitable in Alberta. As a result, installments of wind power have continued into 2020; 76% of new capacity additions are wind power. Additional policy supports for renewable power in Alberta could help accelerate deployment in a similar fashion to the REP.

Key Considerations

When considering the efficiency of renewable energy policy, there are a few considerations of particular importance: greenhouse gas emissions reductions, intermittency of variable renewable power, electricity prices, and distortionary market impacts. These considerations have the potential to significantly influence the welfare of ratepayers, taxpayers, and participants in the market for electricity in Alberta. Consideration of the above things will ensure that renewable energy policy increased deployment of renewable and low-carbon power without producing negative side-effects.

Greenhouse Gas Emissions Reductions:

One of the most important rationales for increasing renewable energy deployment in Alberta is to reduce the emissions intensity of the electricity sector. Consequently, the ability of renewable energy policy to reduce emissions is a key determining factor in its efficiency. Policymakers should prioritize policies that have the greatest potential to significantly reduce emissions reductions.

Variable Renewable Generation and Intermittency

The most popular renewable energy technologies, onshore wind and solar PV, are either cost-competitive or less expensive to build and operate than their fossil fuel alternatives in most of the world. Therefore, cost is not the largest technological barrier to widespread deployment of solar and wind. Solar and wind are both variable renewable technologies, meaning they produce electricity intermittently. Managing supply of an electricity system dominated by intermittent renewables is more challenging than managing a system dominated by on-demand fossil fuels. As a result, intermittency remains the largest technological challenge to an electricity system comprised primarily of renewables, but there are solutions.

Variable renewable energy technologies need to be backstopped by firm electricity generation. Firm low-carbon resources are available on-demand, year-round, at any point in the day[20]. Biomass, geothermal, and hydrogen are all proven firm low-carbon resources that can be used to compliment the deployment of variable renewable technologies. Energy systems comprised of firm low-carbon resources and variable renewables can match demand much easier than those comprised of variable renewables alone. Consequently, if Alberta were to commit to deep decarbonization of the electricity system, they would need to build out large amounts of firm-low carbon resource on top of wind and solar. Unfortunately, these firm low-carbon resources are less market ready than their variable counterparts. The business case for substituting combined cycle natural gas plants with solar and wind makes sense, as the LCOE to build and operate solar and wind is below the marginal cost of operation for natural gas. However, there is not yet a business case to be made for replacing natural gas with geothermal or hydrogen. To optimize the impact of renewable energy policy on deployment, a suite of policies should be concurrently used to reduce the LCOE of comparatively more expensive firm-low carbon resources as well as accelerate deployment of cost-competitive variable renewables.

[20] Jenkins, Jesse. 2019. "We Need More Than Solar and Wind to Power the Green New Deal" NYTimes Opinion. https://www.nytimes.com/2019/01/17/opinion/green-new-deal-climate-change.html

Electricity Prices

The largest determining factor in the public acceptance of government spending on renewables deployment will be the impact on electricity prices. While 74% of Albertans think that Albertan policymakers should be taking steps to increase the amount of electricity generated from renewables[21], ratepayers and taxpayers will reject policies that increase the cost of living. Efficient innovation policy must incent the deployment of renewable energy without increasing electricity prices. Despite the province's efforts to reduce electricity prices through competition and deregulation, Albertans still pay above average prices for electricity in Canada. The average Albertan pays 16.7¢/kWh[22], while the average Canadian pays only 13.5¢/kWh (excluding the territories). Figure 4 below summarizes the average residential electricity prices paid in the Canadian provinces.

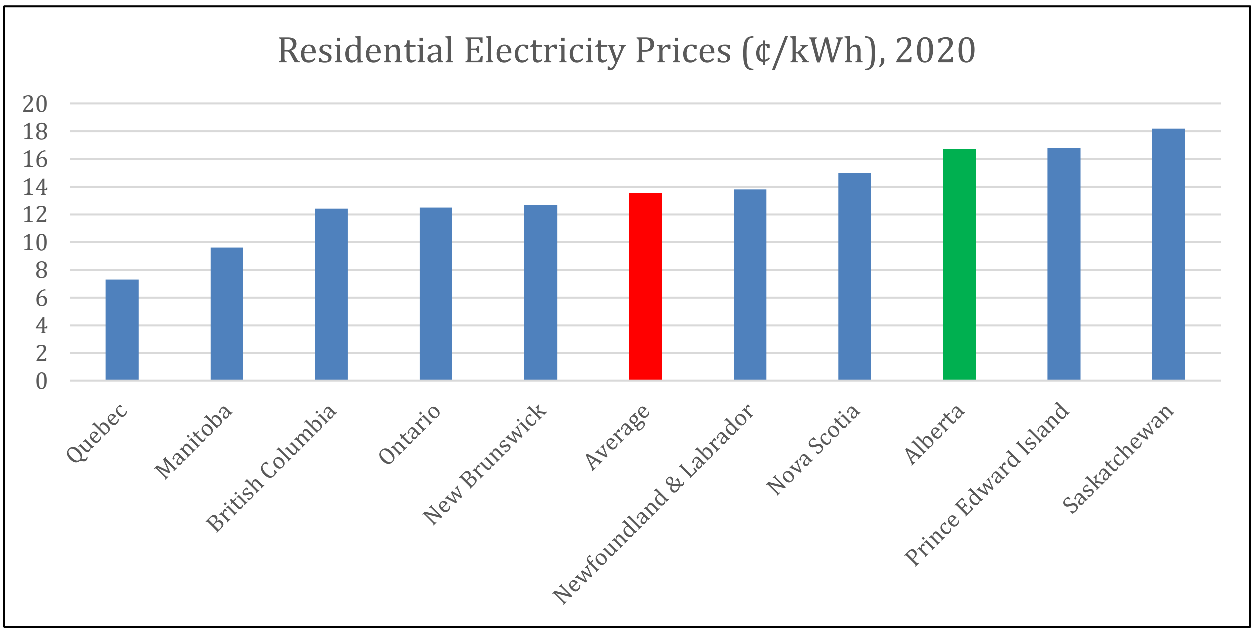

Figure 4: Residential electricity prices (¢/kWh) in the Canadian provinces.

Electricity prices are both an important industrial business expense and a critical component to the cost of living. Consequently, high electricity prices have negative impacts on attracting new businesses and new

[21] Canadian Wind Energy Association. 2019. "*Wind Energy in Alberta*" Accessed September 18, 2020. https://canwea.ca/wind-energy/alberta/#:~:text=Alberta%20now%20ranks%20third%20in,mix%20and%20its%20energy%20economy

[22] Energy Hub. 2020. "*Electricity Prices in Canada 2020*" Accessed November 15, 2020. https://www.energyhub.org/electricity-prices/

Albertans. Furthermore, given that lower-income individuals tend to spend a larger portion of their income on electricity, increasing electricity costs are likely regressive. Managing the impact of renewable energy policy on electricity prices is therefore an essential requirement of policymakers contemplating policies aimed at increasing renewable energy deployment.

