A Brighter Future: Solar Energy in BC

An Application of Multiple Account Cost-benefit Analysis and Barriers Analysis

by

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Abstract

This report collects and analyzes the available information on solar energy development in BC, including existing major barriers, costs and benefits, and externalities. The objective is to assess the future viability of solar and recommend policies that can improve its viability. It is a first step in considering solar energy as a dependable energy alternative to help power BC's future. Under current conditions, the net benefits of solar are negative due to regulatory and cost barriers. Three policy bundles designed to address these barriers are assessed using a set of criteria that include sustainability, stakeholder acceptance, administrative ease, and efficiency. I recommend a combination of regulatory reform, technology assistance, and allowing consumers the option of paying a premium for solar or other green electricity generation. The recommended policy bundle will allow solar to reach grid parity in BC at minimal cost to government and add to BC's electricity capacity.

Keywords: Solar, Energy, Cost-benefit, Barriers, Electricity

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List of Acronyms

GHG	Green House Gases
RPS	Renewable Portfolio Standard
GWhs	Giga-Watt Hours
MW	Mega-Watt of generation capacity
MWp	Mega-Watt Peak
IPP	Independent Power Producer
LCOE	Levelized Cost of Energy
LBOE	Levelized Benefit of Energy
SOP	Standing Offer program
EPA	Energy Purchase Agreement
FIT	Feed-In-Tariff
CBA	Cost-benefit Analysis
CEA	Cost-effective Analysis
NPV	Net Present Value
$/MWh	Dollars per MWh of electricity
$/W	Dollars per Watt of capacity
BC IRP	The British Columbia Integrated Resource Plan
PV	Photovoltaic
RET	Renewable Energy Technology

Glossary

Clean Energy	A BC specific definition, found in the Clean Energy Act. Refers to any eligible energy source that has zero incremental emissions, or is eligible to reach zero incremental emissions through offsets.
Barriers	A broad term to address any factor that may limit the development of a renewable energy technology. Can range from institutional, to regulatory, to technical, to market based.
Economic Viability	A measure to express the net returns to the developer for developing a project. It is the net of the financial costs and benefits of an energy project.
Site C	A new 5100GWh dam project on BC's Peace River. Expected to come into service in 2024. It is the last major dam BC Hydro will build.
SunMine	The first utility scale solar farm in BC. Came into operation in 2015, it has a capacity of 1.05 MWs, and is located in the South Interior city of Kimberly.
Clean Energy Act	The legislation that codifies and enshrines BC's commitment to low emissions. It sets out the targets and conditions that electricity generation must meet in BC.
BC Hydro	The provincial utility that owns and operates the majority of BC's generation and transmission infrastructure.

Executive Summary

BC is endowed with abundant hydroelectric resources. These resources are actively developed by BC Hydro to generate the vast majority of BC's electricity and at one of the lowest costs in North America. These resources have enabled the provincial government to pass and meet stringent clean energy legislation including a 93% renewable portfolio standard and other net-zero emissions requirements. Site C is the last large hydro site acceptable for development, and is currently under construction. BC has run out of readily available energy options that conform to BC's long term energy goals. Exploration of renewables other than hydro is needed to ensure BC is able to continue meeting its long-term energy goals.

There are many potential energy sources that can help BC meet its goals, including solar, run-of-river hydro, wind, geothermal, and tidal. All of these sources need to be evaluated on their own and against each other to enable BC to create an optimal future generation portfolio. This report explores the current situation and future feasibility of solar energy as an alternative BC might rely on. There are many potentially suitable alternatives to investigate, and they all warrant thorough investigation, but I focus on solar because it is the largest growing alterative energy source in the world, continues to experience large cost-reductions, and has never been seriously investigated in BC. This report provides information and analysis on the state and future of solar in BC.

Two data analyses are utilized to understand solar. First a barriers analysis is used to identify what is preventing solar development in BC. Second, a cost-benefit analysis is used to better understand the state of solar in BC, quantify barriers, and help quantify policy analysis. Together these analyses find that the critical barrier to solar development is its economic viability. Solar is too expensive to be developed in BC's market, given the expected returns. However, the two analyses also reveal that there are significant inefficiencies in BC's electricity market that drive up the cost to generate. Solar is also expected to drop nearly 40% in cost between 2014 and the end of 2017. When predicated cost savings are applied and inefficient barriers are eliminated, solar becomes significantly cheaper.

Based on these findings, four policy bundles are generated to improve the viability of solar generation in BC. Broadly, the policy options are defined by their goal. Bundle 1 evaluates the status quo, resulting in minimal solar development and minimal incremental cost. Bundle 2.A implements policies to remove inefficient and burdening cost barriers imposed by the current energy regime. 2.B builds upon these improvements to implement small and voluntary subsidies to allow solar to reach grid parity, without creating significant cost. Bundle 3 implements a generous FIT to achieve maximal solar development in BC, emulating mature solar markets around the world.

From the analysis of all options, I recommend that government enable BC Hydro to implement bundles 2.A and 2.B that allow solar and other emerging renewables to reach grid parity at low direct cost to government. In the short-term, bundle 2.A, develops BC Hydro's solar specific expertise to enable the proper regulation of solar and avoid costly over prescription of regulations. BC Hydro also needs to expand the Micro SOP program to allow more projects and developers to access its cost savings. These two actions are crucial for reducing inefficient costs to solar and other experimental energy technologies and will significantly improve their economic viability.

To bridge the final gap to grid parity, I recommend bundle 2.B: implementing a voluntary green pricing scheme to increase the price received for solar and create a renewable energy investment fund to lower the cost of capital and encourage renewable energy projects. The green pricing scheme would be facilitated through BC Hydro where electricity consumers can volunteer to pay an increased electricity rate, with proceeds going to subsidize experimental renewable energy projects. This type of subsidy has found significant success in the United States. The clean energy fund will operate as a specialized lender, giving favourable rates to energy projects and recouping costs over the long term. These four policy actions will help solar and other renewables to develop at a rate that ensures BC has a low emissions generation future.

Chapter 1. Policy Problem and Background

High levels of greenhouse gas (GHG) emissions are a global problem. The release of these gasses into the atmosphere has negative externalities that impact health, infrastructure and the natural environment. In response to this threat, GHG reduction has become the focal point of many policies around the world. The international community has entered into formal and informal agreements to limit and manage GHGs. Canada has committed to lowering its emissions 30% by 2030 from 2005 levels (Government of Canada, 2015). Proper management of GHGs in the coming decades is critical to ensure the well being of the global population.

One of the most significant sources of GHGs is from the generation of electricity. In 2012, approximately 49% of world's GHG emissions came from the generation of electricity (World Bank, 2014). While electricity generation creates a lower percentage of GHGs in Canada, the percentage is still significant at 13% of Canada's total emissions (EC Canada, 2013, p.15). There is opportunity to address Canada's current emissions from generation by substituting non-carbon renewable energy for fossil fuels and also preparing for increasing future electricity demand in Canada.

