THE SCHOOL OF PUBLIC POLICY

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MASTER OF PUBLIC POLICY CAPSTONE PROJECT

Alberta in the Age of Renewable Power: Policy Lessons from Germany and Sweden

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Capstone Approval Page

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Capstone Executive Summary

In an increasingly carbon-constrained society, governments across the world have designed policies to support the development of renewable electricity. In particular, Germany and Sweden are world leaders in the development of renewable electricity. In contrast, the province of Alberta has limited experience creating a policy environment that encourages renewable electricity generation. This capstone project explores the policy lessons that Alberta can take from Germany and Sweden to foster the development of renewable electricity. By incorporating lessons learned from Germany and Sweden, the Alberta government could adopt new policies that increase the proportion of electricity derived from renewable sources.

This paper is arranged into four chapters. The first chapter provides an overview of Alberta, Sweden, and Germany's past and present renewable electricity policies. The second chapter analyzes each jurisdiction's current policy according to four criteria: 1) effectiveness, as quantified through the compound annual growth rate in renewable electricity capacity or generation; 2) diversity of actors, as evaluated through any special provisions that promote the participation of companies of varying sizes; 3) diversity of technologies, through an analysis of the number of renewable technologies able to secure support under each program; and 4) each program's impact on household electricity costs, as measured by the compound annual growth rate in the size of the electricity surcharge as a share of household electricity costs/kWh. The third chapter compares public acceptance of renewable energy in each region through an analysis of public opinion polls. Finally, the fourth chapter summarizes the policy lessons Alberta can take from Germany and Sweden to foster the development of renewable electricity.

There are four lessons Alberta can take from Germany and Sweden. First, as seen in Germany, the government's ability to anticipate changes required to integrate renewables into the electricity grid may limit the effectiveness of Alberta's future renewable policy. Second, the Alberta government could improve future policy by making special provisions to promote a diversity of actors; however, Alberta can learn from the overwhelming participation of small actors in Germany's auctions by limiting their future provisions to those that provide a level playing field for all actors. Third, for Alberta to encourage a diverse range of technologies while still promoting the most cost-effective electricity production, the province could implement a technology-neutral policy first (as seen in Sweden), followed by a transition to a technology-specific policy (as seen in Germany). Lastly, if Alberta strives to become a large-scale producer of renewable electricity, it may have to impose an electricity surcharge on consumers; however, it is likely the surcharge will stabilize as Alberta's renewable sector matures, as seen in Germany and Sweden.

In brief, this capstone provides the foundational knowledge required to understand renewable electricity policy in Alberta, Sweden, and Germany. This paper also offers specific policy lessons that Alberta may apply to keep pace with the global push towards a clean and renewable power sector.

Introduction

Renewable sources of energy are beneficial as they can provide electricity without the climate-change-inducing effects of fossil fuels. Given this benefit, governments across the world have designed policies to support the development of renewable electricity. Sweden and Germany have taken great strides in creating a policy environment that encourages renewable electricity generation. In contrast, the province of Alberta has limited experience promoting utility scale renewable electricity production. This paper explores the policy lessons Alberta can take from Germany and Sweden to foster a policy environment conducive to renewable electricity generation.

Existing literature in this area has analyzed strategies and potential challenges associated with increasing renewable electricity generation in Alberta (Fellows, Moore, and Shaffer 2016). Another study analyzed the effectiveness of Alberta's climate policy in incentivizing renewable electricity generation and summarized lessons Alberta could learn from British Columbia and Ontario (Ross et al. 2016). In contrast, this paper focuses specifically on Alberta's renewable electricity policy and draws lessons from European jurisdictions rather than Canadian jurisdictions.

An analysis of Alberta's Renewable Electricity Program, Sweden's Electricity Certificate System, and Germany's EEG auction system provides the foundation for Alberta's policy lessons. This paper analyses each program according to four criteria: 1) effectiveness, 2) diversity of actors, 3) diversity of technologies, and 4) impact on household electricity costs per kilowatt-hour (kWh). Below is a description of each criterion.

Effectiveness

The effectiveness of a renewable electricity program is a key indicator of success in encouraging renewable electricity development. For the purposes of this paper, effectiveness is measured differently depending on the type of program. For renewable electricity auctions, such as those in Alberta and Germany, the compound annual growth rate in renewable electricity capacity will measure the program's effectiveness. The effectiveness of an electricity certificate scheme, such as that in Sweden, will be measured by the compound annual growth rate in the share of total electricity generation attributed to the certificate system. Measuring the effectiveness of these two policy instruments differently is necessary due to the lack of available data regarding renewable capacity in Sweden. Regardless of how effectiveness is measured, this metric is important because it captures the purpose of any renewable electricity policy: to encourage the development of renewable electricity (Couture et al. 2015, v).

Diversity of Actors

The second analysis criterion evaluates each region's renewable electricity program in terms of whether it makes special provisions to promote the participation of a diversity of actors. This paper defines actor diversity as the size of different actors receiving support from a renewable electricity program. When evaluating renewable electricity policy, actor diversity is an important consideration for several reasons. A diverse group of actors has been one of the key factors behind the rapid increase in renewable energy production over the past several decades (Lairila 2016, 20). Further, different types of actors implement different types of renewable projects. This allows jurisdictions to better exploit their potential by producing renewable electricity using different technologies. In addition, greater involvement of small actors may increase public acceptance of a government's renewable electricity policy (Lairila 2016, 61). The participation of small actors may increase public acceptance of renewable energy for two reasons. First, small actors often implement small-scale projects, which may limit the 'not in my back yard'-effect seen with larger projects. Second, small companies are often well-known in the community, and their participation in renewable electricity programs may enhance community awareness of renewable energy at a grassroots level (Lairila 2016, 21). Lastly, a diverse range of actors participating in a renewable electricity program drives increased competition, indirect cost reductions, and greater innovation (Endell and Quentin 2017, 7).

Diversity of Technologies

The third criterion evaluates each region's program in terms of the diversity of renewable technologies receiving support (wind, solar, biomass, hydro, etc.). The diversity of technologies receiving support is important when determining if the jurisdiction is fully exploiting its renewable electricity potential (Verbruggen and Lauber 2012, 641). A diverse group of renewable technologies are also important in ensuring reliability in renewable electricity generation, as each renewable technology makes a unique contribution to the electricity grid (Walsh et al. 2016, 17). For instance, solar and wind technologies produce electricity at different times depending on weather conditions. Thus, a diverse range of renewable technologies is beneficial in helping a jurisdiction reach its renewable electricity targets without compromising system reliability (Hill 2018).

Impact on Household Electricity Costs

The fourth criterion evaluates each jurisdiction's program in terms of its impact on household electricity costs. This criterion is important because a program's impact on household electricity costs may be closely linked with public acceptance of renewable electricity. The third chapter of this paper discusses the link between household electricity costs and public acceptance of renewable electricity. Each program's impact on household electricity costs will be measured by the compound annual growth rate of its renewable electricity surcharge as a share of average household electricity costs/kWh. However, Alberta's program was not financed through a consumer surcharge, so this criterion is only applied to Germany and Sweden.

In brief, the policy lessons for Alberta revolve around designing an effective renewable electricity program that promotes a diverse range of actors and technologies. Although Alberta's most recent renewable electricity policy was cancelled in June 2019, these lessons may help inform the design of future renewable electricity policies in the province.

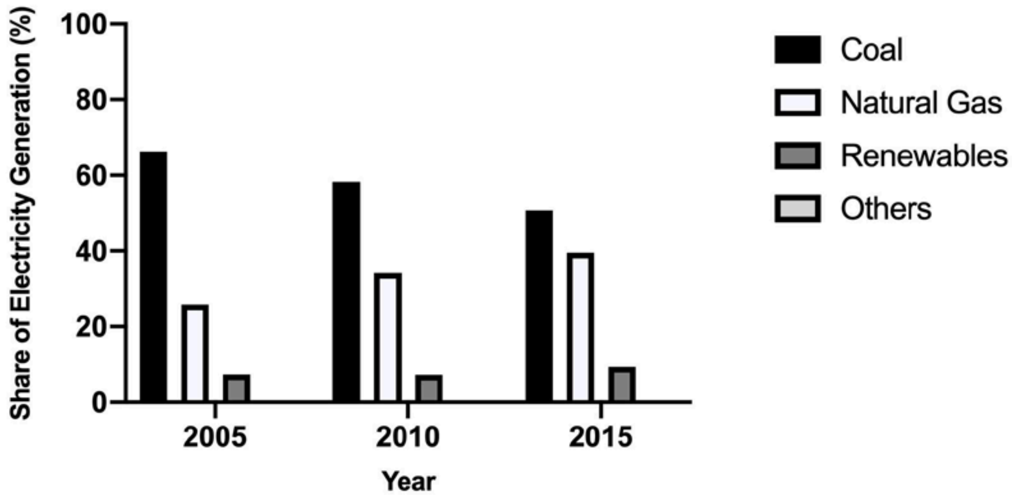
Following this introduction, this paper is arranged into four chapters. The first chapter focuses on Alberta, Sweden, and Germany's past and present renewable electricity policies. The second chapter analyzes each jurisdiction's renewable electricity program according to the four criteria described above. The third chapter compares public acceptance of renewable energy in each region through an analysis of public opinion polls. Finally, the fourth chapter draws from the analysis of Germany and Sweden to offer lessons for Alberta's future renewable electricity policy.

Chapter 1: Renewable Electricity Policy Review

History of Renewable Electricity Policy in Alberta

Renewable sources of energy have not played a large role in Alberta's electricity sector. As shown in Figure 1.1, Alberta's electricity grid has been heavily reliant on carbon intensive energy sources, such as natural gas and coal.

Figure 1.1: The Evolution of Alberta's Electricity Generation.



Note: Figure generated using GraphPad Prism 8. Data source: Alberta Utilities Commission (2018).

Several factors can explain the relatively small role played by renewables in Alberta's electricity sector. First, prior to 2016, Alberta lacked policy supporting utility-scale renewable electricity development. The lack of policy support meant renewable electricity was not cost-competitive against cheaper fossil-fuel based sources of electricity. Second, the Alberta government did not include ambitious renewable electricity targets in past climate change plans. For example, in its first climate change action plan in 2002, *Albertans & Climate Change: Taking Action*, the government set a target to increase the amount of electricity produced by renewable sources by 3.5 percent relative to 2001 levels by 2008 (Government of Alberta 2007, 6). The government did not publicly report on whether this target was met (Auditor General of Alberta 2018, 1); however, data from the Alberta Utilities Commission indicates the government missed the target, as the percentage of electricity generated by renewables increased by only 2.4 percentage points by 2008 (Alberta Utilities Commission 2018a). The government's next climate plan, *Alberta's 2008 Climate Change Strateg*y, lacked a specific framework or target to increase renewable electricity generation. In brief, renewable electricity has not played an important historical role in Alberta's electricity mix. It wasn't until 2015, with the election of the NDP government that renewable electricity gained a more prominent role in Alberta's energy policy.