Distributional Impacts:

Renewable energy policy aims to correct the negative externalities associated with fossil-fuel fired electricity production; however, not all participants in the Alberta electricity market will benefit from these policies. Proponents of renewable energy would undoubtedly benefit from pro-renewables policy, but workers at natural gas facilities would certainly not. Understanding and preparing for the distortionary impacts of renewable energy policy on workers in these displaced industries is therefore also an important consideration for policymakers.

The above considerations are not intended to be an inclusive list of considerations for policymakers, but rather point to the importance of a comprehensive approach to policy development. The efficiency of renewable energy policy is not only determined by its ability to increase renewable energy deployment, but by its cumulative impacts on Albertans. The case studies in renewable energy policy below emphasize this point further.

Case Studies in Renewable Energy Policy

Four flagship renewable energy policy tools are commonly used to incentivize renewables deployment. Carbon prices establish costs of emitting to force utilities to internalize the societal impacts of fossil fuel pollution. Public investments in intertie capacity establish the required infrastructure for interprovincial collaboration to enable renewable integration across broader regions. Green loan guarantees provide financing opportunities for renewable energy proponents to deploy innovative technologies. Lastly, feed-in tariffs provide revenue certainty for proven technologies and assist in deploying renewable technologies into new markets and regions.

To determine the efficacy of these innovation policy tools, I examine case studies to determine how each policy tool influenced renewables deployment in a province or country of interest. Ontario and Germany have both pursued ambitious feed-in tariff programs. New York and Quebec have built out strong intertie connections. The United States Green Loan Guarantee program offered financing opportunities for novel renewable energy technologies. Lastly, Sweden has utilized carbon taxes as a framework for pricing carbon since the 1990s. These case studies will be used to inform the policy recommendations for incentivizing renewables deployment in Alberta.

Feed-In Tariffs:

Feed-in tariffs, or FITs, are among the most common renewable energy policy tools used across the globe. There are 20 countries with an existing FIT regime[23]. A FIT is a long-term contract offered to producers of renewable energy that sets a guaranteed price for electricity production, often at rates above market price. FITs are used by governments when there is a political desire to incentivize renewable energy. They are used to incent the deployment of technologically feasible renewable technologies that would not otherwise be competitive in an open market. FITs enable the government to share the cost of investing in renewable energy with the private sector until technology costs become competitive with conventional generation methods. A growing body of research suggests that among demand-side policies, FITs are among the most cost-effective and most likely to incentivize renewables uptake. In Canada, the most well-

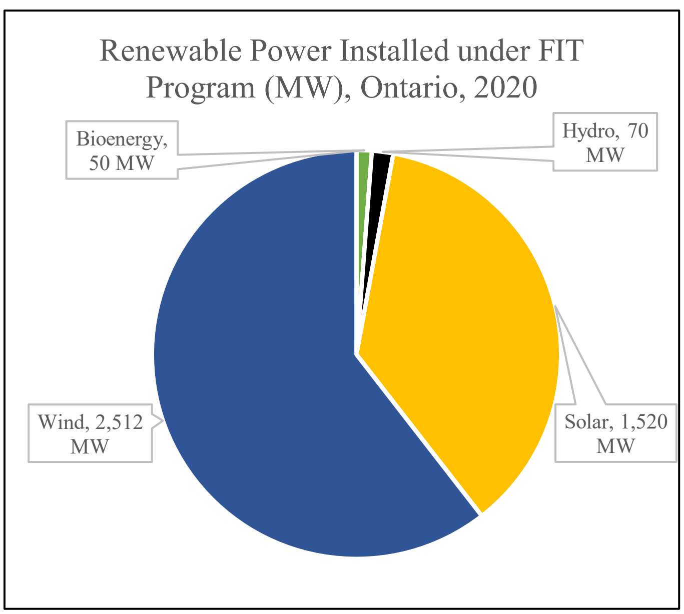

Figure 5: Renewable energy capacity additions made under the Ontario FIT regime.

[23] Pembina Institute. N.d. *"How feed-in tariffs maximize the benefits of renewable energy"* Accessed November 13, 2020. https://www.pembina.org/reports/feed-in-tariffs-factsheet.pdf

known renewable energy policy case study in the renewable energy space is Ontario's FIT program that took place from 2009 to 2016. The Ontario FIT program was one of the first guaranteed pricing regimes for renewable energy in North America. Ontario's electricity system operator, the Independent Electricity System Operator (IESO), executed 3248 FIT contracts in total and executed 4,565MW of wind, solar, and hydropower projects over the course of the programs seven-year lifespan. The FIT program - a pillar of Ontario's renewable energy uptake strategy laid out in the Green Energy and Green Economy Act of 2009[24] - had a massive impact on renewables penetration in Ontario. Renewable electricity generation (excluding hydro) grew almost 700% during the program's tenure, from 2GW in 2005 to 18GW in 2017[25]. Figure 6 demonstrates the rapid increase in renewables deployment that occurred following the implementation of the FIT program.

Despite drastically increasing renewables uptake in Ontario, the program was very controversial. The FIT program offered guaranteed pricing to producers of renewable energy at rates above market prices; the cost of these expensive contracts was passed off to consumers. Consumer electricity prices grew 78% -

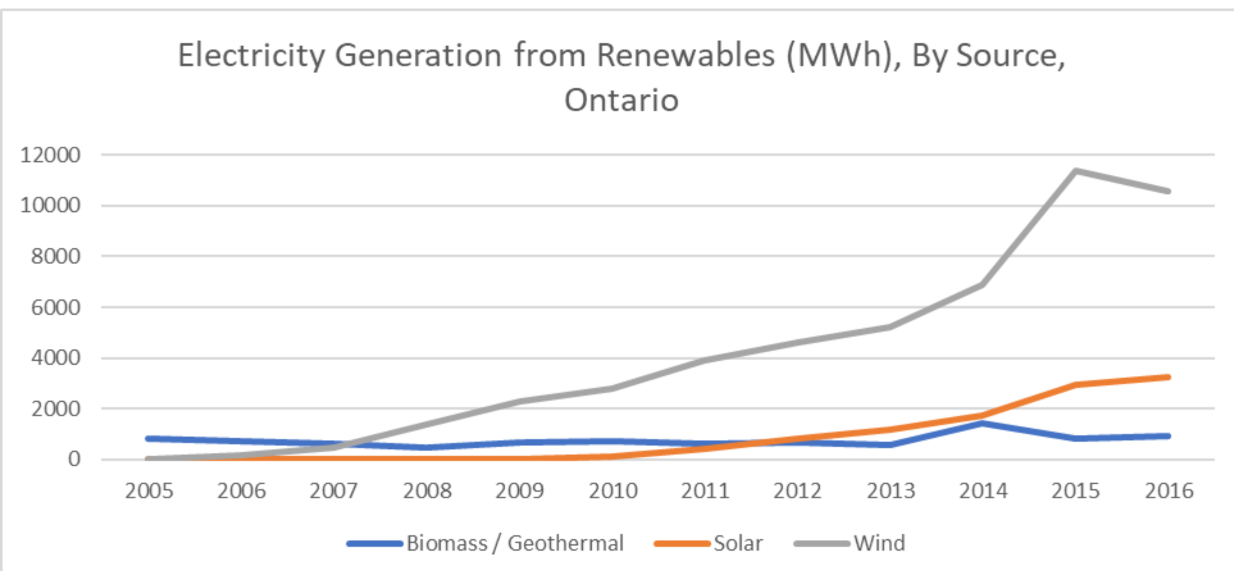

Figure 6: Electricity generation from renewables in Ontario, 2006-2016.