The Province of British Columbia has set a Renewable Portfolio Standard (RPS) that requires 93% of BC's electricity generation to be clean energy. Clean energy refers to any electricity source that does not emit incremental emissions or has net zero emissions (through offsets) (BC Clean Energy Act, 2016. 1(1)). When compared globally, BC's GHG emissions from electricity generation are low, with approximately 95% of BC's electricity supply coming from hydroelectric installations (BC Clean Energy Act, 2016. (2.1)). The low prices reflect the 'heritage' dams built many years ago with large capacity and hence, low unit costs of generation. There is an additional large dam to be constructed - Site C on the Peace River, which is expected to generate 5100 GWhs per year and is scheduled to enter into service in 2024. Site C is expected to allow BC Hydro to meet expected domestic electricity demand until 2030-2035 (BC Hydro, 2013, p. 9). It is also the last major hydro site that has been identified in BC. There are no more suitable sites to build hydroelectric generation on the scale that BC has relied on for decades.

To meet its future energy needs and conform to BC's long term energy goals for reliance on clean renewable energy, a new strategy needs to be developed by the province exploring new energy sources and new energy management. It is uncertain which renewable energy technologies will be relied upon to satisfy future demand. BC is in a position to fully explore the alternative options and develop these technologies to a point where they can be an important part of BC's future generation portfolio. Clean energy options include emerging renewable technologies like solar, wind, geothermal, run of river hydro, and tidal. Efficient use of electricity is also an important part of a comprehensive strategy.

BC must begin investing in clean energy alternatives as soon as possible to best prepare for the future. BC's population is projected to grow by over one and a half million people by 2040 (BC Stats, 2015) and they will need energy. BC's clean energy industry needs time to develop the capacity and experience necessary to power BC's future. If BC does not start developing the capacity and industries to supply renewable electricity generation, BC will either have to quickly build expensive or polluting generation or BC will have to purchase electricity from neighbours, potentially at a large premium. Developing clean energy industries and strategies now will enable BC to keep emissions low while providing electricity at manageable costs in the future.

Clean energy technologies are diverse in form, source, technological maturity, generation capacity, timeline, cost, local acceptability and more. When BC needs to make decisions about how to generate electricity in the future, they must be able to turn to a significant body of experience and established clean energy industries that are capable of supplying energy on the scale BC requires. One of the most crucial steps is determining which energy technologies are viable or could be viable and how well they meet BC's goals. In this report, I will explore one kind of clean energy generation, large scale solar, to determine if it can be developed economically in BC. I consider the barriers to its development and examine policies to address these barriers. There are many clean energy options available for consideration and it is likely that many of these will form part of future generation portfolios in BC. Research and development needs to be conducted on these alternatives to determine the best energy generation future for BC.

Why focus on the solar energy option? Solar has been the fastest growing electricity generation technology globally over the past 5 years (IEA, 2015). It has a history of rapidly falling costs that are expected to fall another 40% between 2015 and the end of 2017. Contrary to popular belief, BC has excellent solar resources in its Southern Interior. The Southern Interior of BC has some of the highest solar potential in Canada and higher than some mature solar markets such as Germany, which accounts for over 20% of the world's solar power generation (SEIA, 2016). The policy problems I address are a lack of solar-specific knowledge in BC and barriers to the development of solar powered electricity. Some solar development has already begun, indicating the potential interest in this technology, but more work is needed to determine the feasibility of large scale solar as a significant component of the future power generation mix for BC.

In this report, I explore the viability of solar energy as a clean energy alternative in BC and outline policy options to address the most significant barriers to BC solar development. Specifically, I assess the current solar energy situation in BC. I undertake a cost benefit analysis (CBA) and qualitative analysis of the barriers to solar development in an effort to identify what is preventing solar development in BC from taking off. While a full CBA was conducted, this report primarily presents the financial cost-effectiveness component. The barriers analysis, a review of policies in other jurisdictions, and a literature scan provide the inputs to conduct an analysis of several potential policy bundles. This analysis leads to the identification of a policy option that fulfills key societal and governmental goals.

1.1. Current energy regime

The Clean Energy Act and existing BC Hydro programs represent the current policy regime that sets out BC's approach to meeting future demand and the required sources of generation. The Clean Energy Act specifies that, other than Site C, incremental growth in electricity needs will be met by Independent Power Producers (IPPs) who will develop generation and sell electricity to BC Hydro. The Standing Offer Program (SOP) and Micro Standing Offer Program are the primary programs administered by BC Hydro that prospective solar generators can access.

BC has an extensive list of long-term energy goals. These goals and guidelines are defined in the Clean Energy Act and supporting documents. The purpose of this act is to codify the emission and energy management targets set out by the province to ensure that responsible management is backed up by legislation. The major tenants for the long-term clean energy policy that will guide the makeup of the future generation portfolios are below (ABC Clean Energy Act, 2016, Part 1).

- All new electricity generating facilities constructed in British Columbia will be required to achieve zero net greenhouse gas emissions.
- By 2016, existing thermal generating power plants will achieve zero net greenhouse gas emissions.
- Require zero greenhouse gas emissions from any coal thermal electricity facilities.
- Ensure clean or renewable electricity generation continues to account for at least 93 per cent of total generation.
- No nuclear generating facilities in BC
- Not reliant on foreign imports to meet energy needs
- Foster development of First Nations and rural communities through the development of clean or renewable resources

The provisions of the Clean Energy Act set the regulatory environment and goals that energy development must abide by in BC. It appears that these guidelines or the general content of the Act will not change in the foreseeable future. This provides a stable environment for the analysis and deployment of solar and solar policy options. But it also means that some policy actions or mandate options that would impact the efficacy of solar and other renewable energy technology (RET) in BC have not been analyzed.

An example would be the electrification of fossil fuel use, primarily through a large increase of electric vehicles in BC. This kind of policy would have significant implications for the feasibility of clean energy development in BC. However, because it is difficult to analyze and not a stated goal in the current energy act, it is outside the scope of this analysis.

BC Hydro is the provincially owned power utility in BC. It handles the vast majority of generation, electricity infrastructure, and general provision of power in BC. It serves 1.8 million customers throughout BC, generating 54,000 GWhs of electricity annually. In 2014, 95% of provincial generation came from hydroelectric facilities. BC Hydro oversees over 18,000 KM of transmission lines, 55,000 KM of distribution lines, and had annual revenue of $5.4 Billion. BC Hydro's responsibilities include price setting, generation construction and management to maintain and operate infrastructure, distribution, IPP relations and management, and more. Essentially BC Hydro exists to ensure the effective provision of energy to BC's residents and consumers within the prevailing regulatory framework.

As noted, current policy specifies that solar and other clean energy alternatives will be developed by IPPs. An IPP requires an Energy Purchase Agreement (EPA) with BC Hydro to build a project and sell energy it produces to the BC Hydro grid. IPPs and EPAs have been used for a few decades but have tended to be small projects compared with BC Hydro's projects. IPPs include power production companies, municipalities, First Nations, businesses, and small producers. There have been some significant projects, including large wind installations, but these are the minority of EPAs. IPPs provide approximately 16,585 GWh of electricity each year through EPAs, representing 31% of BC Hydro's total energy sales (BC Hydro, 2014). There are 92 EPAs in BC, mostly wind, small hydro, and biomass generation. There is one solar EPA contract, SunMine, which came into operation in July 2015.