Alberta's Most Recent Renewable Electricity Policy

In 2015, the Alberta government introduced the *Climate Leadership Plan* (CLP). A key pillar of the CLP was to increase renewable electricity production in the province (Government of Alberta 2019a, 41). The main vehicle for achieving this goal was the Renewable Electricity Program (REP), which the government designed to meet its target of generating 30 percent of the province's electricity from renewable sources by 2030 (Government of Alberta 2019, 8).

Prior to the REP, Alberta produced 9.45 percent of its electricity from renewable sources (Government of Alberta 2019, 40). In 2017, the percentage of electricity generated by renewables was 9.91, an increase of 0.46 percentage points from 2015. The government predicted that growth in renewable electricity generation would accelerate in 2019 as new renewable facilities spurred by the REP came online (Government of Alberta 2019, 42).

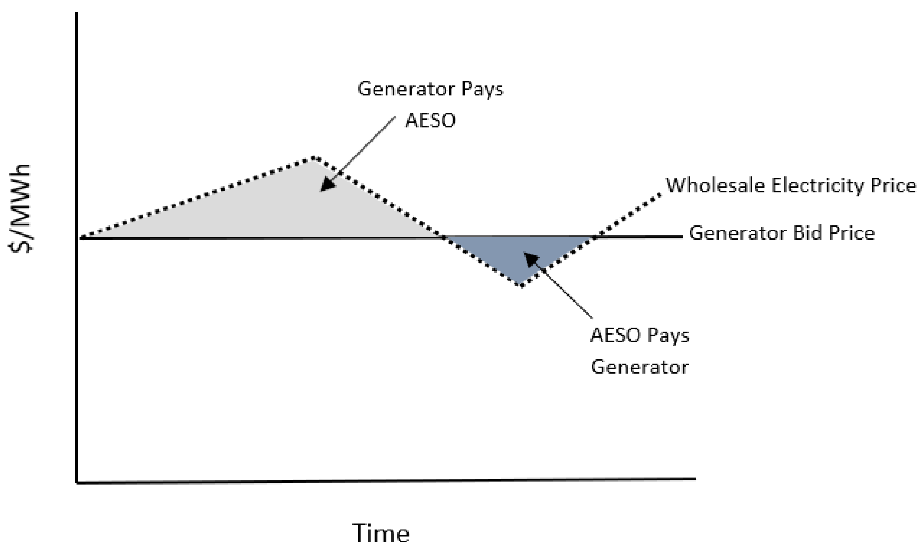
The REP came to an end in June 2019 when the newly elected United Conservative Party (UCP) government advised the Alberta Electric Systems Operator (AESO) of the program's cancellation (AESO 2019). As of August 2019, the UCP government indicated renewables will compete in the electricity market without government support (Howie 2019).

Renewable Electricity Program Description

Administered by the AESO, the REP launched on March 31, 2017. The government designed the program to facilitate large-scale renewable electricity production in the province (Government of

Alberta 2016, 1). The program's purpose was to add 5000 megawatts (MW) of renewable electricity capacity to an existing capacity of 2,785 MW (National Energy Board 2018). The REP functioned through a series of competitive auctions whereby private producers placed bids in price per megawatt-hour ($/MWh) to secure contracts to develop renewable electricity in the province (Government of Alberta 2016b). The government awarded the lowest bidding producers 20-year contracts to develop renewable electricity in the province and receive payment in accordance with a contract-for-difference mechanism (AESO 2016). As illustrated in Figure 1.2, under a contract for difference mechanism, successful bidders are guaranteed to receive remuneration in accordance with their bid price regardless of the wholesale price of electricity (AESO 2019).

Figure 1.2: The Renewable Electricity Program's Contract for Difference Mechanism**.**



Note: If the wholesale price of electricity falls below the producer's bid price, the AESO provides a top up payment to the producer, while if the wholesale price exceeds the bid price, the producer pays the difference to the AESO. Figure generated using Microsoft Word for Office 365. Source: Kristensen (2015).

Under the contract for difference mechanism, successful bidders enjoy the certainty of guaranteed revenue but at the cost of not being able to capitalize on potentially higher wholesale prices of electricity.

History of Renewable Electricity Policy in Sweden

Up until the early 1970s, Sweden's electricity sector relied heavily on oil imports from other countries (Wang 2006, 1209). However, the global oil crisis of the 1970s saw Sweden's electricity sector transition towards nuclear and hydroelectricity to become more energy independent. In 1980, the Swedish government held a non-binding referendum on the future of nuclear power (Wang 2006, 1209). The results indicated the public's desire for a nuclear power phase out, and despite the non-binding nature of the referendum, the Swedish government decided to phase out nuclear power by 2010 (Bergenas 2009; Wang 2006, 1209). This policy decision spurred the development of renewable energy programs to aid the transition away from nuclear energy. Thus, the 1980 nuclear power referendum was a driving force behind the development of renewable electricity policy in Sweden.

Starting in 1991, the Swedish government began to implement investment subsidies for bioenergy, wind, and small-scale hydropower (Wang 2006, 1209). However, following evaluation of its renewable electricity policy, the government determined that subsidies for specific technologies may distort competition or slow technological advances (Wang 2006, 1212). In 2003, the Swedish government changed its renewable electricity policy, introducing the Electricity Certificate System (ECS). This policy change was significant, as the ECS shifted Sweden's policy away from government-provided subsidies and towards a market-based policy that remains in force today.

Sweden's Current Renewable Electricity Policy

Two documents outline Sweden's current renewable energy policy: the 2016 Framework Agreement on Energy Policy (the Framework Agreement) and the National Renewable Energy

Action Plan (NREAP). The Framework Agreement set a target for a 100 percent share of renewables in Sweden's electricity generation by 2040 (Government Offices of Sweden 2016, 1). The NREAP was developed in response to the European Union's Renewable Energy Directive 2009/28/EC, requiring that 20 percent of the European Union's final energy consumption is provided by renewable resources by 2020 (European Commission n.d.). Sweden's NREAP set a target for a 63 percent share of renewable electricity in gross final electricity consumption by 2020 (Government Offices of Sweden 2010, 10). As of 2016, Sweden was successful in meeting this target, with a 64.9 percent share of renewable electricity in its gross final electricity consumption (Government Offices of Sweden 2017, 4). Given Sweden's success in promoting renewable electricity production, it is important to consider its main policy instrument to support renewable electricity, the ECS.

Electricity Certificate System Description

Introduced in 2003, the ECS is a market-based tool with the purpose of increasing renewable electricity production (Tudor 2012, 262). Under the ECS, the government issues electricity generators one tradeable electricity certificate for each MWh of renewable electricity produced (Swedish Energy Agency 2017a, 43). Renewable facilities are eligible to receive certificates for a period of 15 years (Government Offices of Sweden 2006). To generate demand for these certificates, and thus demand for renewable electricity, the government sets an annual quota obligation for electricity retailers and energy intensive industries. The quota obligation represents the percentage of electricity sold by retailers that must come from renewable sources of energy (Swedish Energy Agency 2017a, 43). Electricity retailers demonstrate that they have met the quota obligation by purchasing electricity certificates at a price determined by supply and demand. The ECS incentivizes investment in renewable electricity because renewable generators earn revenue from the sale of electricity and electricity certificates (International Energy Agency 2019, 100). The retailers make up for the extra cost of purchasing certificates by introducing a surcharge on consumers' electricity bills. Electricity-intensive manufacturing industries are exempt from this surcharge to preserve their competitiveness (International Energy Agency 2019, 100). At the end of each year, the Swedish Energy Agency cancels all purchased electricity certificates; retailers must purchase new certificates to meet the next year's higher quota obligation.

In 2012, Sweden collaborated with its neighbor Norway to create a joint market for trading renewable electricity certificates (Tudor 2012, 262). In 2017, the Swedish government extended the ECS until 2030, which will result in an additional 18 TWh of renewable electricity generation by 2030 (Swedish Energy Agency 2017b).

History of Renewable Electricity Policy in Germany

Between 1945 and 1973, coal and nuclear energy dominated Germany's electricity grid (Renn and Marshall 2016, 227). Throughout the 1960s and 70s, concerns about the pollution resulting from coal-generated electricity and the proper disposal of nuclear waste resulted in opposition to these two energy sources (Beveridge and Kern 2013, 5). Opposition to coal and nuclear energy were a driving force behind the development of renewable electricity policy in Germany.

In 1991, the German Parliament passed the Electricity Feed-In Act and became the first country in the world to implement an electricity feed-in tariff (FIT) (Cornfeld and Sauer 2010, 3). Under the Act, electricity retailers were required to purchase at least 10 percent of their electricity from renewable generators at a cost based on the previous year's average retail price of electricity per kWh (Held et al. 2007, 3; International Energy Agency 2013). In 2000, the

German government built upon the Electricity Feed-In Act by passing the Renewable Energy Sources Act (referred to as the EEG). Under the EEG, the German government offered renewable generators a FIT based on a set price per kWh for a 20-year period (Lauber and Mez 2004, 12). The EEG employed a contract for difference mechanism in which generators received top up payments when the wholesale price of electricity fell below the set FIT (Schiffer and Trüby 2018, 6). In Germany’s electricity market, the most expensive electricity dispatched to meet demand sets the wholesale price for electricity (Federal Network Agency 2019b).

In 2014, the German government revised the EEG and unveiled the beginnings of a major policy change for Germany’s renewable electricity sector. According to Section 2 (5) of the EEG 2014, an auction system would replace the FIT mechanism in 2017. This was a significant change because the German government was shifting away from the FIT that dominated its renewable electricity policy for 25 years. Three years later, the German government passed the EEG 2017, which laid out the details of the auction system that remains in force today.

Germany’s Current Renewable Electricity Policy

Similar to Sweden, Germany’s NREAP defines its current renewable electricity policy. Developed in response to the European Union’s Renewable Energy Directive 2009/28/EC, Germany’s NREAP committed to achieving a 38.6 percent share of renewable energy in the electricity sector by 2020 (Federal Republic of Germany 2012, 17). As of 2018, Germany had a 37.8 percent share of renewables in gross final electricity consumption (Federal Ministry for Economic Affairs and Energy 2019b). Thus, progress is still required for Germany to meet its target under the European Union Directive.