[24] Green Energy and Green Economy Act, 2009, S.O. 2009, c.12 – Bill 150
[25] Canadian Energy Regulator. 2019. "*Canadas Energy Future*" https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2019electricity/index.html

from \$0.0694/kWh to \$0.110/kWh over the program's duration[26]. The program was eventually shut down due to its impact on electricity prices. Ontario's FIT program exemplifies one of the most common tradeoffs in renewable energy policy: increased renewables penetration at increased costs to consumers. While Ontario was able to significantly increase the total installed capacity of wind and solar in the province, electricity prices soared. Resultantly, public support for the project dwindled and it was eventually cancelled.

Canada is not the only country to pursue an ambitious FIT regime. Germany was the first country in the world to implement a FIT for renewable energy in 1991; legislated by the Electricity Feed-in Law[27] (or Stromeinspeisungsgesetz) of 1991 and the Renewable Energy Sources Act[28] (or Erneuerbare-Energien-Gesetz) of 2000. The Electricity Feed-in Law was very similar to the Green Energy and Green Economy Act in Ontario, legislating guaranteed purchases of renewable power at fixed prices. Unlike Ontario's system, prices under the Electricity Feed-in Law were calculated using an average of previous years consumer electricity prices. This pricing mechanism minimized the impact of FIT contracts on electricity prices. The Renewable Energy Sources Act replaced this pricing mechanism, and FIT contracts were offered at prices well above market rates. FITs were very effective

in increasing renewables uptake in Germany. The capacity share of renewables in German electricity consumption rose from 3.4% in 1990 to 31.7% in 2016. Researchers have also demonstrated that FITs in Germany lead to increased innovation in the solar PV space, patent filings for solar PV technologies rose during the program's tenure[29]. Reduced LCOE for solar photovoltaics (PV) may have been a large contributing factor to the increased capacity additions. However, Germany vastly outpaced peer countries

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[26] Fraser Institute. 2018. "*Electricity reform in Ontario: getting power prices down*" Accessed October 16, 2020. https://www.fraserinstitute.org/sites/default/files/electricity-reform-in-ontario-getting-power-prices-down.pdf
[27] Germany. 1990. *"Electricity Feed Act*" Ministry for Economic Affairs and Energy. https://www.erneuerbare-energien.de/EE/Redaktion/DE/Dossier/eeg.html?cms_docId=72462
[28] Germany. 2000. "*Renewable Energy Act*" Ministry for Economic Affairs and Energy. https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-gesetz

[29] Bohringer, C. Cuntz, A., Harhoff, D., and Asane-Otoo E. 2017. "*The impact of the German feed-in tariff scheme on innovation: Evidence based on patent filings in renewable energy technologies*" Energy Economics 67: 545-53. https://doi-org.ezproxy.lib.ucalgary.ca/10.1016/j.eneco.2017.09.001

in renewables uptake largely due to FITs. Despite Germany's success in incentivizing renewables uptake, consumer electricity prices were impacted in a similar fashion to Ontario[30]. These case studies in renewable energy policy demonstrate a valuable lesson on how to effectively implement FITs. Striking the balance between incentivizing renewables deployment and raising consumer electricity prices should be a priority for policymakers pursuing FITs.

Green Loan Guarantees:

Proponents of innovative renewable power technologies often struggle to secure financing in the private sector. The resistance is primarily due to the large up-front capital costs and perceived risk associated with renewable energy projects. As a result of this resistance, private sector financing agents are hesitant to provide financing for these projects. Green loan guarantees provide financing opportunities to proponents of renewable energy projects that would not otherwise secure financing in an open market. Green loan guarantees work by the government assuming some or all the risk of default for a given project. This allows proponents of renewable energy to secure private sector financing while the government assumes the risk. Since governments have a far greater ability to handle risk and incur debts than the private sector, loan guarantees incentivize proponents to secure more financing opportunities than they would in an open market and build out more renewable power. Loan guarantees often serve as a mechanism to demonstrate a renewable power technology in a new region. Once a project has demonstrated that it is viable and profitable, the perceived risk for that technology is reduced and private lenders are more likely to provide financing for similar projects in the future.

The Unites States Department of Energy has operated a loan guarantee program since it was legislated in the *Energy Policy Act* of 2005[31]. According to the statute, the program offered loan guarantees for "innovative" generation technologies. The program primarily offered financing opportunities to nuclear

[30] Pembina Instiiute. 2008. "*Using feed-in tariffs to capitalize on renewable energy*" Accessed November 17, 2020. https://www.pembina.org/reports/FITariffs_Primer.pdf

[31] Energy Policy Act. 2005. 109th Congress. 1st sess. https://www.epa.gov/laws-regulations/summary-energy-policy-act

power generation in its early days but began offering guarantees to renewable projects once the Obama administration came into power in 2008. The program has provided approximately USD$35 billion in loan guarantees to more than 30 nuclear and renewable power projects over its 15-year lifespan, leading to USD$50 billion in total project investment[32]. The Loan Programs Office (LPO) that manages the program, is currently offering an addition $43 billion in additional financing for proponents of innovative energy solutions. The program has been largely successful, leading to the deployment of the world's largest concentrating solar plant, the world's largest solar PV system, and one of the world's largest wind farms. These ground-breaking projects, that would not have otherwise been financed, provide evidence of the efficacy of loan guarantees as a mechanism to demonstrate utility-scale renewable power projects. Since the construction of these projects, there has been rapid deployment of utility-scale wind and solar in the United States. Despite the program's general success, some projects have led to large financial losses for the government.