The main way BC Hydro interacts with the IPPs is through the Standing Offer Program, which sets out the amount of generation accepted per year, the price BC Hydro will pay, and the proposed length of a contract. By stating up front what BC Hydro is willing to pay and how much generation they want, BC Hydro does not have to go through extended negotiations for each EPA, easing the management of IPPs. There is a set schedule of prices that vary depending on the location of the project. The average price is currently around $100 per megawatt hours[1]. More remote locations have a slightly higher price than developed areas. The price received for generation increases at 1.6% per year, based on the Consumer Price Index. The generation pool limit is 150 GWhs per year. The process begins with the SOP making an open call for projects. An IPP that wants to build a project applies with the technical details. Projects are accepted on a first come first served basis for complete and thorough applications. When projects are accepted, a series of studies are conducted including a screening study, system impact study, and facilities study to identify and mitigate any potential negative impacts from the project. If the IPP passes the scrutiny and adheres to all of BC Hydro's requirements, an Energy Purchase Agreement will be created that covers the construction, commissioning, and operation of the facility. While the SOP is largely seen as a successful program, there are some issues it creates for small developers such as IPPs that wish to develop solar in the near future.

The process is designed to be able to sufficiently study and regulate all sizes of projects, ranging from 1 megawatt to 100MWs[2]. The study process is very involved and can be quite expensive, often costing hundreds of thousands of dollars. These studies are done to manage risk and ensure projects are worthwhile, will not damage BC Hydro energy infrastructure, and are acceptable in regards to other aspects such as community acceptance and environmental impact. These studies can be a barrier for small projects, like experimental clean energy projects, as they must accept the same fixed costs despite being much smaller and posing less risk.

In response to the challenges faced by small project applicants, BC Hydro has recently created the Micro SOP. This program is a branch of the SOP and serves to provide community and First Nations projects with a cheap and streamlined alternative application and study process that is adequate for small projects. The Micro SOP has a

[1] MW is a measure of the generating capacity of a project; e.g., 1MW of solar in BC can produce approximately 1800MWhs per year.

[2] MWs are how much electricity capacity a project is able to generate. EG: 1MW of solar in BC can produce approximately 1800MWhs per year.

size limit of 1MW per facility. It has a similar price schedule to the regular SOP. Its purpose is to reduce costs and reduce process complexity for small projects to encourage more development. The Micro SOP is only accessible for First Nations and communities at this time. Business IPPs are excluded from the Micro SOP. Together the SOP and Micro SOP shape the regulatory environment in which solar can be built.

1.2. Benefits of building solar

There are two broad types of IPPs that will build solar in BC: 1) Communities and First Nations and 2) private sector businesses. IPPs have different reasons for building solar, unique to each IPP, but they share some broad goals and values. The broad reasons to build are to 1) generate income, 2) provide electricity in remote areas, or 3) invest in green goods. Solar has the same approximate costs for all projects, but the benefits are different depending on who is building, for what reasons, and the total value developers have for this generation. The decision to build solar varies with the type of organization, its values and incentives. Business IPPs tend to build solar to make an income. Community and First Nations IPPs build solar to make an income, but often also build solar to supply energy to a remote area, or to invest in green goods.

Business IPPs will base the decision to build solar on the anticipated financial returns. When considering the financial performance of energy alternate, grid parity is used to describe when the levelized cost of energy (LCOE)[3] development are less than or equal to the levelized price of power received (benefits) by the project. For IPPs focused on earning financial benefits, a technology reaching grid parity marks when it is able to directly compete with conventional energy technologies. The LCOE represent the value that must be earned for developers to make back their discounted investment.

[3] Levelized Cost of Energy is used as a convenient and consistent measure when comparing the costs to generate energy. It is the sum of the discounted costs accumulated throughout the lifetime of a project over the discounted total benefits (MWhs). This solves to a similar discounted cost per single discounted unit of production (MWh). It is also called Levelized Unit Cost. Levelized Benefit of Energy is similar the total discounted benefits over the discounted output.

A green good is a commodity that provides both private use benefit and environmental benefit such as recycled sourced materials or low emissions production methods that produce less air pollution and GHGs (Munro and Marieta, 2015, p. 2). Some consumers value the environmental aspect of goods and are willing to pay a premium to obtain a green good over a non-green substitute. For example, approximately five hundred households in BC have installed solar panels on their homes. At this point in time, this investment requires a long period to earn a net zero return to the homeowner. But homeowners are willing to spend this premium to purchase the green good because it has environmental benefits to them and society, which they value. This additional green good value of solar over other energy sources means that developers may be prepared to accept unfavourable price points because there are additional, unvalued, benefits received.

Another reason to build solar is to provide electricity to remote regions of the province, which often have poor access to the BC Hydro grid or no access due to the high cost of running electricity infrastructure through remote and mountainous areas. Solar and other small renewables can provide electricity to these areas, often at lower cost than alternatives.

The differing motives of potential IPP builders of solar projects are further explored in the cost-effectiveness analysis section to illustrate the acceptable cost and price points for different types of IPPs. Regardless of the reasons for development, the economic viability of a project is key. While the benefits of projects may differ, the basic unit costs are roughly the same because the solar inputs (equipment) are an internationally traded commodity with many efficient producers selling the necessary equipment at competitive margins (Deutsche Bank, 2015). This report attempts to quantify the construction process of large scale solar to understand the costs, where inefficiencies arise, and how to address these inefficiencies in BC.

1.3. Scope

This report looks specifically at large-scale solar production. These are installations over 1MW of generation capacity, and tend to be ground mounted. They are utility scale installations that are able to enter the EPAs through the SOP or Micro SOP. Other established jurisdictions have projects over 100MW in size, so BC's large solar is considered small by those standards. There are other forms of solar, like commercial rooftop and household rooftop. These are outside of the scope of this analysis and they tend to be more expensive per unit of electricity generated than utility scale solar. However, some of the lessons learned from the analysis in this report also apply to smaller solar and the development of other clean energy alternatives in BC.

1.4. Technical description of solar generation and important points

Photovoltaic (PV) solar energy generation is a relatively simple process. It works by light hitting two layers of semi conducting materials, which creates an electric field across the layers causing electricity to flow (Eco2Solar, 2015). These flows can then be concentrated and converted into the appropriate current and amperage, and then added to the general electrical grid. There are several important factors that impact how productive and how cost effective a particular solar installation is. These include the scale of the operation, production and installation costs, solar potential of the land (the potential KWh/day generated for a given place), technologies used, type of panel, and local regulations and policies. Electricity is generated during the day with amounts dependent on how sunny it is and the angle of the sun hitting the panels.

There are some technical limitations to solar. Solar is a non-dispatchable form of energy generation; it cannot be turned on or off as needed. Conversely, solar's intermittency is a barrier to its development, as it typically does not hit maximum production during peak demand. It is also not storable without additional battery technology. Its main benefit over many other energy options is that it is a safe, non-emitting source of power that can be installed in many places (e.g., on rooftops, ground mounted), can be easily scaled to different levels, and has declining installation costs.