The EEG 2017 also prescribed a 35 percent share of renewable electricity in final gross electricity consumption by 2020, a 50 percent share by 2030, a 65 percent share by 2040, and an 80 percent share by 2050 (Federal Ministry for Economic Affairs and Energy 2018, 29). The government established these targets to aid the country's transition away from coal and nuclear energy, which are being phased out before 2022 and 2038 respectively (Ethics Commission on a Safe Energy Supply 2011, 5; Keating 2019). As Germany's two most historically important energy sources (nuclear and coal) are phased out of the power mix, the role of renewable electricity will become increasingly important. As such, it is important to understand the main policy instrument currently used by Germany to support the production of renewable electricity, the EEG 2017.

EEG 2017 Description

Administered by the Federal Network Agency, the EEG auctions determine the FIT received by renewable electricity generators (The Federal Network Agency 2019). The auction system applies to most renewable technologies, including onshore wind energy, offshore wind energy, photovoltaics, and biomass. Hydropower and geothermal installations are exempt from the auctions due to the lack of competition surrounding these technologies. Notably, the auctions held under the EEG are technology-specific, meaning the Federal Network Agency designs individual auctions for each renewable technology.

During each auction, renewable electricity generators place sealed bids indicating the capacity of their proposed installation in kilowatts (kW) and their bid value in cents per kilowatt-hour (ct/kWh) (Endell and Quentin 2017, 16). When the call for bids closes, the Federal Network Agency sorts through the bids and accepts the lowest bids until the capacity under auction is met

(Endell and Quentin 2017, 21). Following the auction, the Federal Network Agency announces the highest, lowest, and average accepted bid prices. As described in Section 3(51) of the EEG, successful bidders receive remuneration equal to their bid price for each kWh of renewable electricity produced. The EEG 2017 maintained the contract for difference mechanism used in previous versions of the legislation. The German government finances the payments to renewable generators through a consumer surcharge.

Chapter 2: Renewable Electricity Policy Analysis

Alberta: Renewable Electricity Program Analysis

Effectiveness

This paper measures the effectiveness of a renewable electricity auction system as the compound annual growth rate in renewable electricity capacity. As shown in Table 2.1, the REP awarded a total of 1358.6 MW of renewable electricity capacity.

Table 2.1: Renewable Electricity Program Results.

Auction Date	Number of Bids	Number of Accepted Bids	Weighted Average Bid Price ($/MWh)	Procurement Target (MW)	Installed Capacity Awarded (MW)
December 2017	26	4	37	400	595.6
December 2018	18	5	38.69	300	362.9
December 2018	15	3	40.14	400	400.8

Note: For each auction, data includes the number of bids, the number of accepted bids, the weighted average bid price ($/MWh), the procurement target (MW), and the installed capacity awarded (MW). Data source: AESO (2018).

Before launch of the REP in 2016, Alberta had 2,830.81 MW of installed renewable electricity capacity (Alberta Utilities Commission 2018b). With the added capacity resulting from the REP, the province will have 4,188.6 MW of installed renewable capacity by 2021. Given this data, the REP is responsible for an 8.15 percent compound annual growth rate in Alberta's renewable electricity capacity from 2017-2021 (see Appendix A for calculation). The compound annual growth rate of 8.15 percent reflects the effectiveness of the REP.

The competitive bids placed by generators enhanced the effectiveness of the REP. For instance, the first and second auctions awarded capacity greater than the procurement target (Table 2.1). The AESO was able to award more capacity than initially targeted due to the low bids placed by producers. For example, the first round weighted-average price of $37/MWh set a record for the lowest price of renewable electricity across Canada (Government of Alberta 2019b). Therefore, the competitive bids placed by generators allowed the government to procure additional renewable electricity capacity while remaining within the program's budget.

Diversity of Actors

Under Alberta's REP, companies of all sizes were subject to the same requirements to participate and secure support in the auctions. Thus, the REP did not make special provisions to promote actor diversity, and this correlates with the fact that all 12 contracts were awarded to large, multinational companies (AESO 2018). This result is not surprising, because compared to larger companies, smaller companies are less likely to participate in auctions due to the high administrative costs and risk of placing an unsuccessful bid (Walsh et al. 2016, 17). Further, the REP required eligible projects to have a capacity of at least 5 MW (as installations under 5 MW fall under Alberta's *Microgeneration Regulation*). This 5 MW minimum may have potentially deterred smaller companies from participating in the auctions (Government of Alberta 2016b; International Renewable Energy Agency 2015, 32). However, the AESO only held three auctions before the REP's cancellation, and it is unclear whether the AESO intended to change the auction rules in future rounds. Nevertheless, the REP did not contain provisions to promote actor diversity, and this highlights a potential area that Alberta may learn from Sweden or Germany.

Diversity of Technologies

Alberta's REP was technology neutral, meaning all eligible technologies competed in the auctions against one another. Eligible technologies included wind, solar, hydro, geothermal, and biomass (Government of Alberta 2016a). Interestingly, all 12 of the REP's successful projects were wind energy projects (AESO 2018). The low cost of wind energy (relative to other technologies) allowed wind energy developers to place more competitive bids compared to developers with higher capital and operating costs (Saric, Carson, and Bachmann 2017, 334). Thus, the technology-neutral design of the auctions limited the diversity of technologies that secured support. In turn, this negatively affected the province's ability to fully exploit its renewable electricity potential. For instance, Alberta is home to favorable conditions for solar energy, yet no solar projects were able to secure support through the auctions (AESO 2018).[1] This is likely due to the higher bids placed by solar projects as a result of the higher initial costs of solar energy compared to wind (Barretto 2017). Despite the low diversity of technologies receiving support under the REP, the technology neutral design of the auctions proved beneficial in securing the lowest possible price for renewable electricity.

[1] Although the AESO did not publicly disclose the number of bids for each technology, data indicates that C&B Alberta Solar Development placed a bid in the first auction. This information confirms that at least one unsuccessful bid was placed for a solar project.

Impact on Household Electricity Costs

According to Section 12 of the now-repealed *Renewable Electricity Act*, the Alberta government funded payments to renewable generators through the Climate Change and Emissions Management Fund, revenue collected from Alberta's carbon tax on large industrial emitters (Government of Alberta 2016a). Therefore, the REP was not financed by a consumer surcharge, meaning the program did not directly impact household electricity costs. Further, the auction mechanism required that all winning projects be "connected to existing transmission or distribution infrastructure to avoid indirect costs to electricity consumers" (Government of Alberta 2016b, 1).

In fact, following construction of all winning projects in 2021, the REP may cause household electricity costs to decrease. For instance, in 2018, the average wholesale price of electricity was approximately $51/MWh (AESO n.d.). In all three auctions, the weighted average accepted bid price was between $37 and $40/MWh (Table 1). As such, the average accepted bid prices were consistently lower than the average wholesale price of electricity in Alberta. This may cause future electricity prices to decrease as other generators strive to compete with the low prices offered by renewable generators in the deregulated electricity market.

In Alberta's deregulated electricity market, the demand for electricity is met by the AESO selecting the lowest electricity supply offers first. Once the demand for electricity is met, all selected producers receive payment equal to the highest selected supply offer. The increased renewable capacity added by the REP will be beneficial under this system because renewable generators have no fuel costs and thus place relatively lower electricity supply offers compared to coal or natural gas generators (Pembina Institute 2018, 3). Therefore, the AESO will select renewable electricity producers first, and a smaller portion of demand will need to be met by producers with higher electricity supply offers. In turn, this means the price of the marginal generator selected to meet demand will be lower, resulting in a lower wholesale electricity price. Depending on individual household electricity contracts, a drop in the wholesale price of electricity may result in falling average household electricity costs. Average household electricity costs may fall because the wholesale price of electricity makes up between 19 and 35 percent of the charges on the average household's electricity bill (Alberta Utilities Commission n.d.). For this reason, decreasing wholesale electricity prices, as a result of increased renewable electricity generation by the REP, may decrease Albertans' household electricity costs.

Summary

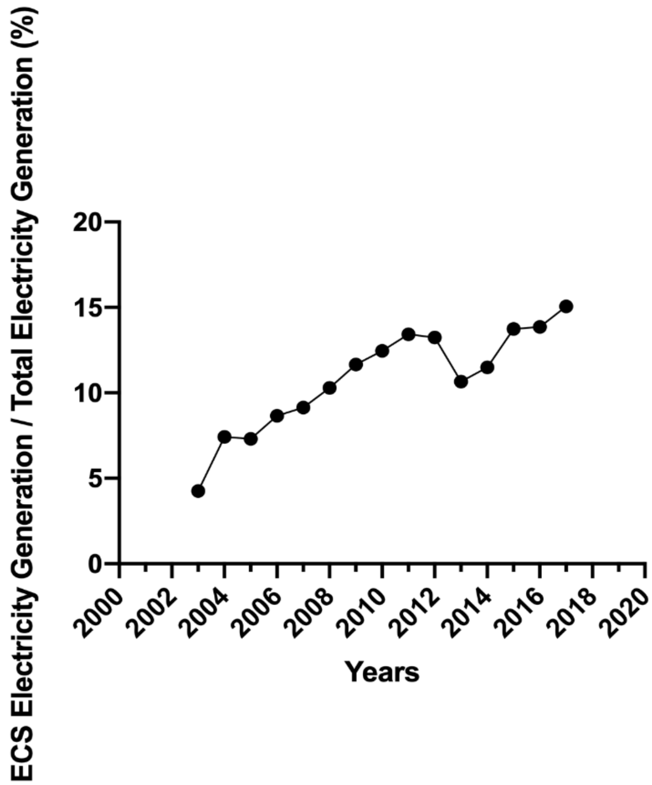
Between 2017 and 2021, Alberta's renewable electricity capacity will grow by 8.15 percent per year due to the capacity awarded under the REP. Theoretically, the program will also result in decreasing household electricity costs once the REP's successful projects come online. Lastly, Alberta's REP did not contain provisions to promote actor diversity and wind energy dominated all awarded projects.

Sweden: Electricity Certificate System Analysis

Effectiveness

This paper measures the effectiveness of Sweden's ECS as the compound annual growth rate in the ECS electricity generation as a share of Sweden's total electricity generation. Since the inception of the ECS, the share of Sweden's total electricity generation supplied by generators participating in the ECS has been increasing (Figure 2.1).

Figure 2.1: ECS Electricity Generation as Share of Total Electricity Generation (%).



Note: Figure generated using GraphPad Prism 8. Data source: Swedish Energy Agency (2019).

In 2003, renewable electricity plants under the ECS[2] generated 4.26 percent of Sweden's total electricity (5.64 TWh out of 132.3 TWh). As of 2017, renewable electricity plants under the ECS generated 15.06 percent of Sweden's total electricity (24.124 TWh out of 160.2 TWh). Given these values, ECS electricity generation as a share of Sweden's total electricity generation has grown at an annual rate of 9.44 percent (see Appendix A for calculation). This annual growth rate represents the effectiveness of the ECS and can be attributed to the increasing quota obligation, which requires electricity retailers to purchase an increasing amount of electricity

[2] As of 2018, some plants are ineligible to receive certificates because plants may only receive certificates for a span of 15 years.

from renewable electricity suppliers. As the quota obligation increases, there is a higher demand for electricity certificates and thus a larger incentive for generators to produce renewable electricity.