The first loan guarantee offered by the LPO in 2005 went to Solyndra, a solar panel company based in California. In 2011, the company defaulted on the USD$535 million loan guarantee, handing the program its first losses. Financial analysts in the United States offer strong critiques of the decision to provide the loan guarantee to Solyndra, saying political pressure lead to an expedited review process that overlooked key risk factors. The program has suffered relatively few additional losses since Solyndra, $799.7 million total, or 4.3% of the total amount dispersed[33]. Despite this, Solyndra's failures provide key lessons in how to efficiently run a green loan guarantee program. While governments have a greater ability to incur debts than the private sector, they should still avoid providing loans to risky companies. The DOE has added many third-party and private sector advisors to the LPO since the Solyndra default to ensure that political influences are excluded from the review process. For green loan guarantee programs to be effective, risk mitigation must remain an essential component to the review process. Collaboration between financial

[32] United States Department of Energy. Loan Guarantee Program. https://www.energy.gov/lpo/about-us-home
[33] United States Department of Energy. "An update on Fisker Automotive and the Energy Department's Loan Portfolio" . https://www.energy.gov/articles/update-fisker-automotive-and-energy-department-s-loan-portfolio

analysts, industry experts, policymakers, and proponents of renewable energy is necessary to ensure that loan guarantees do not become large financial liabilities for governments.

The DOE loan guarantee program provides evidence of the efficacy of green loan guarantees to incentivize the deployment of renewable energy. Loan guarantees are most effective for demonstrating the financial viability of renewable power projects. Once government-backed projects are demonstrated to be competitive in the market, financial institutions can feel more confident in providing financing for renewable power projects, accelerating the commercial diffusion of renewable energy.

Public Investment in Intertie Capacity:

Intermittency of renewable power generation remains one of the largest barriers to widespread deployment of renewable energy. Wind and solar are both variable renewable energy sources, meaning they produce electricity intermittently when the wind blows and the sun shines. Reductions in LCOE for wind and solar has driven investment, but intermittency in supply of variable renewable energy limits the potential for widespread deployment. Consumers of electricity will not tolerate an absence of electricity on a particularly windless, cloudy day. Consequently, on-demand electricity production is required to backstop variable renewables during periods of low generation. In regions with ample firm low-carbon resources, like Quebec with its plentiful hydropower resources, intermittent renewables are backstopped with hydropower and pumped water storage to deliver on-demand electricity. In regions with fewer firm-low carbon resource options, like New York, fossil-fuel fired electricity is used. New York would have a more difficult time transitioning to a net-zero future as a result of this. One solution to this problem is to develop intertie capacity between New York and Quebec to utilize its vast hydropower generation. This would enable New York to build out vastly more variable renewable energy than if it were isolated. In periods of low variable renewable energy generation, electricity can be imported from Quebec, and vice versa. New York benefits by decarbonizing its electricity system, and avoiding problems with intermittent generation. Quebec benefits by accessing cheap electricity when variable renewable generation is high.

This theoretical intertie arrangement has actually been in place in New York and Quebec for quite some time; Quebec has supplied hydropower energy to New York for over a century. Two interties connect the regions electricity systems; the 200MW Les Cedres-Dennison intertie was built in 1910; and the 1,200MW Chateauguay-Marcy intertie was built in 1978. In 2020, over 7TWh of energy is traded across the interties, avoiding an average of 1.7 million tonnes of CO2 emissions.

The intertie has been very effective at incentivizing renewables deployment in the region. Installed wind capacity grew from only 48MW in 2004 to 1,987MW in 2019[34]. Furthermore, New York has set ambitious decarbonization targets moving forward; committing to 70% renewable power by 2030. Without well-developed intertie capacity, these goals would be unattainable. Fortunately, New York has access to ample on-demand electricity imports. This case study demonstrates the effectiveness of intertie capacity as a stimulant for investments in variable renewable power.

<u>Carbon Pricing:</u>

Carbon pricing is the most frequently used renewable energy policy in the world. More than 40 countries have some form of national price on CO2 emissions, as well as many states, provinces, and municipalities[35]. Carbon taxes set a price on the negative externality of CO2 pollution, forcing polluters to internalize the societal impacts of their emissions[36]. Most economists support carbon pricing as an effective policy tool to reduce domestic emissions. In addition to reducing CO2 emissions, carbon prices may also be effective in increasing renewable energy deployment. By increasing the operating costs of fossil-fuel fired power generation, carbon prices make renewable energy technologies more cost-competitive with conventional generation technologies. The most prominent example of long-term carbon pricing impacts on renewables deployment is from Sweden. Sweden has had a tax for CO2 emissions

[34] United States Energy Information Administration. 2020. "*Electricity Data Browser*" Accessed November 17, 2020. https://www.eia.gov/electricity/data/browser/

[35] World Bank. N.d. "*Pricing Carbon*" Accessed November 17, 2020. https://www.worldbank.org/en/programs/pricing-carbon#:~:text=Some%2040%20countries%20and%20more,annual%20global%20greenhouse%20gas%20emissions

[36] Weitzman, Martin. 2014. "*Can Negotiating a Uniform Carbon Price Help to Internalize the Global Warming Externality*?" Journal of the Association of Environmental and Resource Economics 1(2): 29-49 https://www.journals.uchicago.edu/doi/10.1086/676039

since 1991, and currently has the largest carbon tax in the world, pricing CO_2 emissions at approximately CAD$170/tonne[37]. In comparison, the price set by Canada's federal carbon backstop is CAD$30/tonne[38]. A comparison of international carbon prices is provided in Figure 7.

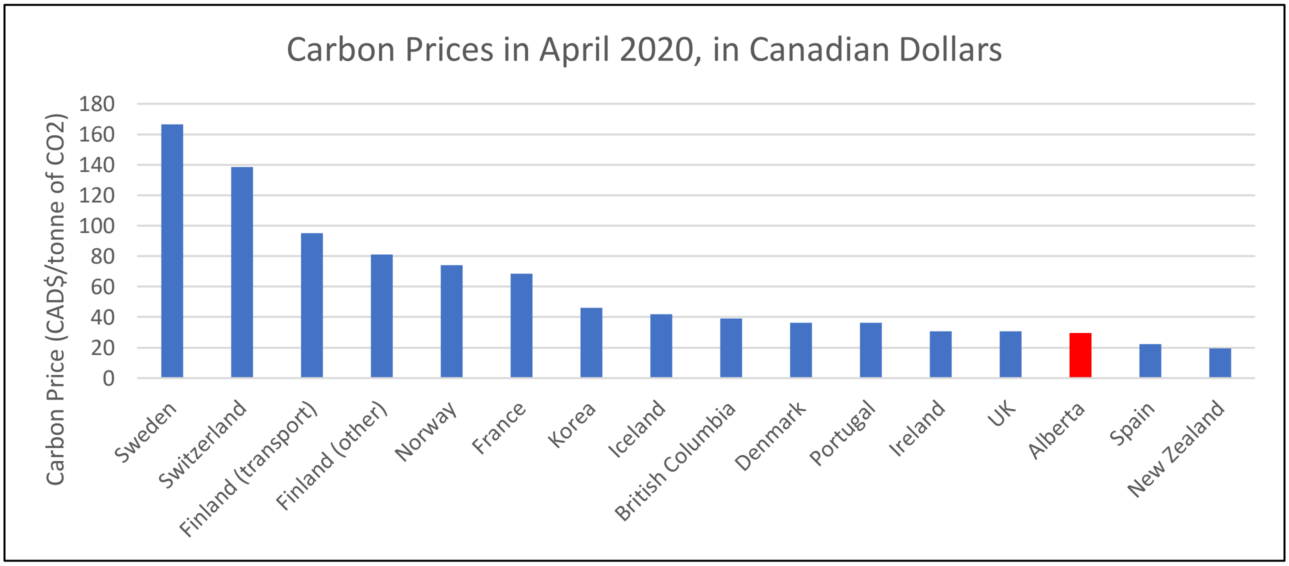

Figure 7: Carbon prices (CAD$/tonne) from 15 countries.