1.5. Current state of solar energy in the world

Solar is one of the fastest growing energy sources in the world. It is a relatively young technology, but over its short commercial lifetime, installation costs have fallen considerably due to economies of scale in production and technological and efficiency improvements (EIA, 2014, p. 2). These changes are projected to continue. As average costs fall, they will hit a point that makes it not only feasible for large-scale generation, but a preferred option in many suitable regions around the world (Deutsche Bank, 2015, p. 9). This point is rapidly approaching as solar reaches grid parity in many jurisdictions (Deutsche Bank, 2015, p. 8).

Global production of photovoltaic systems has been increasing rapidly, growing from 40,000 megawatts peak[4] in 2010 to over 175,000MWps in 2014 (EIA, 2014, p. 6). Solar adoption has been primarily led by European countries, where jurisdictions have been undergoing a significant shift away from traditional energy bases, expanding into renewable energy alternatives including solar and wind. Germany is considered a model for solar development and in 2014 produced over 20% of the world's solar energy (EIA, 2014, p. 12). Germany has a government mandate to shift away from nuclear energy and is using any available energy source to meet its demand including renewables and non-renewables. Solar and many other renewables are able to thrive in Germany due to the policy regime that encourages renewable development. This is due to capacity becoming constrained and prices increasing to a point where many renewables are able to compete. Italy is also generating electricity with significant amounts of solar, accounting for 10% of the world's supply, with similar policies to those in Germany.

Other notable places with significant solar generation include California, which represents the vast majority of USA solar generation (SEIA, 2015). California has over 11,000 MWp of capacity as of 2015, with much more planned or currently under construction (SEIA, 2015). China is the leading Asian solar source with 28,000 MWp in 2014 (EIA, 2014, p. 6). Common factors that have allowed these places to generate a large amount of solar include solar boosting/friendly policies and pro-solar/other

[4] MWp is a measure of the peak generating capacity of PV solar panels.

renewables government mandates, which result in actions that promote technological innovation and result in favourable prices. This type of environment allows solar and other renewables to be economically developed.

The global outlook for solar development is promising. Solar will very likely play a key part in reaching emission goals around the world. Canada is the 15th largest producer of solar energy in the world, but solar accounts for less than 1% of Canada's total electricity production. In 2011 Canada had installed 5MWp of capacity (Poissant, Bateman, p. 8), and had increased that capacity to 1843MWp by 2014 (Poissant, Bateman, p. 8). Solar in Canada is concentrated in Ontario, which has nearly all of Canada's solar generation (Poissant, Bateman, p. 8). There has been a government mandate to shift away from fossil fuels in Ontario, requiring the rapid exploration and expansion of renewable alternatives. To aid this expansion, Ontario has provided several policies that have bolstered the development of rooftop, utility scale installations, and other renewables. The types of policies used by Ontario and other jurisdictions are detailed in subsequent chapters.

1.6. Solar potential and installation in BC

BC is often considered to have limited opportunities for solar production because of the perceived cloudiness that the majority of residents experience in Greater Vancouver, The Fraser Valley, and coastal BC. However, there are areas in the Southern Interior that have some of the best solar potential in Canada, able to generate over 1,200 KWhs/day/m^2 (Compass Consulting, 2015, p. 16) Compared with the Lower Mainland's potential of 1000 KWhs/day/m^2, the South Interior can produce 20% more electricity with the same technology (Compass Consulting, 2015, p. 16). KWhs/day/m^2 is a measure commonly used to calculate the strength of solar resources around the world given certain levels of solar technology. For emerging energy sources, this 20% could easily be the difference between the project being profitable or not. Comparatively, Ontario has a solar potential between 1,100-1,300 KWhs/day/m^2 (NRCan, n.d.). Even the cloudy lower mainland experiences, on average, more annual solar potential than Berlin, which has a significant amount of solar development (Wirth, 2015, p. 43). BC thus has a comparable level of solar potential compared to some other similar mature markets.

While there is significant solar potential in BC, there are several barriers to its development. There is limited demand for additional sources of electricity capacity in the near term. The regulatory framework does not yet have solar-specific regulations and BC Hydro lacks the institutional expertise to properly regulate solar. The price of electricity is another barrier. BC has low prices compared with the rest of Canada, inhibiting investment in relatively expensive experimental energy projects. In BC, solar remains comparatively costly to develop. There is also a lack of awareness of solar; people do not know about it or think that it is an option. And there are many more barriers to solar development beyond the scope of this study. However, if the most significant barriers can be addressed, the outlook for solar development could be significantly improved in BC. Chapter 3 examines these barriers in more detail as they provide the basis for development of policies to help promote the expansion of solar.

Currently, solar generation in BC accounts for only approximately 2 MWs of capacity. About 1 MW is from small solar rooftop projects, comprised of about 500 small rooftop installations, operating through the net metering program with BC Hydro, which allows small solar projects to sell excess energy back to the grid. The net metering program has been around for a few years, experiencing only minor use. There is one existing larger solar development in BC, SunMine, a modest 1.05MW utility scale solar installation in Kimberly BC that began operating July 2015. SunMine is BC's solar trial project and many lessons can be learned from its experiences. The majority of analysis in this report is based on the practices and outcomes of SunMine.

There are several projects currently in the planning stage or under development in BC. A community solar garden is in development in Nelson, which will produce between 75-100KWs and is primarily financed by resident investors. An interviewee stated that there are two additional 2MW projects in the planning process and potentially a large 15MW solar farm that has been proposed. These are still in the early stages of the planning process so there is limited information available and they are subject to change. These potential projects show that there is an appetite for solar in BC, and large scale solar appears to be the area of significant growth in solar development. There are no major plans or trends indicating significant expansion of small solar in the near future.

While solar has many virtues, it is just one of a number of renewable energy options for BC, each of which should be considered on their merits by any power policy in the province, so that the promotion of inefficient power generation is avoided. My recommendations in this study are for solar only, as other energy types are outside the project's scope. However, the policies recommended should be applied, when appropriate, to other forms of energy.

This section argues that BC should study emerging and alternate energy sources to satisfy future demand; we cannot rely so heavily on large hydro as we have in the past. It has also reviewed BC's current energy regime and the state of solar. While solar is a tiny part of current generation, its global success and the fact that it has not been seriously looked at in BC is a knowledge gap and are reasons to conduct a fulsome analysis of solar and solar policies in BC. The following methodology section will outline the two major analyses used in this project that inform the policy analysis.

Chapter 2. Methodology

The overall objective in this report is to determine which policy or policy bundle utilizes solar as a cost effective and viable energy alternative. This chapter outlines the data analyses used throughout the report. This study has two main avenues of analysis. The first is an analysis of barriers to the development of solar generation in BC, including a review of literature relevant to solar energy and a series of expert interviews to refine the barriers and to investigate BC-specific solutions to reduce the impact of barriers. The second analysis is a Multiple Account Cost-benefit Analysis used to compare solar under different policy scenarios and to understand the economic viability of solar. These two tools generate information to populate a Multiple Criteria Analysis, which helps deliver a final recommendation on options for solar development in BC. More technical information on how analysis was conducted and results can be obtained from the author upon request.