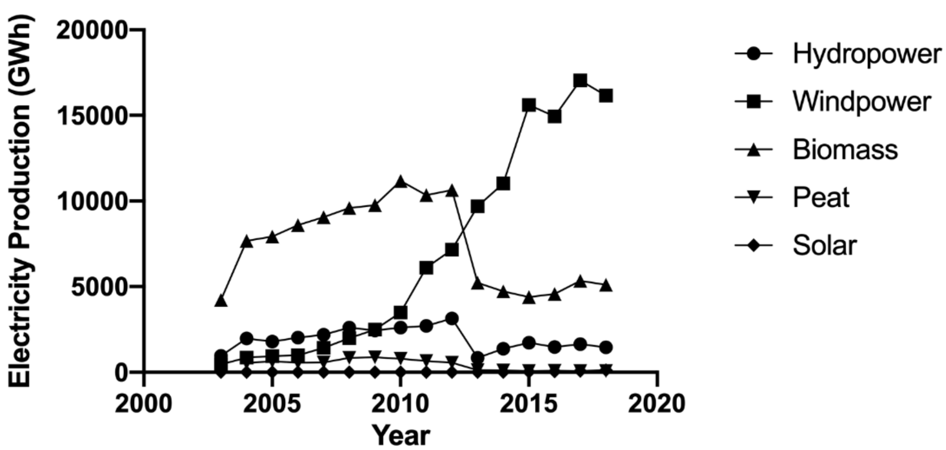
Diversity of Actors

Sweden's 2016 Framework Agreement on Energy Policy stated that "It must become easier to be a small-scale electricity producer"(Government Offices of Sweden 2016, 4). This statement reflects the Swedish government's understanding of the importance of both small and large actors participating in the ECS. However, after an exhaustive literature search, it appears that Sweden's ECS does not have special provisions that promote the participation of a diversity of actors. As previous studies have highlighted the difficulties faced by small actors in electricity certificate systems, the lack of specialized support for these actors in the ECS may be reducing their participation in the market. For instance, minor changes to supply or demand in the electricity certificate market can create considerable variability in the price of certificates and thus revenue, which may deter small companies from participating in the market (Hustveit, Frogner, and Fleten 2017, 1726). This is a concern in Sweden based on the highly variable electricity certificate prices seen in past years. For example, in 2008, the price of a certificate was 350 SEK, while in 2014, due to the unexpectedly high production of renewable electricity, the price plummeted to under SEK 180 (Swedish Energy Agency 2015, 37). This example illustrates the uncertainty surrounding the price of certificates, which may deter smaller companies from participating in the ECS. Small companies also face difficulty making new investments in renewable facilities as the unpredictable price of certificates makes it difficult to obtain bank loans (Najdawi et al. 2013). However, due to the lack of data regarding the diversity of actors in the ECS, it cannot be concluded that the ECS has reduced or discouraged the participation of a diverse range of actors.

Diversity of Technologies

Sweden's ECS is technology-neutral, meaning all eligible renewable technologies compete in the certificate market against one another (Bergek and Jacobsson 2009, 1264). Eligible technologies under the ECS include wind, hydro, solar, geothermal, wave, biofuel, and peat (Swedish Energy Agency and Norwegian Water Resources and Energy Directorate 2015, 9). With all technologies competing against each other, retailers purchase the lowest cost electricity first, thus placing the more expensive renewable technologies at a disadvantage (del Río 2007, 210). This was a deliberate policy choice made by the Swedish government to ensure the most cost-efficient renewable electricity production (Bergek and Jacobsson 2009, 1264). However, as illustrated by Figure 2.2, the technology-neutral system has resulted in wind projects dominating Sweden's ECS.

Figure 2.2: ECS Electricity Production by Type of Reneawable Technology from 2003-2018.



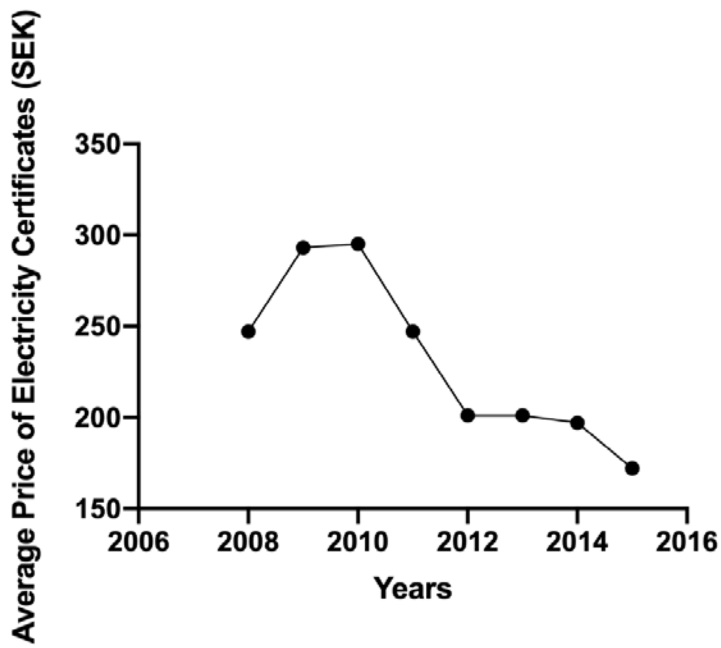
Note: Figure generated using GraphPad Prism 8. Data source: Swedish Energy Agency (2019).

As seen in Figure 2.2, biomass dominated the ECS prior to 2012. Since then, wind energy production has steadily grown and has completely overtaken other renewable technologies. Thus, the design of the ECS may be incentivizing the construction of wind energy facilities because they provide the lowest cost electricity that retailers purchase first (Verbruggen and Lauber 2012, 641). A statement made by a spokesperson for the Swedish Energy Agency supports this conclusion: "15.2 TWh of renewable energy projects are in construction today, of which 11.6 TWh is wind power" (Gray 2018). It is unlikely that the higher-cost renewable technologies will be able to thrive in the ECS until the government raises the quota obligation to a higher level. If the quota obligation is raised, the price of electricity certificates will increase, which may incentivize higher cost renewable technologies (and more wind projects) to enter the market and earn revenue (Bergek and Jacobsson 2009, 1265). However, based on current data, the design of Sweden's ECS has promoted the most cost-efficient renewable technology as opposed to promoting a diverse range of technologies.

Impact on Household Electricity Costs

This paper measures the ECS' impact on household electricity costs as the compound annual growth rate in the ECS surcharge as a share of household electricity costs/kWh. The government introduced the ECS surcharge to allow quota-obligated entities to make up for the additional costs of purchasing electricity certificates. Therefore, the ECS surcharge as a share of household electricity costs/kWh should correlate with the price of electricity certificates over time. As shown in Figure 2.3, between 2008 and 2015, the price of electricity certificates showed a decreasing trend.

Figure 2.3: Average Price of Electricity Certificates from 2008-2015 (SEK).

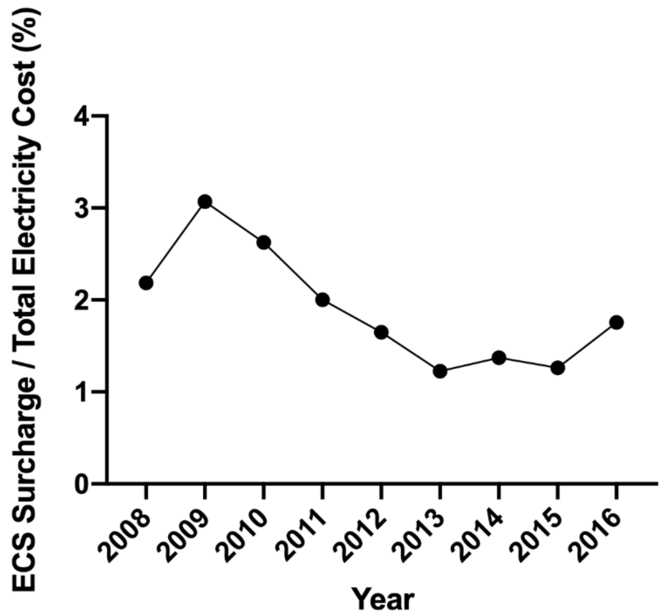


Data source: Swedish Energy Agency and Norwegian Water Resources and Energy Directorate (2015, 32).

An increase in ECS renewable electricity generation may have caused this decreasing trend in the price of electricity certificates. If renewable electricity plants are generating more electricity than expected, the government must issue more electricity certificates, thus increasing the supply of certificates and deflating their price. Falling capital and operating costs caused by Sweden's maturing renewable electricity sector may also explain the decreasing trend in the price of certificates.

The declining trend in the price of electricity certificates suggests that the EEG surcharge as a share of household electricity costs/kWh should also decline over time. As shown in Figure 2.4, the ECS surcharge as a share of household total electricity costs/kWh was relatively constant with a slight decreasing trend from 2008-2016.

Figure 2.4: ECS Surcharge as a Share of Household Electricity Costs/kWh (%).



Note: Total household electricity costs include charges for electricity production, distribution, transmission, administrative costs, and the ECS surcharge. Due to data limitations, the annual growth rate metric was calculated using data from the years 2008-2016 despite the ECS launching in 2003. Data source: Swedish Energy Agency and Norwegian Water Resources and Energy Directorate (2015, 32); Statistica (2018).

In 2008, the ECS surcharge accounted for 2.18 percent of household total electricity costs/kWh, while in 2016 this figure fell to 1.76 percent. Thus, between 2008 and 2016, the compound annual growth rate in the ECS surcharge as a share of household electricity costs per kWh is negative 2.64 percent (see Appendix A for calculation).