Sweden's ambitious carbon pricing regime has had a significant impact on the composition of their electricity system. In 1990, one year before the implementation of the carbon price, renewable power comprised 33% of Sweden's grid[39]. In 2020, Sweden gets roughly 55% of its power from renewables. Annual wind production grew from 0.5TWh in 2000 16.6TWh in 2020, or 12% of the total energy production in the region.

Some of the growth in renewables deployment in Sweden can be explained by reduced costs for wind and solar, but Sweden still rapidly outpaces its peers in the European Union. Carbon pricing explains the accelerated deployment of renewables in Sweden. Conventional fossil-fuel fired generation technologies, when subjected to Sweden's aggressive carbon pricing regime, are not cost-competitive with renewable

[37] Sweden. Ministry of Finance. 2018. "*Sweden's Carbon Tax*" Accessed November 13, 2020. https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/
[38] Canada. 2018. "*Technical paper: federal carbon pricing backstop*" Accessed November 3, 2020. https://www.canada.ca/en/services/environment/weather/climatechange/technical-paper-federal-carbon-pricing-backstop.html
[39] International Energy Agency. N.d. "*Sweden*" Accessed November 3, 2020. https://www.iea.org/countries/sweden

power. Researchers have developed models to test this connection between carbon pricing and renewables deployment. If the United States were to adopt a $50/tonne tax on CO_2 emissions, emissions would fall 40-50% below 2005 levels by 2030, mostly due to coal-to-renewables switching. This theoretical model reinforces the findings from Sweden's carbon pricing regime. Carbon prices make fossil-fuel fired power generation more expensive, incentivizing investment in low-carbon alternatives, like wind and solar.

Analysis of Policy Options in Alberta:

Feed-in Tariffs

The REP, Ontario FIT, and German FIT demonstrate that long-term power contracts are effective mechanisms to accelerate the deployment of renewable power, though FITs were more costly than the REP. REP contracts played a critical role in the early deployment of wind power in 2017; stimulating waves of investment in wind power in Alberta. Similarly, FITs could be used to procure the firm low-carbon power that will be required to achieve deep decarbonization of the Alberta electricity system. While wind and solar have become cost competitive in the Alberta electricity market, geothermal, hydrogen, and biomass energy are yet to become competitive with fossil fuels. These firm low-carbon resources will be critical pieces of the decarbonization puzzle but are not yet market ready. A FIT regime could help reduce the LCOE for these new firm technologies and accelerate the transition from fossil fuels to renewables. If firm-low carbon technologies become cost-competitive with fossil fuels through innovation and technological advancements, then Alberta would be well positioned to fully decarbonize the electricity system. Until then, combined cycle natural gas will remain essential to backstop variable renewable technologies to prevent intermittency issues.

What made the REP process more cost effective than the Ontario FIT? The REP process operated in a similar fashion to the FIT system in Ontario, wherein renewable power generation was incentivized through long term contracts. However, the REP relied on competitive bidding processes to set rates, unlike Ontario's administratively set rates. The Ontario FIT rates were often set well above what would be achievable in a free market. Resultantly, the cost of high FIT rates were passed along to consumers in the form of more expensive electricity. While the REP process is less likely than the FIT process to incentivize rapid development and uptake of renewable power due to the limited supply of contracts, it is also less likely to have harmful impacts on electricity prices due to the competitive bidding process. If a future FIT program utilized a competitive bidding process akin to the REP process, it could incentivize renewables deployment with minimal impacts on consumer electricity prices.

Green Loan Guarantees

Similar to feed-in tariffs, green loan guarantees provide opportunities for proponents of novel technologies to prove their innovative renewable energy solutions and reduce the LCOE for firm-low carbon solutions. Evidence from the United States DOE LPO program demonstrates that green loan guarantees are effective tools to incentivize the deployment of innovative technologies. If the Alberta government were to offer loan guarantees for innovative renewable technologies, particularly for technologies that address Alberta's intermittency problems, similar results could likely be achieved.

Alberta is well positioned to be an innovator in geothermal and hydrogen resource development. The existing oil and gas infrastructure, skilled workforce and regulatory regimes are well situated to adopt these new renewable energy opportunities. Consequently, green loan guarantees for firm low-carbon resources tangentially related to conventional resources could carve out a role for oil and gas workers in the energy transition towards renewables.

The Alberta government has a long history of providing loan guarantees for risky energy projects. In 2020, the Alberta government agreed provided TC Energy with loan guarantees worth $6 billion for the construction of the Keystone XL pipeline[40]. The decision has been criticized for being too risky, as the election of democratic candidate Joe Biden in November 2020 would likely lead to the termination of the

[40] Calgary Herald. 2020. "*Varcoe: Risks rising on Alberta's multibillion-dollar pipeline investment*" Accessed November 12, 2020. https://calgaryherald.com/business/energy/varcoe-risks-rising-on-albertas-multibillion-dollar-pipeline-investment

project. The massive investment from the provincial government sets the precedent for loan guarantees for renewable power projects in Alberta. They would be effective tools to stimulate innovation in the firm-low carbon space. Geothermal, hydrogen, and modular nuclear technologies are currently uncompetitive with combined cycle natural gas power generation, but green loan guarantees could assist in making them more competitive. Providing financing opportunities for innovators in the firm-low carbon space may help drive cost reductions and efficiencies in these novel technologies. Evidence from the DOE program shows that low-cost debt made available through the green loan program reduced LCOE for certain projects by more than 20%[41]. A one-fifth reduction in LCOE is significant. If capital and operating costs for geothermal energy were reduced by 20%, they would reach parity with combined cycle natural gas. Meaningful cost reductions for firm-low carbon solutions like geothermal and hydrogen would rapidly accelerate their deployment and lead to a faster energy transition.