2.1. Barriers analysis

Barriers analysis is the identification of aspects of the regulatory and economic environment that prevent or inhibit the development of solar in BC. The barriers analysis draws upon barriers identified in other jurisdictions to see if those barriers are present in BC. It also provides a methodology to identify context specific barriers. Identifying and understanding barriers that limit development in BC can help identify policies to mitigate or remove the impact of those barriers. Barriers analysis is a widely used tool in the analysis of renewable energy resources. The analysis in this report is informed by five previous studies, the most important of which is *Barriers to renewable energy penetration; a framework for analysis* by J.P Painuly (2001). Subsequent analyses have built on these barriers analyses. The findings from these previous studies are compared to the situation in BC with additional information gleaned from interviews and the regulatory situation.

2.2. Expert interviews

In order to gain a more complete understanding of the BC-specific barriers to the development of solar and potential remedies, I conducted four interviews with individuals and associations who are familiar with BC's energy environment. The interviews were with representatives of organizations that play a role in BC's energy environment: BC Hydro, Clean Energy BC, ECO smart (technical developer of SunMine and other potential solar projects), and the Town of Kimberly.

2.3. Cost-benefit analysis

I conducted a cost-benefit analysis (CBA) to understand the current and predicted costs, benefits, and prices faced by solar in BC, to quantify the barriers, and to identify the measures used in my policy analysis. No similar previous CBA for large solar in BC was identified. The majority of the cost-benefit analysis follows the guidelines provided in Shaffer (2010) and is based on SunMine's financial data and other solar data accumulated through other studies. While a cost-benefit study was completed, it is not fully utilized in the subsequent analysis of solar energy policies. Rather, the data analysis focuses on the financial benefits – my CBA is essentially a cost-effectiveness study and the other components of the cost-benefit analysis are available upon request from the author..

Broadly, the multiple account framework includes a Market Valuation account (actual revenues and expenditures to construct the project), Target-beneficiary account (electricity consumers in BC), Economic Activity account (how the project impact the BC Economy), Environmental account (how the projects impact their local and regional environments), and a Social account (how the project impact the local communities). The market valuation is used to inform the criteria and measures analysis, which yields a final policy recommendation. The other accounts are used to provide a more robust CBA, and to help inform future comparison of solar to other energy types. The majority of the cost-benefit analysis is available upon request from the author and will be available as a short report for the Pacific Institute for Climate Solutions in the summer of 2016.

Chapter 3. Analysis of Data

This chapter details the results of two primary data analyses conducted for this study: barriers to solar development and data to assess cost effectiveness. The barriers section details the cost and price barriers that are critical to solar development in BC. This section provides an overview of the costs the current market faces, the makeup of these costs, the financial impact of the critical barriers, and expected changes coming to the BC solar market.

3.1. Barriers section

There exists "several types of barriers to the penetration of renewable energy" development (Painuly, 2001, p. 1). Barriers to solar development are attributes that make solar development more difficult or impossible in a given geographic or regulatory situation (Painuly, 2001, p. 2). The issues include economic viability, regulation, technical, social acceptance, and knowledge. "Barriers to renewable energy may vary across technologies and countries" (Painuly, 2001, p. 2) and many of the barriers are widespread across many different renewable energy technologies.

Economic viability – the financial net benefits from development – is the critical barrier to building solar in BC. Economic viability includes the cost of component parts, the cost to install, the regulatory and policy environment, and the price received for the electricity sold. Economic viability is identified in the literature as one of the largest and most universal barriers to solar and other RETs, and was indicated by all interviewees. The next sections explore the components of economic viability more fully.

3.1.1. Cost

Cost is the dollar value spent by solar producers to install and operate the solar capital that provides electricity to the grid; in other words, the cost to supply MWhs to the grid. A broad scope of the capital costs includes the cost of solar panels, the cost of the mounts and any tracking system used, equipment to convert and concentrate the energy collected by the panels, equipment to connect to the broader grid, any other specialized equipment, cost of the land, labour for the installation, and specialized labour for the technical design and assessment. Cost is not a singular barrier; it has many component barriers that include lack of experience, bureaucratic inefficiencies, cost of financial capital, in addition to the high cost of PV systems. SunMine has a Levelized Cost of Energy around $300 /MWh in BC, which is prohibitively expensive for most projects to develop solar. However, the cost is expected go down in the near future; more detail will be given in the CBA section.

3.1.2. Price

Cost and price can only be properly understood as barriers in relation to each other. High costs are less of a barrier if prices paid to the producer per MWh delivered to the grid are high enough to exceed the costs. However, BC has one of the lowest prices paid to the producers of power in North America. In BC the current price paid by the SOP is $100/MWh (BC Hydro, 2016, p. 10). The price in BC is a major barrier for large solar, small solar, and other emerging renewable technologies, as it does not allow these relatively expensive emerging technologies to be built unless their costs are below the price paid for the energy output or they receive an adequate subsidy. But, since they are very new and not actively subsidized, they remain expensive. It follows that if they cannot develop projects, they cannot gain the necessary experience to innovate and reduce costs.

At current costs and prices, solar would incur a loss of up to $200 per MWh generated. Factors that may mitigate the loss per MWh are explored in the cost-effectiveness section. Other barriers to solar development include: (1) constraints set by government policy on the amount of electricity development; (2) lack of knowledge and understanding of solar technology and potential; and (3) characteristics and dispatch ability of solar technology. Currently, these are less significant than the critical barrier of economic viability. But, as the economic viability of solar improves, these other barriers will come to play a larger role in preventing development and should be addressed as appropriate.

To encourage the development of solar power, cost, price, or both need to change. Throughout the analysis, the cost for developing solar is portrayed as a negative value, this negative value will become smaller when actions are taken to reduce costs, which will in turn increase the value given to economic viability (the net of price and cost). Price increases also improve economic viability. In the policy analysis sections of this report, the goal will be to reduce the cost and increase the price when evaluating if a policy makes solar more economically feasible.

3.2. Cost-effectiveness analysis

Current costs are explored to better understand solar's situation and to identify inefficiencies and compare BC to other jurisdictions. Solar is not compared to other alternatives; the goal will be to understand the magnitude of costs facing BC solar. The section has been heavily informed by interviews of experts from Kimberly SunMine and BC Hydro, clean energy association representatives, and reviewing publicly available documents to determine the costs that solar projects face in BC.