Summary

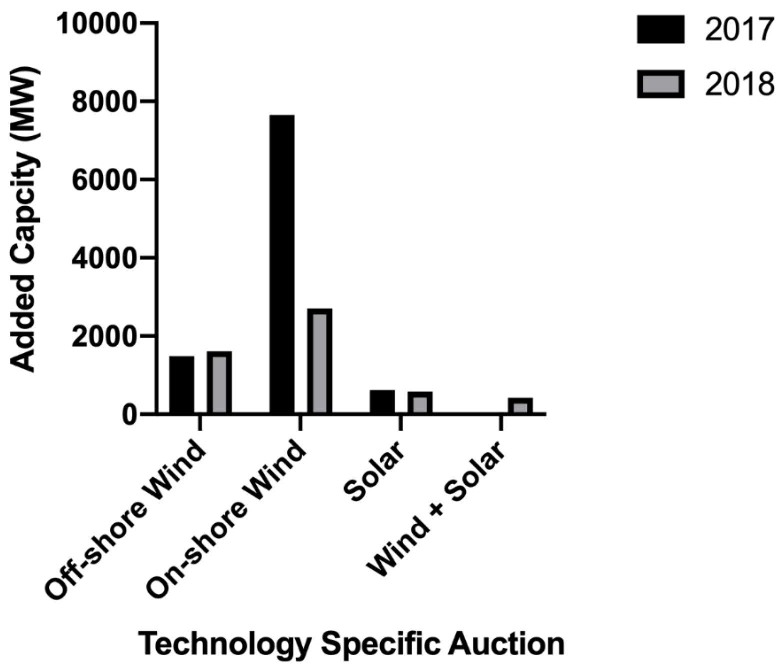
The 9.44 percent compound annual growth rate in the share of Sweden's total electricity generation supplied by the ECS reflects the effectiveness of the ECS. Further, due to the decreasing prices of electricity certificates, the ECS surcharge as a share of total household electricity costs/kWh has been decreasing at an annual rate of 2.64 percent. Lastly, the ECS has not made special provisions to promote the participation of a diversity of actors and has seen wind energy dominate the electricity certificate market since 2012.

Germany: EEG 2017 Analysis

Effectiveness

This paper measures the effectiveness of the EEG 2017 auction system as the compound annual growth rate in renewable electricity capacity. As shown in Figure 2.5, the EEG 2017 auction system has resulted in a substantial increase in Germany's renewable electricity capacity.

Figure 2.5: Added Renewable Capacity from EEG Auctions 2017-2018 (MW).



Note: Biomass was excluded as biomass auctions began in 2019. Figure generated using GraphPad Prism 8. Data source: Federal Ministry for Economic Affairs and Energy (2019c).

In 2016, before the launch of the auction mechanism, Germany had 102.98 GW of renewable electricity capacity (Fraunhofer ISE 2019). With the added capacity resulting from the EEG auctions (15,076 MW), Germany will have at least 126.34 GW of renewable electricity capacity by the end of 2020 (as successful bidders have a two-year project implementation period). Given this data, the EEG auctions have resulted in a 5.24 percent compound annual growth rate in Germany's renewable electricity capacity (see Appendix A for calculation).

Diversity of Actors

When designing the EEG 2017, the German government created a working group to investigate how the transition to the auction mechanism might impact actor diversity (Federal Ministry for Economic Affairs and Energy 2019d). The working group was influential in shaping the final form of the EEG 2017, which included provisions to facilitate participation of groups of small actors known as citizens' energy companies. A citizen's energy company is a company participating in an onshore wind auction that has at least ten private individuals in which no member holds more than 10 percent of the voting rights of the company (Endell and Quentin 2017, 30). If a citizens' energy company is successful in securing a contract through an onshore wind auction, the Federal Network Agency grants them the following privileges:

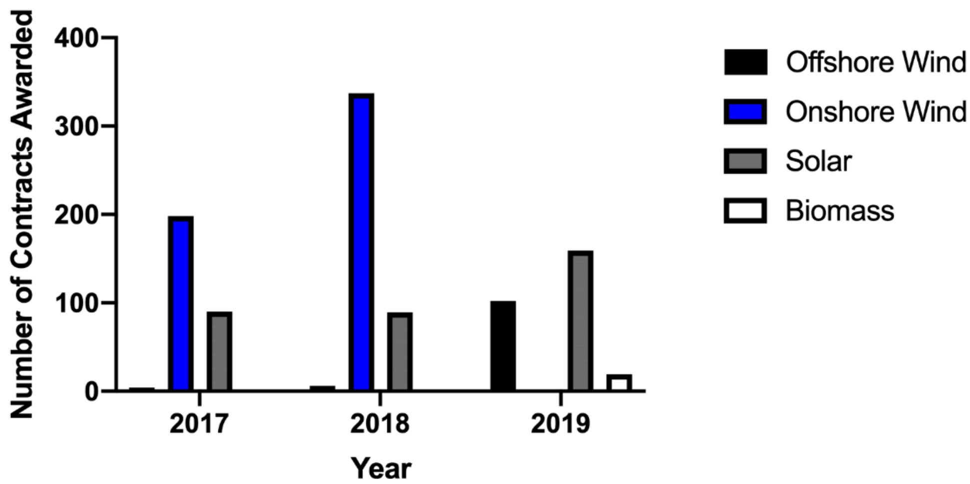
1. A two-step security deposit payment as opposed to the single security deposit payment required of other actors, as per Section 36g (2) of the EEG.
2. A market premium equal to the highest successful bid, rather than the value of their own bid, as per Section 36g (5) of the EEG.
3. A 54-month implementation period rather than the 30-month implementation period required of other companies (Endell and Quentin 2017, 37).

The special provisions granted to citizens' energy companies have proved successful in promoting the participation of these small actors. For instance, Germany's first onshore wind auction saw a total of 70 bids accepted, of which 65 (or 93 percent) came from citizens' energy companies (Wehrmann 2017). The second onshore wind auction showed similar results, with citizens' energy companies having submitted 84 percent of all bids and winning 90 percent of accepted bids (Federal Ministry for Economic Affairs and Energy 2017). The strong participation and success of citizens' energy companies in the auctions reflects the success of the EEG in promoting small actors; however, the overwhelming success of these actors in the onshore wind auctions raises concerns regarding the fairness of the provisions for larger actors. For instance, the auction results may suggest that the provisions for citizens' energy companies place larger companies at a disadvantage and discourage their participation in the auctions. In this sense, the provisions may inherently favour small actors rather than providing a level playing field for actors of all sizes.

Diversity of Technologies

The Federal Network Agency conducts technology-specific auctions for onshore wind, offshore wind, solar, and biomass (Federal Ministry for Economic Affairs and Energy 2019c). Since the EEG auctions began in 2017, the Federal Network Agency has received the most bids for solar and onshore wind projects (902 and 1,143 respectively). A substantially lower number of bids have been received for offshore wind and biomass projects (10 and 20 respectively). However, due to the technology-specific design of the auctions, all types of renewable technologies have been able to secure support under the auctions. Figure 2.6 illustrates the number of contracts awarded to each renewable technology from 2017-2019.

Figure 2.6: EEG Awarded Contracts by Type of Renewable Technology 2017-2019.



Note: Biomass contracts were not awarded in 2017 and 2018 as biomass auctions began in 2019. Figure generated using GraphPad Prism 8. Data source: Federal Ministry for Economic Affairs and Energy (2019c).

The technology-specific design of the auctions has ensured that all technologies, regardless of their cost-competitiveness, are able to secure financial support. The technology-specific auctions also allow the German government to precisely plan their renewable electricity transition by tendering specific amounts of capacity for specific technologies (Hill 2018).

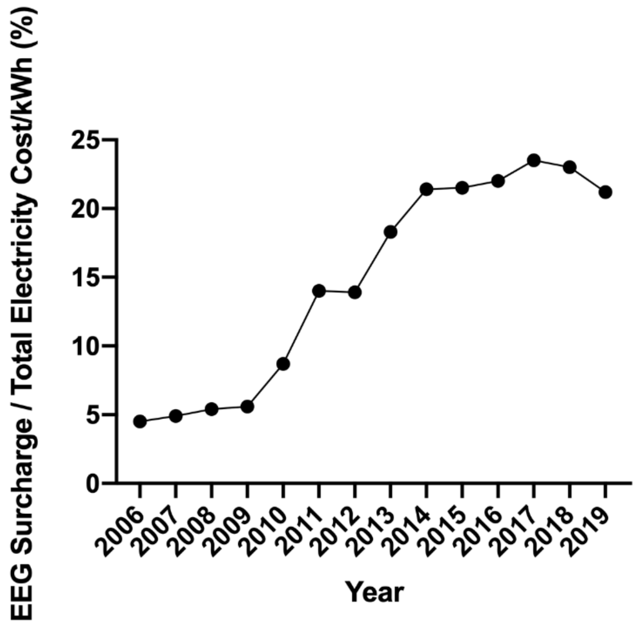
Starting in 2018, the German government piloted three joint auctions in which both solar and wind projects could place competitive bids. Interestingly, wind energy projects failed to secure a single contract in any of the joint auctions. The relatively lower cost of solar electricity compared to wind explains the dominance of solar power in the EEG auctions. For example, the April 2018 joint solar and wind auction received bids ranging from 5.6 ct/kWh - 8.76 ct/kWh for wind projects and bids ranging from 3.96 ct/kWh - 6.16 ct/kWh for solar projects (Federal Ministry for Economic Affairs and Energy 2019c). The lower cost of solar electricity compared to wind may be due to two factors. First, Germany has one of the most mature solar electricity industries in the world (Deign 2019). For this reason, the capital and operating costs of solar technologies are likely less expensive than Germany's wind sector. Second, solar project capital costs were reduced in 2018 when the European Union eliminated the import duty on Chinese produced photovoltaic modules. (Deign 2019).

The German government piloted the joint auctions to evaluate the functionality of "cross-technology tenders", and the results demonstrate how the diversity of technologies receiving support plummets when the government holds technology-neutral auctions over technology-specific auctions (Federal Ministry for Economic Affairs and Energy 2019c). Despite this, the EEG 2017 auctions excelled at promoting a diverse range of renewable technologies, mainly due to the technology specific design of most of the auctions.

Impact on Household Electricity Costs

Since its inception in 2000, the German government has financed the EEG through a surcharge on consumer electricity bills (Federal Network Agency 2019a). The EEG surcharge is set yearly by the transmission system operator (Federal Network Agency 2019a) and funds the difference between the wholesale price of electricity and the set remuneration received by renewable electricity generators (Haller, Loreck, and Graichen 2016, 7). This paper measures the EEG's impact on household electricity costs as the compound annual growth rate of the surcharge as a share of household electricity costs/kWh (Figure 2.7).

Figure 2.7: The EEG Surcharge as a Share of Household Electricity Costs/kWh 2006-2019 (%).



Note: Total household electricity costs include charges for electricity production, distribution, transmission, administrative costs, and the EEG surcharge. Data source: Thalman and Wehrmann (2019).