Public Investments in Intertie Capacity

Intermittency remains one of the largest barriers to the adoption of variable renewable energy in Alberta. Public investments in intertie capacity could help overcome the intermittency problem. Alberta currently has three interprovincial interties that connect with British Columbia (1200MW), Saskatchewan (150MW), and Montana (300MW)[42]. Cumulatively, interprovincial interties are capable of supplying approximately 10% of Alberta's peak demand for electricity. In 2018, a total 2.9TWh of electricity was transmitted across these three lines. However, the largest of the three interties, the AB-BC intertie, does not currently operate at its 1200MW path rating. The intertie currently has export capacity of 1000MW and import capacity of 800MW, far below its original capabilities. The AESO is currently planning to restore the intertie to its full capacity in the next few years. A summary of historical and projected

[41] Mundica, Luis and Jessika Richter. 2015. "*Assessing 'green energy economy' stimulus packages: Evidence from the U.S. programs targeting renewable energy*" Renewable and Sustainable Energy Reviews 42: 1174-1186. https://doi.org/10.1016/j.rser.2014.10.060
[42] Alberta Utilities Commission. 2013. "*Objections to ISO rules Section 203.6 Available Transfer Capability and Transfer Path Managemen*t" Accessed November 15, 2020.

interprovincial flows of electricity is provided in Figure 8.

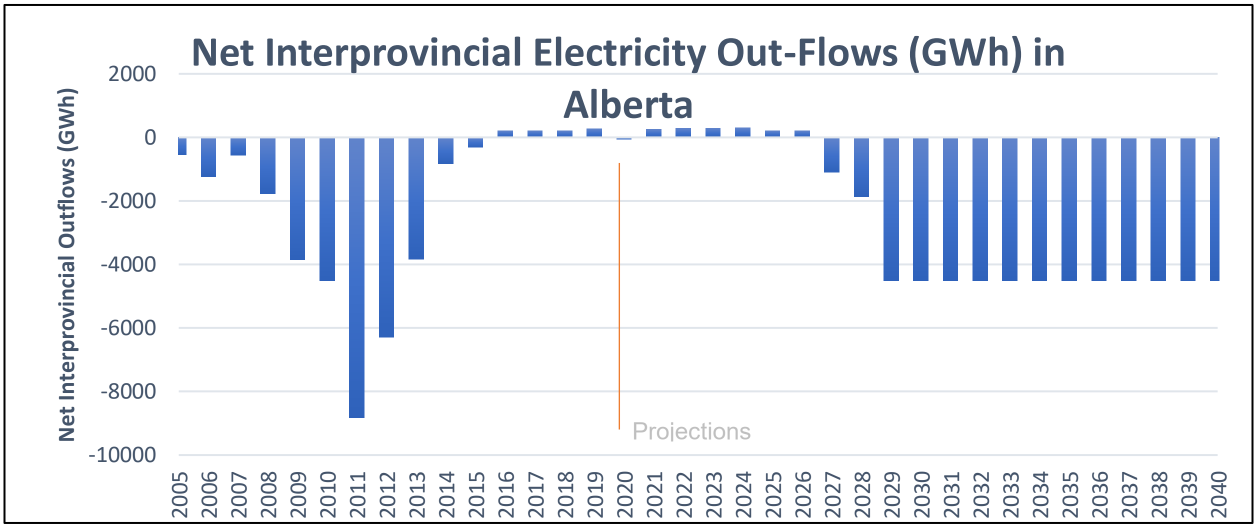

Figure 8: Net interprovincial electricity outflows in Alberta. 2005-2019 is historical data, 2019-2040 are projections.

Developing more intertie capacity with British Columbia reduces the risk of building out more variable renewable energy. This is because electricity can be imported from British Columbia's expansive hydropower reserves during periods of low variable renewable power generation to ensure that the supply of electricity always matches demand. Consequently, expanding the intertie capacity between the two provinces would enable Alberta to build out vastly more renewable power. British Columbians would also benefit from additional intertie capacity, as extremely cheap electricity would be available to when variable renewable generation in Alberta exceeds demand. Therefore, expanding the volume of intertie capacity between the two provinces could provide benefits for both regions. Having additional intertie capacity would produce meaningful economic and environmental benefits for the two western-most provinces. While doubling the intertie capacity between Alberta and its two provincial neighbors would generate a net benefit of $156 million[43] and reduce GHG emissions by approximately two tonnes per annum[44].

[43] Canadian Energy Research Institute. 2018. "*A comprehensive guide to electricity generation options in Canada*" Accessed November 6, 2020. https://ceri.ca/assets/files/Study_168_Full_Report.pdf

Despite the clear benefits of investing in additional intertie capacity, a few key barriers inhibit the success of this policy option. First, while intertie capacity ensures that there is always a buyer for Alberta's variable renewable power, Alberta will always be on the losing end of the deal. Whenever there is excess demand in Alberta and imports are required to supplement variable renewable power generation, Albertans will be pay higher prices. Whenever there is excess supply of renewable power, Albertans will receive lower prices. This might make additional intertie capacity a tough sell in Alberta, but that doesn't mean policymakers shouldn't pursue the option. A market that pays lower prices for surplus electricity is far better than no market at all.

The second barrier to the rollout of this policy option is the regional differences in market composition in Alberta and BC. Coordinating interprovincial trade between Alberta's competitive market regime and BC's crown corporation BC Hydro is no easy task. Providing regulatory reform to enable the cooperation of these two very different markets would be a critical role of policymakers if they were to pursue this option. Despite the regulatory and market barriers, additional intertie capacity would be largely beneficial for both provinces and enable Alberta to overcome intermittency issues associated with an electricity system consisting of more variable renewable power.

Carbon Pricing

Alberta has a rich history of pricing greenhouse gas emissions. Alberta was the first province in Canada to legislate a price on CO2 emissions in 2007 with the Specified Gas Emitters Regulation (SGER)[45]. The legislation placed a $15/tonne levy on emissions from large facilities producing more than 100,000 tonnes of greenhouse gases per year. The levy was calculated based on a facility's historical emissions, on an emissions intensity basis. SGER placed a price on 50% of Alberta's total emissions. The scope of the provinces carbon pricing regime was broadened in 2015 with the Climate Leadership Plan (CLP), raising

[45] Alberta. 2007. "Specified Gas Emitters Regulation" Accessed November 17, 2020. http://canlii.ca/t/83nf

the levy on carbon emissions to \$20/tonne in 2017 and \$30/tonne in 2018[46]. The levy was applied province-wide, not just on emissions from large industrial emitters. As a part of the CLP, SGER was replaced the Carbon Competitiveness Incentive Regulation (CCIR). CCIR significantly raised the carbon costs for coal-fired power plants from approximately \$2/MWh to \$20/MWh[47]. Together, CCIR and the carbon levy priced emissions from both consumers and producers in Alberta and incentivized a transition to lower-carbon energy production.

The success of carbon pricing in Alberta and in the Swedish and BC case studies provide evidence of the efficiency of carbon prices as a tool to incentivize renewables deployment.