SunMine is effectively the only data point for solar development in BC and is therefore the core of this analysis. As more solar projects are built and completed, further analysis can be done to better understand the costs, the variability of cost, and the specific challenges that are faced by projects in BC. This analysis is a generalization based on a single case informed through experts and experiences in other jurisdictions. A market valuation of SunMine is the calculation of incremental financial benefits minus the incremental financial costs of the project. Several useful metrics can be used to understand and compare utility scale solar in BC. Three main calculations are: 1) the levelized cost of energy (LCOE) of solar currently in BC, 2) the levelized benefit of energy (LBOE) for solar currently in BC, and 3) the valuations of impact from different cost barriers on economic viability. Two main measures used to estimate costs and benefits: dollars per watt of capacity installed and dollars per watt-hour of electricity provided to the grid. This analysis uses MWh, which equals 1 million watt hours. Dollars per watt ($/W) is a common way to express costs to install generation capacity and allows easy comparison across jurisdictions. For solar the watts of capacity do not change across areas if the same equipment is used, but there are different solar potentials in different locations so the watt-hours generated are different. $/W is used to compare installation costs; it only accounts for the costs to set up the project and does not count future costs like maintenance or loan repayment. Dollars per mega watt-hour can be used to compare the cost to supply electricity to the grid and allows for accounting of future revenue and costs.

Table 1 Complete breakdown of SunMine costs

Category	Description	Share of overall cost in BC context (DNV report)	$ (2014)/W installation cost
Solar module	The solar cell, silicon wafer, and housing module	25.6%	1.37
Inverter	Equipment to convert and aggregate energy produced by individual solar panels into useable electricity	10.7%	0.57
Mount/Tracker	The system the panels rest on. Trackers orient the panels throughout the day to face the sun, increasing the electricity generated. Sophisticated trackers significantly increase the generation in BC, due to our high latitude and the large arc the sun travels in the summer. Trackers at Sun Mine increase production by 38%	16.6%	0.89
Balance of Systems Materials	The materials to connect the installation to the overall grid.	11.2%	0.60
Labour / Technical Labour	The labour needed to install and connect the facility to the grid and to design and manage the project. Technical labour (engineers) are required to plan the project	10.6%	0.56
Permitting/ studies	Studies are needed to understand what the IPP is doing, studies, certifications, and permits are required by BC Hydro to approve the installations and connect it to the grid.	12.6%	0.67
Other	Smaller miscellaneous costs including site preparation, payment for financial instruments, public consultation/awareness costs, etc. (more	12.8%	0.69

	detail can be found in the SunMine documents)		
Total	-	100%	5.35

Costs were calculated by adding all available cost information (budget, budget overrun), applying the SunMine DNV technical report cost breakdowns, and averaging for watt of installed capacity.

There are additional costs that are incurred over the lifetime of the installation. These include ongoing operating and maintenance costs, and employing the labour to run the facility and payments on the loan taken out to build the installation. However, these costs are not part of the initial investment and are taken out of the net revenue earned. This project is expected to have undiscounted revenue of $6 million. Installation costs include $5.35 million for the initial planning and construction, and an additional ~$250,000 for unexpected equipment purchases. There will be some financial losses from this project when discounting and ongoing costs are factored in. But, the other benefits of construction outweighed the small loss and SunMine was built.

It must be acknowledged that Kimberly SunMine is an ideal project in BC, which greatly reduces costs. It is located within the limits of Kimberly, meaning it is close to labour, transportation infrastructure and transmission infrastructure. It is situated on brownfield land for which the owner, Teck Industries, had no alternative use and thus donated the land to the project, as well as investing financially in the project. The project has received numerous grants and funding from several entities including BC Hydro and NGOs. It has massive public support by locals, with 78% of residents voting in favour of the project in a referendum. The contract with the installer was a fixed price contract, limiting the risk of cost overruns. This sets a high bar of ideal conditions for prospective solar projects to be considered for construction in BC.

The incremental benefits of the SunMine project are the incremental revenue received for the sale of electricity to the grid. The direct benefit of the project is the addition of megawatt hours to the grid for consumption. There is a functional and competitive market to properly value what society gets from a single MWh. There are thorough estimates of the generation capabilities for SunMine. In one year, 1 MW of solar generating capacity is able to generate about 1850 MWhs in BC. We can calculate the value of these MWhs over the lifetime of the project and come to a net present value of the direct benefits of the project.

Table 2 Total NPV of SunMine

NPV (2014$)	V1 (r=6%)	V2 (R=3%	V3 (r=0%)
NPV revenue	2,881,140	3,985,056	5,816,012
NPV Cost	6,908,347	7,378,505	8,151,633
NPV total	-4,027,207	-3,393,449	-2,335,621
Discounted MWhs of project lifetime	22,241	29,999	42,608

Revenue from generation is not the only benefit. Some remote communities are considering solar for energy use and the value will be higher than the commercial price because they are far enough removed from infrastructure to make connection difficult. In these cases the generation would be valued above the revenue generated because getting electricity in remote areas can be very challenging. Another incremental benefit is the value of a green good. This is the premium people are willing to pay above the market value for a substitutable good because the premium good is environmentally friendly. These benefits are counted as societal benefits and are difficult to quantify. However, business IPP projects are looking primarily at the financial benefits, and thus have to make a better financial return before deciding to invest in solar.

The incremental costs apply to the construction timeline and operational lifetime. The net present value of each broad category was then taken and added up to find the NPV of cost. The operational lifetime of the installation will be 25 years, as set out in the energy purchase agreement with BC Hydro. Also in the EPA is the rate paid for each MWh generated. The rate is about $100 per MWh, scaled up over time by 1.6% per year (estimated CPI).

Three interest rates are used in the analysis to illustrate the different goals and benefits of different types of IPPs. For a commercial IPP a 6% interest rate is used, which is also the rate used to evaluate projects by the BC government. Two other interest rates are used to reflect the other two major groups that can be IPPs; communities and First Nations where I assume they have lower rates of time preference and target a lower return on investment.

Table 3 Levelized costs and benefits per MWH

Metric (2014 dollars)[5]	V1 r = 6%	V2 r =3%	V3 r = 0% (nominal)
LCOE $/MWh	310.61	245.96	191.32
LBOE $/MWh	129.54	132.84	136.50
Difference (loss per MWh)	-181.07	-113.12	-54.82
$/W installation	5.349	5.349	5.349

To give context to these numbers, it will be useful to look at solar development in other jurisdictions and some of the estimates from other forms of energy development in BC. One of the most recent levelized cost of energy publications is Lazard's LCOE 9 (2015). In this analysis, utility solar PV has a LCOE of $CAN 74-90/MWh in the US. Lazard's LCOE is an industry publication reflecting the changing costs of renewable and conventional energy in the USA. Another analysis has around $CAN 3.8/W for US commercial installations (utility scale estimates are for 100mw plants, so the contexts are not quite transferable; US utility scale facilities cost under $2.5/W) (NREL, 2015, p. 29). The Canadian context is primarily Ontario, and the most recent estimate has costs around $2-$2.6/W. It is evident that BC has a long way to go to reach the costs achieved by mature markets.

A combination of factors make solar in BC more expensive than in other jurisdictions. First, BC does not have access to economies of scale; this plays a huge role in driving up the $/MWh and $/W costs. BC still has significant costs that mature jurisdictions have eliminated, like permitting fees (which are almost non-existent in the US), redundant equipment fees, and more expensive and less skilled labour. The technical requirements of BC solar also drive up cost; we need more sophisticated trackers to generate an acceptable amount of energy per W (i.e., BC needs to build expensive trackers that are not required in other regions). Mature industries have significant competition, which further drives down costs. A final and significant factor that reduces costs in the US compared to BC, are America's beneficial solar policies, including large federal tax credits for solar, and significant stateside policies aimed at

[5] All values for $/MWh are in PV terms, with respect to their scenario version.

producing more solar. These policies have allowed for cheaper construction by eliminating barriers and providing some subsidies. While significant cost savings can result from open borders and access to equipment from other jurisdictions, BC's solar developments tend to be in fairly remote areas, so transportation costs can be very high. In general BC is paying almost twice as much as mature American markets for similar equipment costs.