When first introduced in 2000, the EEG surcharge was 0.19 ct/kWh and accounted for 1.36 percent of household total electricity costs/kWh. In 2018, the EEG surcharge was 6.79 ct/kWh and accounted for 22.72 percent of household total electricity costs/kWh (Federal Network Agency 2019a). Given these values, the EEG surcharge as a share of household electricity costs/kWh grew at a compound annual rate of 16.93 percent between 2000 and 2018 (see Appendix A for calculation). Thus, the EEG surcharge has substantially contributed to increasing household electricity costs/kWh in Germany. Despite this, it is important to note that the EEG surcharge has stabilized in recent years. In 2014, the EEG surcharge was 6.24 ct/kWh and in 2019 the surcharge is 6.4 ct/kWh. Over this time, electricity generation from renewables increased over 50 percent, which reflects the fact that renewable electricity facilities need less funding due to falling capital and operational costs (Federal Ministry for Economic Affairs and Energy 2018a).

Summary

The 5.24 percent annual growth rate in Germany's renewable electricity capacity (between 2016 and 2020) reflects the effectiveness of the EEG auctions. The EEG 2017 contains special provisions to promote the participation of small actors, but the overwhelming participation of these actors in the auction system raises concerns about the fairness of the provisions to large actors. Further, the EEG 2017 was carefully designed to ensure the participation of a diverse range of technologies, including solar, wind, and biomass. Lastly, since its introduction in 2000, the EEG surcharge as a share of household electricity costs/kWh has grown annually at a rate of 16.93 percent.

Chapter 3: Public Opinions of Renewable Electricity

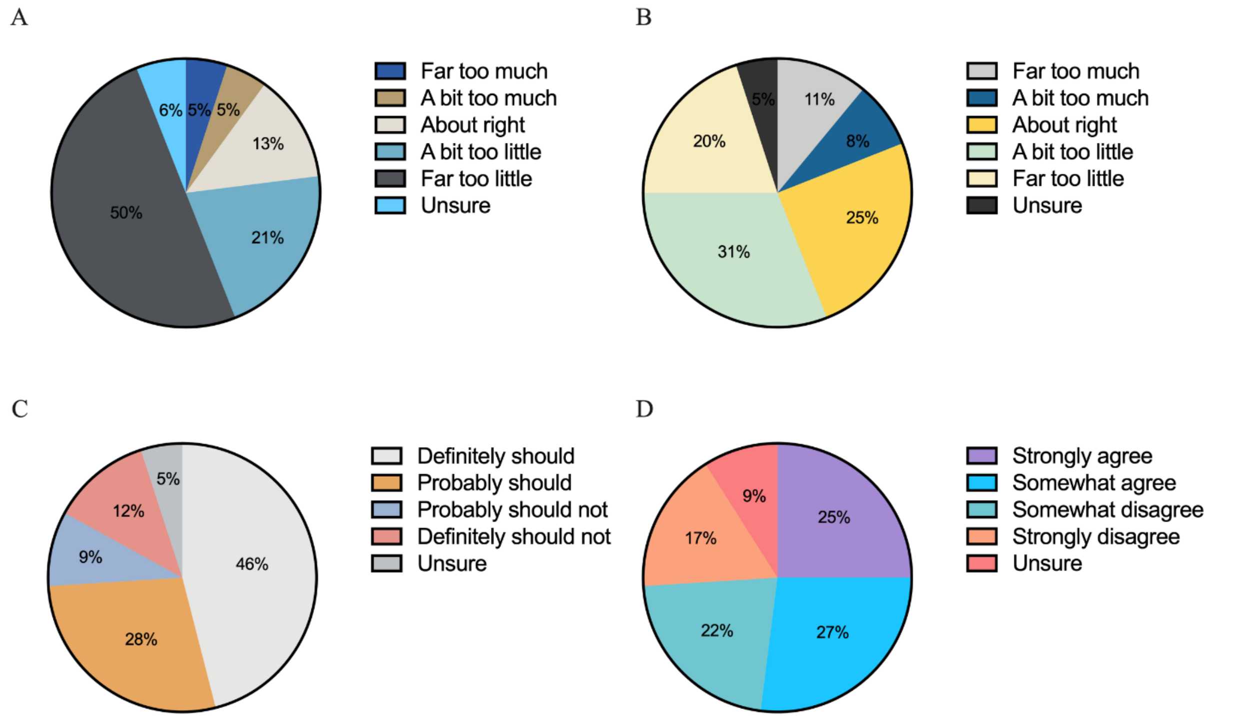
Anderson, Bohmelt, and Ward (2017, 2) identified that as public concern about the environment increases, there is a "significant and positive effect on the rate of renewable energy policy outputs by governments in Europe" (Anderson, Bohmelt, and Ward 2017, 1). These renewable energy policy outputs are wide-ranging and could include renewable portfolio standards, quotas, subsidies, feed-in tariffs, or auctions. Another study highlighted the direct link between pro-environmental public opinion and environmental policy measures, such as renewable energy programs (Weaver 2008, 122). These studies suggest that the public's level of concern about the environment correlates with increased numbers of policies supporting renewables. Further, the environment has become an increasingly important issue in election campaigns. In a recent Canadian poll, the environment topped the list of the most important issues to voters leading into the 2019 federal election (Ballingall 2019). With increasing public concern for the environment, governments will respond by implementing renewable energy policies in an attempt to maximize their chances of re-election (Anderson, Bohmelt, and Ward 2017, 3). As described by Anderson, Bohmelt, and Ward (2017, 8), "public opinion sets the constraints in which policy can develop". From this perspective, although public opinion is not the only factor shaping renewable energy policy, public support for the environment and renewable energy may be a key requirement for a country to develop effective, long-lasting renewable energy policies. Given these arguments, it is important to consider the link between public opinion and renewable energy policies in Alberta, Sweden, and Germany. This chapter describes and analyzes public opinion of renewable energy in each region using recent survey data available online.

Several assumptions limit the conclusions drawn by this analysis. First, different polling organizations administered different opinion polls in different years. This means that the sample sizes and wording of survey questions are different in each jurisdiction. Despite this, this paper assumes that the survey results are comparable between the three jurisdictions. Further, several survey questions highlighted in this section focus on renewable energy as opposed to renewable electricity. The lack of survey data focused on renewable electricity requires that public opinion of renewable energy is equal to public opinion of renewable electricity. Given these assumptions, we next examine public opinion of renewable energy in Alberta, Germany, and Sweden.

Public Opinions of Renewable Energy in Alberta

In March 2019, ThinkHQ, a public opinion research firm, surveyed 1,196 Albertans to gain an understanding of Albertans' opinions on renewable energy (ThinkHQ 2019, 1). Figure 3.1 highlights four questions from the survey.

Figure 3.1: Public Opinion of Renewable Energy in Alberta (2019).



Note: Survey results of four questions asked to a sample of 1,196 Albertans in March 2019. **A)** Participants were asked "All things considered, do you personally think that too much, too little, or just the right amount of electricity is being generated by renewables today"? **B)** Participants were asked "All things considered, do you personally think that too much, too little, or about the right amount of electricity will be generated by each of these sources by 2030? **C)** Participants were asked "Thinking about the future, overall do you think the Provincial Government should or should not be taking steps to increase the amount of electricity generated from renewable sources (like wind and solar) in Alberta?" **D)** Participants were asked to what extent they personally agree with the following statement: "Alberta will always need most of its electricity from fossil fuels because renewables are not enough to meet our needs." Data source: (ThinkHQ 2019).

From this data, there are several key points. First, 71 percent of survey respondents believe that renewable sources of energy do not contribute enough to Alberta's current electricity mix (Figure 3.1A). When asked about Alberta's previously projected 2030 electricity mix, 51 percent of participants still believed that renewables will not play a large enough role (Figure 3.1B). Seventy-four percent of participants also indicated their support for the Alberta government to take steps to increase the amount of electricity generated from renewable sources (Figure 3.1C). These survey results suggest that most Albertans believe the province needs to further develop and implement policy to encourage renewable energy production. A 2018 Alberta survey supports this data, revealing that 61 percent of respondents supported the development of non-emitting electricity (Canadian Wind Energy Association 2018).

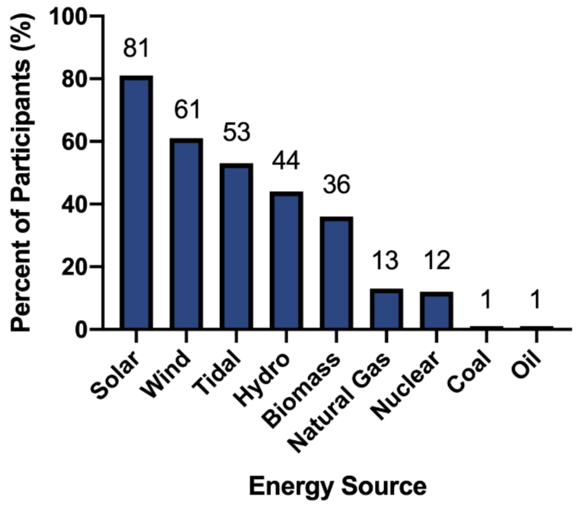
However, some Albertans may be reluctant to fully embrace renewable energy due to the significant role of the oil and gas industry in supporting the province's economy. In 2018, Alberta's mining and oil and gas extraction industry contributed over 20 percent of the province's gross domestic product (Alberta Economic Development and Trade 2018, 6). Some Albertans may view support for renewable energy as a threat to the economic benefits and job security afforded by the fossil fuel industry. A 2018 study provides support for this notion, concluding that individuals living in regions with extensive mining activity or natural gas production are less likely to support renewable energy policies compared to individuals living outside these areas (Olson-Hazboun, Howe, and Leiserowitz 2018, 117). Further, a spokesperson for the Alberta Association of Municipal Districts and Counties acknowledged the significant job opportunities that stem from the construction phase of solar and wind projects but expressed concern about the lack of long-term positions required by these facilities (Southwick 2017). The province's recent economic downtown also likely enhanced public concern over the economy. Survey data supports Albertans' perceived loyalty to the fossil fuel industry, as 62 percent of respondents disagreed with the statement that "Alberta should eliminate use of fossil fuels (including natural gas) for electricity generation and home heating within the next 30 years" (ThinkHQ 2019). Further, as shown in Figure 3.1D, 52 percent of participants agreed that Alberta will always need most of its electricity from fossil fuels because renewables are not enough to meet its electricity needs. A 2017 survey conducted by Abacus Data supports this data, having revealed that 73 percent of Albertan respondents would prefer the demand for oil to increase or stay the same over the next ten years (Bruce Anderson and Coletto 2017). As noted earlier, public opinion is an important determinate of government policy. While the previous government had taken strides towards the creation of a policy environment supportive of renewable energy, Alberta's lack of progress over past decades may be partially attributed to a lack of strong public support for renewables.

Public Opinions of Renewable Energy in Sweden

Despite Sweden's significant progress in developing renewable energy, there is a surprising lack of data related to public opinion of renewable energy in the country. The lack of data may be because renewable energy in Sweden is not a political talking point, and the government does not want to expend resources to conduct surveys when public consensus around renewable energy already exists.