Policy Recommendations

The evidence from the Canadian provinces and international peer countries, as well as the analysis of Alberta-specific considerations point to the ability of renewable energy policies to efficiently increase renewables deployment in Alberta. To best incentivize the deployment of renewables, there are four key policy recommendations that the Alberta government should follow:

1. **Increase carbon prices in the electricity sector**. Given the simplicity and efficacy of carbon pricing as a tool to price the externalities of GHG emissions from fossil fuel fired electricity generation, carbon prices should be central to the governments policy regime. Increasing the carbon levy to reflect the true social costs of pollution would further shift the economics in favor of renewable power.
2. **Provide financing opportunities to proponents of renewable energy through FITs and green loan guarantees.** Feed-in tariffs and green loan guarantees should be used as complements to carbon pricing to procure renewable energy technologies that are less market ready, namely

[46] Pembina Institute. 2019. "*Pricing carbon pollution in Alberta*" Accessed November 1, 2020. https://www.pembina.org/reports/pricing-carbon-pollution-in-alberta-mar2019-final.pdf
[47] Shaffer, B. and Andrew Leach. 2020. "*Alberta's shift away from coal power is a climate action success stor*y" Canadian Broadcasting Corporation. Accessed November 15, 2020. https://www.cbc.ca/news/canada/calgary/road-ahead-alberta-coal-power-electricity-decline-1.5761858

geothermal, hydrogen, and biomass. Providing financing opportunities to firm-low carbon resources through these policies would stimulate innovation and cost reductions that will be essential for future deployments of these technologies.

3. **Invest in stronger intertie capacity with British Columbia to encourage the deployment of variable renewable energy.** Developing strong intertie capacity with British Columbia would assist in managing intermittency of generation from variable renewables and further incentivize their deployment.
4. **Follow a comprehensive policymaking approach that considers the impacts of renewable energy policy on GHG emissions, electricity prices, and participants in the Albertan electricity market.** The efficiency of a renewable energy policy will not only be determined by its ability to deploy additional renewable energy capacity, but by its cumulative effects on Albertans. Policymakers must weigh the distortionary and distributional impacts of their policies to ensure the implementation of the above policy recommendations is in the best interests of Albertans at large.

Following the above policy recommendations could establish a policy framework that supports the deployment of renewable power in Alberta. There are numerous barriers to the uptake of renewable energy; namely, intermittency, cost-competitiveness, and public impacts on taxpayers and ratepayers. Implementing the above suite of policies would assist in overcoming these barriers to establish the necessary conditions for the growth of renewables in Alberta.

Conclusion

Increasing the penetration of renewable energy in Alberta would assist in decarbonizing one of the most emissions intensive provinces in Canada and generate meaningful economic and climate benefits. This paper set out to determine whether renewable energy policy could be used in Alberta to efficiently accelerate the deployment of renewable power. Case studies were examined in both Canadian and international contexts to evaluate the efficacy of these policies. The case studies demonstrated that renewable energy policy was effective at increasing renewables deployment, though external impacts often occurred. The analysis of the Alberta specific implications further supported this. To ensure the efficient implementation of renewable energy policy, policymakers must also consider the impacts of policy beyond renewables deployment. Key considerations included GHG reductions, electricity prices, intermittency, and impacts on participants in the electricity market. Pursuing a comprehensive approach to policy development will ensure that renewable energy policies are efficient in increasing renewables deployment. Carbon prices, FITs, green loan guarantees, and investments in intertie capacity have proven to be effective tools to increase renewables deployment. If Albertan policymakers wish to decarbonize the province's electricity system, these policies would be efficient methods of doing so.

References

Alberta Electricity System Operator. N.d. "*Guide to understanding Alberta's electricity market*" Accessed November 24, 2020. https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/

---. N.d. "*Renewable Electricity Program*" Accessed Nov 11, 2020. https://www.aeso.ca/market/renewable-electricity-program/

---. N.d. "*Reports – System Marginal Price*" Accessed November 25, 2020. http://ets.aeso.ca/

Alberta Utilities Commission. 2013. "*Objections to ISO rules Section 203.6 Available Transfer Capability and Transfer Path Managemen*t" Accessed November 15, 2020.

Alberta. 2007. "Specified Gas Emitters Regulation" Accessed November 17, 2020. http://canlii.ca/t/83nf

----. 2015. "*Climate Leadership Plan: Progressive Climate Policy*" Accessed August 21, 2020. https://open.alberta.ca/publications/alberta-s-climate-leadership-plan-progressive-climate-policy

----. 2020. "*Budget 2020*" Accessed November 15, 2020. https://www.alberta.ca/budget.aspx

---. N.d. "*History of Alberta Royalties*" Accessed October 31, 2020. https://www.alberta.ca/royalty-history.aspx

Bohringer, C. Cuntz, A., Harhoff, D., and Asane-Otoo E. 2017. "*The impact of the German feed-in tariff scheme on innovation: Evidence based on patent filings in renewable energy technologies*" Energy Economics 67: 545-53. https://doi-org.ezproxy.lib.ucalgary.ca/10.1016/j.eneco.2017.09.001

Calgary Herald. 2020. "*Varcoe: Risks rising on Alberta's multibillion-dollar pipeline investment*" Accessed November 12, 2020. https://calgaryherald.com/business/energy/varcoe-risks-rising-on-albertas-multibillion-dollar-pipeline-investment

Canada Energy Regulator. 2020. "*Economics of Solar Power in Canada – Results*" Accessed October 20, 2020. https://gridworksenergy.com/myth-alberta-is-not-a-good-place-for-solar-power/

---. N.d. "*Provincial and Territorial Energy Profiles*" Accessed November 16, 2020. cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles

Canada. 2016. "*Wind Atlas*" Accessed Nov 11, 2020. http://www.windatlas.ca/maps-en.php?field=E1&height=50&season=ANU

Canada. 2018. "*Technical paper: federal carbon pricing backstop*" Accessed November 3, 2020. https://www.canada.ca/en/services/environment/weather/climatechange/technical-paper-federal-carbon-pricing-backstop.html

Canadian Broadcasting Corporation. 2019. *"People with severe disabilities feel 'duped' by Alberta government, AISH recipient says*" Accessed October 15, 2020. https://www.cbc.ca/news/canada/edmonton/aish-alberta-jason-kenney-1.5346856

---. 2020. "*Alberta Health Services to lay off up to 11,000 staff, mostly through outsourcing*" Accessed November 15, 2020. https://www.cbc.ca/news/canada/edmonton/alberta-health-services-job-cuts-tyler-shandro-1.5760155

---. 2020. "*Alberta on track to historic $24.2B deficit thanks to pandemic, oil price slump*" Accessed November 15, 2020. https://www.cbc.ca/news/canada/edmonton/alberta-deficit-record-jason-kenney-1.5701349

Canadian Energy Research Institute. 2018. "*A comprehensive guide to electricity generation options in Canada*" Accessed November 6, 2020. https://ceri.ca/assets/files/Study_168_Full_Report.pdf

Canadian Energy Systems Analysis Research. 2020. "*Alberta can lead the Transition to a Net-Zero Canada – While Re-Energising its Economy*" Accessed October 1, 2020. https://www.cesarnet.ca/blog/alberta-can-lead-transition-net-zero-canada-while-re-energising-its-economy

Canadian Geothermal Association. N.d. "*Alberta well filtering study overview, wellhead analysis, methodology, and dashboards*" Accessed November 17, 2020.