To compare other BC energy sources to solar, the BC Integrated Resources Plan (IRP) contains BC Hydro estimates for costs of wind and Site C hydro. They estimate Site C to cost about $85/MWh (BC Hydro (2), 2013) with some estimates as high as $120 (Bryenton, 2015) and wind to cost between $90 and $309 averaging around $135/MWh (BC Hydro (3), 2013 Page 5-31). These estimates were done in 2013 and the values may need updating (cost reductions from learning in wind, and budget increase for Site C). Nevertheless, these values can be seen as benchmarks that solar should reach to become a more viable option for large-scale development in BC. When solar is compared against these values, it is clear that a lack of economic viability is preventing the development of solar in BC and needs to be addressed for solar to develop as a clean energy industry.

3.2.1. Effect of technology and time on costs and benefits

Solar technology is getting cheaper and better. Cost per watt of installation is going down and panels are becoming more efficient. The technological limits and future cost reductions of solar are not known. There are promising technologies in the early development phase that may substantially increase solar efficiency. There are also significant year-to-year improvements on existing technology. The advances coming in the near future should be investigated to understand how the solar development environment might improve in the next few years.

Estimates from a recent Deutsche Bank report (Deutsch Bank, 2015) can be applied to BC to find an estimated reduction in costs for solar. The global solar panel market is very much a commodity market, so cost savings in equipment in one jurisdiction are applicable to others. I estimate the impact of these technological improvements on the construction costs of the SunMine if it were built at the end of 2017. The breakdown of expected cost savings and their rationale are in the table below. These are cost savings independent of any policy changes by the BC government, as the main driver of these cost reductions are other mature markets. There are two effects from waiting: increase in price of power received due to CPI increases, and cost reductions from technological change. Combined, they both work to increase the economic viability of solar development in BC.

Table 4 Expected cost reductions in solar equipment Q3 2014 to Q4 2017

Area	Price	Percentage Change	Reasoning
Panels	$0.75 to $0.50	33% reduction	Private companies have publically targeted $0.4/W and Tier 1 Chinese manufacturers have reached sub $0.5/W. Additionally, soft costs and transportation costs are reduced.
Inverter	$0.25 to $0.17	32% reduction	Inverter prices typically decline 10-15% per year, Deutsche Bank expects this trend to continue. Due to component cost reduction, next generation improvements, and incremental production efficiencies. Also price competition will keep margins competitive and pass savings onto installers
Racking/ other BoS	$0.25/w to $0.16 (racking) $0.30/W to $.17/W (other)	36% reduction 43% reduction	Ongoing efficiency improvements, streamlining, and potential advances in materials to lead to incremental improvements. Increased standardization will reduce BoS costs.
Installation	$0.65/W to $0.45/W	31% reduction	More experienced installers using better tools and techniques on larger systems are likely to more than offset any wage growth through efficiency gains.

Source: Deutsch Bank, 2015, p. 35

Changes to utility scale CBA is a result of expected technology improvements and costs reductions if development occurs at the end of 2017. These cost savings are applied to the different estimated cost components of SunMine and the change is added up in net present value terms. There is also a price increase effect, furthering the improvement that solar receives for delaying development a few years.

Table 5 Impacts of technology on BC solar costs

Barrier savings $(2014)/MWh	**V1 r = 6%**	**V2 r=3%**	**V3 r=0 (nominal)**
Technology cost reductions (construction year 2017/18)	52.73	39.1	27.53
Cost before barrier removal and technology improvements	310.61	245.96	191.32
Cost after technology improvements - *2 years delay*	257.88	206.86	163.79
Rate increase from tech construction schedule (impacts LBOE, not LCOE) - 2 years	*9.58*	*9.83*	*10.1*
Price after 2 years, barrier removal	139.12	142.67	146.6
Net after technology and 2 years	-118.76	-64.19	-17.19

The net benefit from building the project remains negative in all scenarios, but it is significantly lower (in absolute value) than the initial cost to build SunMine. While it is negative, it is approaching a value that makes solar development viable when factoring in net social benefits, especially for communities or First Nation IPPs.

These costs of solar energy in BC can be compared with the costs discussed in the above sections, including the initial costs of solar in BC, the costs of solar in other jurisdictions and the cost of other energy sources in BC. The values show us is that in a few years solar will be very close to being able to compete with BC Hydro's 2013 estimate for wind. Of course these estimations must be updated (in the future to account for changes in energy costs), but the current data indicates that with the correct policy steps and removal of barriers, solar can approach economic viability from cost reductions, developments in other jurisdictions, and a small subsidy to bridge the final gap. If costs continue their downward trajectory, in less than a decade solar could reach grid parity in BC without a subsidy and thus be at minimal cost to government.

3.3. Cost barriers identified and quantified

With a complete estimation of the cost components, inefficiencies can be identified. Comparisons to mature markets and expert interviews are used to identify three significant cost barriers: expensive capital and financial services, unexpected equipment requirements, and regulatory study requirements. More detail is given for each cost component barrier in the policy sections.

3.3.1. Cost of capital

The present value of the discounted cost of capital for SunMine is nearly $18 per MWh. This is the cost to acquire the capital to build the project, and the cost to pay back the capital, above the loan amount (including the interest on the loan). This cost is the discounted value of the payments made on the loan, and the cost to purchase financial services. The total value of the loan repayment is nearly $500,000. SunMine received a lot of free capital for this project, which lowered the cost of capital significantly; future projects will face higher costs of capital than this one. The funding entities are TECK Industries, BC Hydro Innovative Energy Grant, and local NGOs, which provided over $3 million of the $5.6 million initial budget. Kimberly relied on a bank loan for the remaining capital. If the town had to rely on bank capital for its entire capital stock, the project would have had capital costs above $1.5 million. This is a prohibitive cost to future solar developments that may not be able to find as many financial supporters as Kimberly. Government would be able to reduce these costs by absorbing risk from the project (guaranteeing loans), forcing banks to give preferential rates, or provide cheap funding themselves.

The cost of capital probably cannot be fully eliminated; there will always be a cost to acquire capital. But this barrier can be mitigated to save up to $13.68 per MWh. This value is the direct repayment value of capital, which can be reduced by government intervention, specifically through government absorbing this cost; for example, if the project were able to access more low cost capital or capital with alternative payment plans (such as partial ownership instead of a payback period). The remainder of the cost of capital (~$5/MWh) is for financial services. These services will be needed no matter how capital is secured, meaning there are few opportunities for cost saving for that component of capital cost.