The SOM (Society, Opinion, and Media) Institute in Sweden conducts a yearly survey asking participants, "During the next 5-10 years, how much should we in Sweden invest in the following energy sources?" (SOM Institute 2018). Figure 3.4 illustrates the percentage of participants answering "more than today" for each energy source (SOM Institute 2017, 43).

Figure 3.4: Public Opinion of Energy Sources that Should be Invested in More in Sweden.



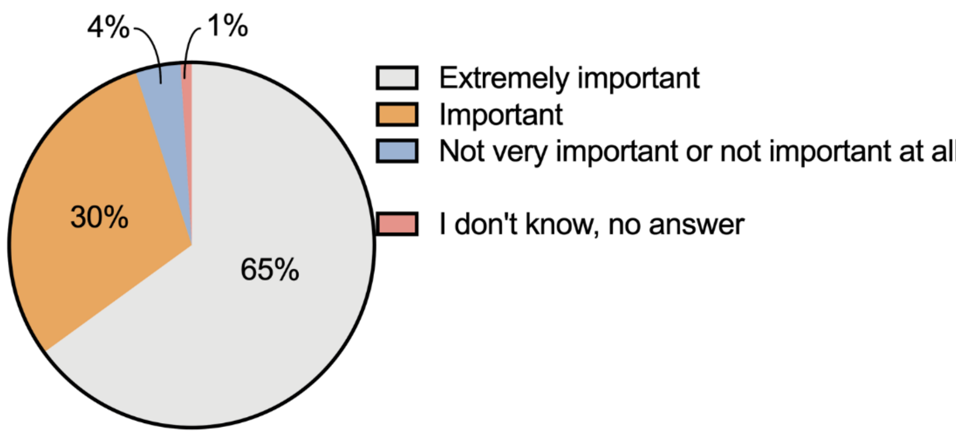
Note: Participants were posed the following question: "During the next 5-10 years, how much should we in Sweden invest in the following energy sources?" Five alternatives were given: more than today, about the same as today, less than today; abolish/give up the energy source completely, and no opinion. The results show the percentage of participants answering “More than today”. The SOM Institute conducted the survey in 2017 and included 3,400 participants. Data source: SOM Institute (2017, 43).

Given this data, the Swedish public show a strong preference for the development of renewable energy sources over nuclear or fossil-fuel-based energy sources. Notably, greater investment in coal and oil were extremely unpopular, reflecting the Swedish public’s desire to shift away from fossil-fuel derived energy. It is likely that the Swedish public’s strong preference for renewable energy, as reflected in this survey, has played a role in shaping the country’s current energy policy. For instance, it is unlikely the government would have introduced a target of 100 percent renewable electricity production by 2040 without significant public support for renewables.

Public Opinions of Renewable Energy in Germany

In July 2017, the German Renewable Energies Agency commissioned a survey to inform the government of the public’s opinion of renewable energy. Kantar Emnid conducted the survey, which included 1,016 individuals over the age of 14 (Renewable Energies Agency 2017). When asked their opinion on the importance of “increased use and expansion of renewable electricity”, 95 percent of individuals responded either “extremely important” or “important” (Renewable Energies Agency 2017) (Figure 3.2).

Figure 3.2: Public Opinion of Increased Use and Expansion of Renewable Energy in Germany.

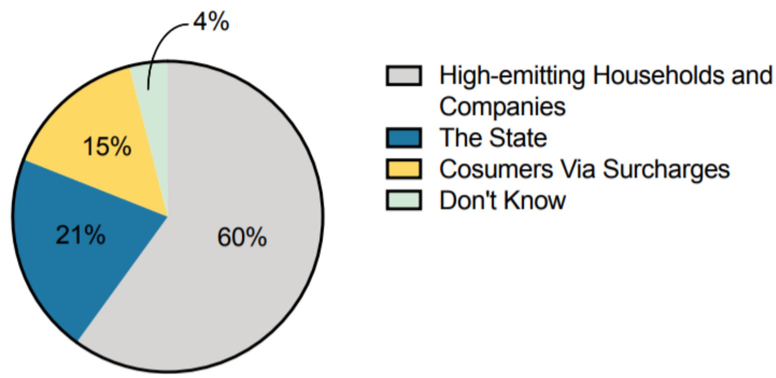


Note: Participants were presented with the following statement: “Increased use and expansion of renewable energy is…”. The survey was conducted by Kantar Emnid in July 2017 and included 1,016 individuals over the age of 14. Data source: Renewable Energies Agency (2017).

Based on this survey question, there is overwhelming support for renewable energy in Germany. Notably, the Renewable Energies Agency has commissioned this same study over the past several years, and the percentage of participants indicating “extremely important” or “important” has exceeded 92 percent every year since 2012 (Amelang, Wehrmann, and Wettengel 2019). The strong public support for renewable energy is likely one of the driving forces behind Germany’s current and historical commitment to developing policy in support of renewable energy. An additional factor behind Germany’s commitment to renewable energy is likely its obligations under the European Union’s Renewable Energy Directive 2009/28/EC.

A survey administered by the Institute of Advanced Sustainability in 2017 provides further insight into public opinion of renewable energy in Germany. When asked who should bear the bulk of the costs of the Energiewende, 60 percent of participants indicated households and companies that are responsible for high, climate-damaging emissions (Figure 3.3).

Figure 3.3: Public Opinion of Who Should Bear the Costs of the Energiewende in Germany.



Note: Participants were asked the following question: "Who should bear the bulk of the costs of the Energiewende?" The survey was administered by Institute of Advanced Sustainability in 2017 and included 7,350 households. Data source: Setton et al. (2017, 21).

Currently, the German government distributes the costs of the EEG equally across households and small companies. Power intensive industries can apply for a partial exemption from the per kWh surcharge. Interestingly, despite dissatisfaction with the distribution of costs, the survey points towards the public's willingness to accept increased personal costs in the interest of progressing the Energiewende. For example, 79 percent of participants who think that the Energiewende has resulted in higher electricity costs still support the Energiewende. Additionally, 86 percent of participants who believe the Energiewende will negatively impact their personal finances over the next decade still endorse the energy transition (Setton et al. 2017, 12). These two surveys are important in highlighting the German public's support for the renewable energy transition despite dissatisfaction with the distribution of the costs.

Comparing Public Opinions of Renewable Energy

Based on available survey data, Germany and Sweden currently show strong public support for renewables. Based on recent surveys conducted in Alberta, Albertans also support renewable energy, but not at the levels witnessed in Germany (95 percent in Germany compared to 74 percent in Alberta). Since government policy is in part a response to public desires, it may be important for the Alberta government to invest in strategies to bolster public support for the environment and renewable energy. As previously mentioned, there is a positive correlation between public support for the environment and renewable energy policy output in European Union countries (Brile Anderson, Bohmelt, and Ward 2017, 1). Therefore, by garnering greater public support for the environment and renewable energy, the Alberta government may reduce an important obstacle for the development and expansion of its future renewable energy policy.

Chapter 4: Lessons for Alberta

This chapter draws from the analysis of Alberta, Germany, and Sweden to offer lessons for Alberta's future renewable electricity policy. Lessons stem from the four analysis criteria: 1) effectiveness, 2) diversity of actors, 3) diversity of technologies, and 4) impact on household electricity costs/kWh. Outlined below is each lesson, followed by a more detailed description.

Effectiveness

Lesson: The effectiveness of Alberta's REP was similar to that of Sweden's ECS. This demonstrates Alberta's success in promoting renewable electricity development. However, Alberta can learn from Germany's EEG auctions and its lower level of effectiveness by anticipating necessary changes to its electricity grid caused by the expansion of renewable electricity.

As seen in Table 4.1, Alberta's REP and Sweden's ECS provided similar levels of effectiveness, while Germany's EEG auctions showed a lower level of effectiveness.

Table 4.1: The Effectiveness of Alberta, Sweden, and Germany's Renewable Electricity Policies.

Jurisdiction	Policy Instrument	Growth in Capacity (%)
Alberta	Renewable Electricity Program	8.15
Sweden	Electricity Certificate System	9.44
Germany	EEG Auctions	5.24

Note: This paper measured the effectiveness of Alberta and Germany's policies as the compound annual growth rate in renewable electricity capacity. The effectiveness of Sweden's policy was measured by the compound annual growth rate in the share of total electricity generation attributed to the certificate system.

Interestingly, the lower effectiveness of the EEG auctions, as measured by the annual growth rate in renewable electricity capacity, may be a result of Germany's success in promoting renewable electricity. As Germany's renewable electricity sector has grown, the government has taken action to expand the national transmission grid by constructing new transmission lines that will take wind and solar electricity generated in northern Germany to the south (Federal Ministry for Economic Affairs and Energy 2019a). Therefore, the Federal Network Agency has had to conduct the EEG auctions strategically, auctioning off capacity in a manner that coincides with the expansion of Germany's transmission grid (Parkin and Wilkes 2019). Thus, although Germany's EEG auctions were less effective than Alberta's auctions, this is likely due to limitations caused by the need to expand the country's transmission system. Germany's experience highlights an important lesson: the Alberta government's ability to anticipate changes required to integrate renewables into the electricity grid may limit the effectiveness of its future renewable electricity policy.

Diversity of Actors

Lesson: Alberta's REP did not make special provisions to promote the participation of actors of all sizes. Alberta could learn from the provisions in Germany's EEG 2017, which resulted in the strong participation of small actors in the auction system; however, any future Alberta government must implement such provisions with the intent of providing a level playing field rather than inherently favouring actors of a certain size.

Alberta's REP did not make special provisions to promote the participation of a diversity of actors, and this correlates with the fact that all successful bidding companies in the REP were large, multi-national companies. The REP may have deterred small actors from participating in the auctions due to the high administrative costs of preparing a bid or the high risk of placing an unsuccessful bid. The Alberta government could improve its future renewable electricity policy by including provisions to promote a diversity of actors, such as those seen in Germany's EEG auctions. Under Germany's EEG auctions, the German government grants citizens' energy companies special privileges, which have shown success in ensuring that citizens' energy companies are able to participate in and secure support under the EEG auctions. For instance, one auction saw citizens' energy companies place 93 percent of the accepted bids (Wehrmann 2017). Alberta may learn from Germany's strong performance in promoting small actors by implementing similar provisions in its future electricity policy. If Alberta were to implement similar provisions, the government could facilitate both small and large companies to participate and receive financial support under its future renewable electricity policy.