Canadian Wind Energy Association. 2017. "*Alberta Wind Energy Supply Chain Study*" Accessed November 16, 2020. https://canwea.ca/wp-content/uploads/2017/09/Delphi-AB-Wind-Supply-Chain-Study-Final-Report.pdf

---. 2019. "*Wind Energy in Alberta*" Accessed September 18, 2020. https://canwea.ca/wind-energy/alberta/#:~:text=Alberta%20now%20ranks%20third%20in,mix%20and%20its%20energy%20economy

---. 2019. "*Wind Facts: Affordable Power*" Accessed October 29, 2020. https://canwea.ca/wind-facts/affordable-power/#:~:text=Wind%20energy%20is%20now%20the,of%20%2437%20per%20megawatt%20hour.m

Canadian Energy Regulator. 2019. "*Canadas Energy Future*" https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2019electricity/index.html

Energy Hub. 2020. "*Electricity Prices in Canada 2020*" Accessed November 15, 2020. https://www.energyhub.org/electricity-prices/

Energy Policy Act. 2005. 109th Congress. 1st sess. https://www.epa.gov/laws-regulations/summary-energy-policy-act

Fraser Institute. 2018. "*Electricity reform in Ontario: getting power prices down*" Accessed October 16, 2020. https://www.fraserinstitute.org/sites/default/files/electricity-reform-in-ontario-getting-power-prices-down.pdf

Germany. 1990. *"Electricity Feed Act*" Ministry for Economic Affairs and Energy. https://www.erneuerbare-energien.de/EE/Redaktion/DE/Dossier/eeg.html?cms_docId=72462

---. 2000. "*Renewable Energy Act*" Ministry for Economic Affairs and Energy. https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-gesetz

Green Alberta Energy. N.d. "*Energy in Alberta – Statistics*" Accessed November 3, 2020. https://www.greenalbertaenergy.ca/statistics.html#:~:text=In%20Alberta%2C%20there%20is%20a,and%20other%20eco%2Dfriendly%20resources

Green Energy and Green Economy Act, 2009, S.O. 2009, c.12 – Bill 150

Gridworks Energy. N.d. "*Myth: Alberta is not a good place for solar power*" Accessed November 12. 2020. https://gridworksenergy.com/myth-alberta-is-not-a-good-place-for-solar-power/

Hastings-Simon, Sara. 2019. "*Industrial policy in Alberta: lessons from AOSTRA and the oil sands*" School of Public Policy Publications. SPP Research Paper 12(38) 1-32. http://dx.doi.org/10.11575/sppp.v12i0.68092

International Energy Agency. N.d. "*Sweden*" Accessed November 3, 2020. https://www.iea.org/countries/sweden

International Renewable Energy Agency. 2013 "*Renewable Energy Innovation Policy: Success Criteria and Strategies*" Accessed November 16, 2020. https://www.irena.org/publications/2013/Mar/Renewable-Energy-Innovation-Policy-Success-Criteria-and-Strategies

Jenkins, Jesse. 2019. "*We Need More Than Solar and Wind to Power the Green New Deal*" NYTimes Opinion. Accessed November 4, 2020. https://www.nytimes.com/2019/01/17/opinion/green-new-deal-climate-change.html

Mundica, Luis and Jessika Richter. 2015. "*Assessing 'green energy economy' stimulus packages: Evidence from the U.S. programs targeting renewable energy*" Renewable and Sustainable Energy Reviews 42: 1174-1186. https://doi.org/10.1016/j.rser.2014.10.060

Natural Resources Canada. 2020. "*Photovoltaic potential and solar resource maps of Canada*" Accessed November 17, 2020. https://canwea.ca/wind-facts/affordable-power/#:~:text=Wind%20energy%20is%20now%20the,of%20%2437%20per%20megawatt%20hour.m

Patel, P. and V., Gunderson. "*Deep decarbonization faces deep challenges*" MRS Bulletin 42(9): 632-33. https://doi-org.ezproxy.lib.ucalgary.ca/10.1557/mrs.2017.191

Pembina Institute. 2008. "*Using feed-in tariffs to capitalize on renewable energy*" Accessed November 17, 2020. https://www.pembina.org/reports/FITariffs_Primer.pdf

---. 2019. "*Pricing carbon pollution in Alberta*" Accessed November 1, 2020. https://www.pembina.org/reports/pricing-carbon-pollution-in-alberta-mar2019-final.pdf

---. N.d. *"How feed-in tariffs maximize the benefits of renewable energy*" Accessed November 13, 2020. https://www.pembina.org/reports/feed-in-tariffs-factsheet.pdf

Renewable Electricity Act. 2016. Bill 27. S.2 29th Legislature.

Shaffer, B. and Andrew Leach. 2020. "*Alberta's shift away from coal power is a climate action success story*" Canadian Broadcasting Corporation. Accessed November 15, 2020. https://www.cbc.ca/news/canada/calgary/road-ahead-alberta-coal-power-electricity-decline-1.5761858

Sweden. Ministry of Finance. 2018. "*Sweden's Carbon Tax*" Accessed November 13, 2020. https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/

Transportation Alberta. N.d. "*Analysis of Hourly Wind Data*" Accessed November 9, 2020. http://www.transportation.alberta.ca/Content/docType30/Production/hrwinddata.pdf

United States Department of Energy. 2013. "*An update on Fisker Automotive and the Energy Department's Loan Portfolio*" Accessed October 28, 2020. https://www.energy.gov/articles/update-fisker-automotive-and-energy-department-s-loan-portfolio

---. N.d. "*About us: Loan Programs Office*" Accessed October 23, 2020. https://www.energy.gov/lpo/about-us-home

United States Energy Information Administration. 2020. "*Electricity Data Browser*" Accessed November 17, 2020. https://www.eia.gov/electricity/data/browser/

Weitzman, Martin. 2014. "*Can Negotiating a Uniform Carbon Price Help to Internalize the Global Warming Externality*?" Journal of the Association of Environmental and Resource Economics 1(2): 29-49 https://www.journals.uchicago.edu/doi/10.1086/676039

World Bank. N.d. "*Pricing Carbon*" Accessed November 17, 2020. https://www.worldbank.org/en/programs/pricing-carbon#:~:text=Some%2040%20countries%20and%20more,annual%20global%20greenhouse%20gas%20emissions