Promoting a diversity of actors in Alberta's renewable electricity sector is important for several reasons. For instance, the participation of small actors in renewable electricity support policies has been associated with increased public acceptance of renewable energy (Lairila 2016, 61; Enevoldsen and Permien 2018, 1). The strong public acceptance of renewable energy in Germany lends support to this notion (Renewable Energies Agency 2017). It may be that the auction system and previous FIT policy's support for small actors contributed to the German public's strong acceptance of renewable electricity. Thus, by making provisions that promote the participation of small actors, Alberta could not only benefit from the increased competition, greater innovation, and greater renewable generation brought about by small actors, but may also increase the public's acceptance of renewable electricity.

It is important to note that provisions promoting actor diversity, although beneficial, must be fair to actors of all sizes and provide a level playing field for all participants. A program should theoretically promote diversity without inherent bias for actors of a given size. The auction in Germany in which citizens' energy companies placed 93 percent of accepted bids raises the question of whether Germany's provisions for small actors are dissuading participation from large actors. Alternatively, it raises the question as to whether there is a strongly disproportionate representation of small actors in Germany's renewable electricity economy. Further research may analyze the composition of large- and small-scale actors in Germany's renewable electricity economy and the extent to which special provisions dissuade large actors from participating. Despite this concern, Alberta's future renewable electricity policy could benefit by incorporating provisions to promote the participation of companies of all sizes.

Similar to Alberta, Sweden's ECS did not make special provisions to promote the participation of small actors. A quantitative assessment of small and large companies participating in the ECS was not conducted due to the lack of available data. This limits Alberta's lessons regarding actor diversity to Germany's EEG auctions.

Diversity of Technologies

Lesson: Technology-neutral policies, such as Alberta's REP and Sweden's ECS, promote development of the lowest cost technology, while technology-specific policies, such as Germany's EEG auctions, promote an array of renewable technologies. For Alberta to encourage a diverse range of technologies while still promoting the most cost-efficient electricity production, the province may implement a technology-neutral policy first, followed by a transition to a technology-specific policy.

Alberta's REP held three rounds of technology-neutral auctions and awarded 12 contracts to renewable generators. The technology-neutral auctions resulted in the most cost-competitive renewable technology, wind, securing all 12 contracts. Thus, the REP did not promote a diverse range of renewable technologies, even though the province has favorable conditions for production of other forms of renewable electricity, such as solar energy. Similar to Alberta's REP, Sweden's ECS also operates as a technology-neutral support policy and has resulted in a single renewable technology (wind) dominating the electricity certificate market (Figure 2.2). On the other hand, Germany's EEG auctions are technology-specific and have resulted in a diverse range of renewable technologies (onshore wind, offshore wind, solar, and biomass) securing support (Figure 2.6). As such, technology-specific support policies, rather than neutral support policies, promote the development of a diverse range of renewable technologies. However, technology-neutral schemes have been beneficial in securing the cheapest cost renewable electricity production, as seen in Alberta.

Interestingly, Germany's joint solar and wind auctions saw solar projects secure all contracts. Solar projects dominated the joint auctions due to the relatively cheaper cost of solar electricity. The cheaper cost of solar compared to wind in Germany is opposite the trend seen in Alberta (where wind provides the cheapest cost electricity). The relatively cheaper cost of solar electricity in Germany demonstrates how a mature solar sector can deflate the capital and operating costs of solar facilities. For this reason, it is important for the Alberta government to promote a diverse range of technologies, including solar electricity. In this way, the government can spur innovation and cost reductions for all renewable technologies and allow more than just wind to dominate Alberta's renewable electricity mix.

For Alberta to promote a diverse range of renewable technologies while maintaining cheap renewable electricity production, the Alberta government's future renewable electricity policy may borrow from both Sweden and Germany's policies. For instance, the Alberta government's next renewable electricity policy may employ a technology-neutral approach for the first few years, followed by a transition to a technology-specific approach. The technology-neutral approach will ensure that the most cost-efficient renewables are developed first, at a time when public acceptance of renewables may be at its lowest. The transition to a technology-specific policy several years later may promote development and innovation in more renewable electricity technologies and allow the province to exploit more of its renewable potential. Further, promoting development of many renewable technologies may also act as a fail-safe to reduce the impact of volatile electricity sources on renewable electricity generation.

Impact on Household Electricity Costs

Lesson: Germany and Sweden have funded large-scale production of renewable electricity through a consumer surcharge. If Alberta chooses to substantially increase the share of electricity derived from renewable sources, it may have to adopt an electricity surcharge. Based on survey data in Germany, the Alberta government should introduce any potential surcharge when public acceptance of renewables is high. Further, electricity surcharges would likely stabilize following the maturation of Alberta's renewable electricity sector, as seen in both Germany and Sweden.

Alberta's REP did not increase average household electricity costs. This is because the Alberta government financed the REP through the carbon tax on large industrial emitters (Government of Alberta 2016a). On the other hand, the governments in Sweden and Germany financed their programs using a surcharge on consumer electricity bills. Table 4.2 summarizes each program's impact on average household electricity costs/kWh.

Table 4.2: Renewable Electricity Policy Impact on Average Household Electricity Costs/kWh (%).

Jurisdiction	Policy Instrument	Impact on Household Electricity Costs/kWh (%)
Alberta	Renewable Electricity Program	None
Sweden	Electricity Certificate System	-2.64
Germany	EEG Auctions	16.93

Note: The impact of Sweden and Germany's renewable electricity support programs on average household electricity costs was measured as the annual growth rate of the electricity surcharge as a share of average household electricity costs/kWh. Alberta's program was not financed using a surcharge, so this criterion did not apply. Calculations shown in Appendix A.

The Alberta government was able to leverage large emitters to fund the REP and avoid imposing a surcharge on consumer electricity bills. By avoiding an electricity surcharge, the Alberta government was able to avoid potential public backlash and prevented the REP from affecting public acceptance of renewable electricity in the province. However, if a future Alberta government strives to attain a high percentage of electricity generated from renewable sources, an electricity surcharge may be necessary. A surcharge may be necessary, particularly if carbon tax revenues begin to decline as a result of reduced industrial emissions.

In a 2017 survey, the German public showed strong support for the renewable electricity transition despite the surcharge negatively affecting their personal finances. For instance, 86 percent of respondents indicated their endorsement of renewable energy despite rising average household electricity costs (Setton et al. 2017, 12). In Alberta's case, this suggests that if a future government introduces an electricity surcharge, it should be introduced at a time when public acceptance for renewable electricity is high. For this reason, it is important for the Alberta government to invest in strategies to promote public acceptance of renewable electricity.

In addition, it is likely that as Alberta's renewable electricity sector matures and the technologies become more cost effective, the electricity surcharge will stabilize, as seen in Sweden and Germany (Figure 2.4). Sweden and Germany's programs have been effective in encouraging the development of renewable electricity, yet each country's renewables surcharge as a share of household electricity costs/kWh has remained relatively constant in recent years. This may be due to the falling price of renewable electricity and the overall maturation of the renewable electricity technologies in these jurisdictions. Thus, a potential surcharge in Alberta would likely stabilize following maturation of its renewable electricity sector.

Conclusion

This paper set out to outline lessons that Alberta could take from Germany and Sweden to inform Alberta's future renewable electricity policy. To achieve this, the paper provided an in-depth analysis of each jurisdiction's current renewable electricity program. The analysis highlighted each program's performance in four key areas: effectiveness, diversity of actors, diversity of technologies, and impact on household electricity costs. The results of the analysis can be summarized in four points. First, Sweden's ECS was most effective, followed closely behind by Alberta's REP. Second, Germany's EEG contains special provisions promoting small actors, while Alberta's REP and Sweden's ECS lack such provisions. Third, wind projects dominated Alberta and Sweden's programs, while the design of Germany's auction system has allowed an array of technologies to secure support. Lastly, Sweden and Germany finance their renewable electricity programs using consumer surcharges, but these surcharges have levelled off in recent years. The final chapter drew lessons for Alberta based on these results.

In brief, as seen in Germany, the effectiveness of Alberta's future renewable policy could be limited by the government's ability to anticipate changes required to integrate renewables into the electricity grid. The Alberta government could improve future policy by making special provisions to promote a diversity of actors; however, Alberta can learn from the overwhelming participation of small actors in Germany's auctions by limiting their future provisions to those that provide a level playing field for all actors. Further, for Alberta to encourage a diverse range of technologies while still promoting the most cost-efficient electricity production, the province may implement a technology-neutral policy first (as seen in Sweden), followed by a transition to a technology-specific policy (as seen in Germany). Lastly, if Alberta strives to become a large-scale producer of renewable electricity, it may have to impose an electricity surcharge on households; however, it is important that the surcharge is introduced when public acceptance of renewables is high, and it is likely the surcharge will stabilize as Alberta’s renewable sector matures.

Overall, Alberta’s future renewable electricity policy may benefit from applying lessons learned from Germany and Sweden. It is important to note that Alberta’s next renewable electricity policy may not be successful immediately. As seen in Germany and its multiple amendments of the EEG, Alberta will need to remain open to revising its policy as necessary to keep pace with its evolving renewable electricity sector. Further, apart from Germany and Sweden, many other countries are transitioning towards renewable electricity. Thus, Alberta can also look to the experiences of other jurisdictions when designing its future renewable electricity policy.

Appendix A - Calculations

Alberta, Sweden, and Germany's renewable electricity policies were evaluated using four criteria. Two of these criteria, effectiveness and impact on household electricity costs/kWh, were measured using a compound annual growth rate (CAGR). The formula for a compound annual growth rate is shown below followed by the calculations performed for Alberta, Sweden and Germany:

$$(\frac{x}{y})^{\frac{1}{n}} - 1 = CAGR$$

Where:

X is final value

Y is the initial value

n is the number of years

Alberta's Renewable Electricity Program:

Effectiveness: $(\frac{4188.6\ MW}{2830.81\ MW})^{\frac{1}{5}} - 1 = 0.0815 = 8.15\%$

Impact on Household Electricity Price/kWh: Could not be quantified since auctions began in 2017 and successful projects are granted a two-year implementation period.

Sweden's Electricity Certificate System

Effectiveness: $(\frac{15.06}{4.26})^{\frac{1}{14}} - 1 = 0.0944 = 9.44\%$

Impact on Household Electricity Price/kWh: $(\frac{1.76}{2.18})^{\frac{1}{8}} - 1 = -0.0264 = -2.64\%$

Germany's EEG Auctions

Effectiveness: $(\frac{126.34\ GW}{102.98\ GW})^{\frac{1}{4}} - 1 = 0.0524 = 5.24\%$

Impact on Household Electricity Price/kWh: $(\frac{22.72}{1.36})^{\frac{1}{18}} - 1 = 0.1693 = 16.93\%$

Note: The impact on household electricity price/kWh could not be measured for the EEG 2017 auction system for the same reason as Alberta's auction system. Therefore, the impact on household electricity price/kWh was measured for Germany's EEG since its implementation in 2000.

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