3.3.2. Unexpected connection equipment costs

SunMine went over budget because of unexpected connection equipment requirements. This equipment was required by BC Hydro to protect its infrastructure and equipment. But the equipment required was unnecessary because the risks that it protected against were non-existent for solar, as identified through interviews. BC Hydro, lacking the expert knowledge to properly regulate solar energy, created this extra cost. Solar has not been regulated before in BC, and as a responsible regulator, BC Hydro over-prescribed regulations to prevent adverse outcomes. Developing expert knowledge and solar specific regulations can eliminate this cost. The CBA reveals that this cost is approximately $11 per MWh under the 6% scenario. The lack of expert knowledge and extra equipment requirement also triggered additional regulatory study requirements, further exacerbating the cost.

3.3.3. Regulatory study requirements

BC Hydro has complex and thorough requirements before a project can be built and connected to the grid, requiring potential projects to go through rigorous studies. The costs are offset to IPPs. However, in the case of smaller utility solar projects, like those that would be built in BC, these requirements are a major burden. The cost of these study requirements is $36.27 per MWh. BC Hydro's requirements are designed to handle large 100MW facilities. It does not make sense to require the same extensive study for a 1 MW plant as for a 100MW facility. By creating a different set of study requirements, costs can be significantly reduced. This is the most significant cost component barrier identified that can be easily remedied through policy.

3.4. Results of barriers analysis

This table shows the present value of different actions to reduce the cost of development and the cost saving impact of waiting two years for technology development. The values were calculated by isolating the cost for specific components of solar and applying predicted cost savings, then calculating the difference between the new cost and old cost, applied to each interest rate scenario. Finally the differences are applied to the cost before barrier removal and technology, resulting in the predicted net benefits of solar per MWH.

Table 6 levelized unit cost and benefit of solar after technology, time, and barrier removal

2014 $/MWh	**V1 r = 6%**	**V2 r=3%**	**V3 R=0 (nominal)**
Technology (construction year 2017/18)	52.73	39.10	27.53
Cost to borrow/acquire capital	13.68	12.53	11.24
Unexpected connection equipment	11.42	8.47	5.96
Feasibility and connection studies completely removed for solar	36.27	26.89	18.93
Cumulative impact (studies removed)	**114.1**	**86.99**	**63.66**
Cost before changes	310.61	245.96	191.32
Cost after barrier removal and technology n.	196.51	158.97	127.66
Price after technology m.	139.12	142.67	146.60
Rate increase from tech construction schedule (impacts LBOE, not LCOE)	*9.58*	*9.83*	*10.10*
Net present value of solar projects (m.–n.)	-57.39	-16.3	18.94

This analysis has allowed for the identification of barriers and their quantification. It has placed a levelized unit cost on solar, identified what the acceptable costs might be under different considerations, and quantified barriers. The key point is that there exists the possibility to lower the potential cost of solar through technological improvements and the reduction in barriers. The next sections will explore policies to address cost barriers, to close the economic viability gap and to encourage the development of solar energy.

Chapter 4. Policy Tools to Address Solar Barriers

There are many potential policies that can be used in concert or alone to improve the development environment and the economic viability for solar in BC. Potential policies are organized by three broad categories: 1) Increasing the price received by solar producers; 2) Reducing the effective cost to provide power; 3) Regulating to require the development of solar energy. A description of each policy or policy type follows. These policies are the broad tools available; more refined policies will be assembled into bundles for the policy evaluation. Chapter 7 assesses each policy using the criteria and measures developed in Chapter 6. My analysis draws on the findings from the cost effectiveness study and barriers study as discussed in Chapter 3. The policies that follow were derived from multiple sources including CANsia reports (Poissant and Bateman, 2014, p. 29), previous analyses in this report, other jurisdictions, and expert interviews.

4.1. Increase prices received for solar

One of the most common policy types to encourage solar development is to increase the price received by the developer. The magnitude of price increase is a variable that can be changed over time to reflect factors such as regional differences and new developments or new goals. The price increase also needs to be large enough relative to costs to make solar viable and encourage development, if that is the goal. These policies are often rationalized as promoting ‘infant industries’ to help them mature and benefit from economies of scale. They are sometimes used to allow solar to just reach grid parity.

4.1.1. Policy type 1: feed-in-tariff

A Feed-in-Tariff (FIT) is when an explicit subsidy is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that is higher than the retail electricity rates being paid by the customer (Poissant and Bateman, 2014, p. 29). FITs are effective in developing solar energy because they raise the price received for solar energy significantly above its cost to develop and are heavily relied on in many of the mature solar industries around the world. The economic argument for FITs is typically to stimulate an infant industry and ultimately achieve lower costs of production.

Generally, a FIT falls into the broad category of policies that shift price and costs away from producers of electricity towards government (and hence, taxpayers) and/or ratepayers. Cost reductions are not directly addressed in this kind of policy, as cost reductions are expected to take place as the industry develops and technological development and competition happen. FITs have been the most widely used policy in mature markets such as Europe, California, and Ontario. While they are successful in stimulating solar development, they have often been criticized for their expensive cost.

4.1.2. Policy 2: green electrical schemes, PV-specific green electrical schemes, compensation schemes, and activities of electrical utilities

These policies address the same barriers as above, low price, with effectively the same solution, increasing the price received by solar generation. However, this is done via electricity consumers voluntarily agreeing to pay an additional premium for energy to subsidize solar or other clean energy generation instead of government/ratepayers absorbing the cost. Customers can opt to pay a premium to solar or other renewable projects in order to support the development of renewable energy technologies.

4.2. Reduce cost to provide solar energy

Low cost provision of power is the most fundamental requirement for successful projects in any energy market. The policies explored below are identified from the analysis of barriers in Chapter 3 and the cost-effectiveness analysis for BC.

4.2.1. Policy 3: subsidies/tax breaks/government cost absorption

These policies make it cheaper for developers to build solar generation capacity through the government providing tax incentives such as an investment tax credit or direct subsidies. Capital subsides are direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost (Poissant and Bateman, 2014, p. 29). Tax policies can vary in size and by the taxes targeted under different conditions. The subsidies or tax breaks can target the cost of solar panels, balance of systems materials, connection equipment and installation. It utilizes the same policy mechanic as FITs or price increases to improve economic viability of solar and shifts part of the costs away from developers to the taxpayers. If implemented at the appropriate scale, it has similar outcomes to a FIT. The decision to build has been altered to improve the financial returns to investment in solar, which spurs development, innovation, and competition by lowering the cost.

4.2.2. Policy 4: investment funds for PV, commercial bank activities to directly reduce the effective cost of solar, technology investment fund, low interest loan

Capital and funding can be difficult and costly to obtain for solar developments in BC. The goal of these policies is to make capital less expensive and funding more readily available to those who are interested in developing solar or other new clean energy projects when capital is not available or prohibitively expensive. If a project could be fully funded without a loan or other costly financial services then there could be significant cost savings.

The securing of funding is also important. The SunMine project was originally supposed to be twice as large as it is. Being larger would have allowed the project to benefit more from economies of scale, likely resulting in a significantly lower $/W installation cost and $/MWh LCOE. The project was supposed to receive a significant amount of funding from the federal government. But, the funding fell through and the project was downsized significantly. Policies that increase the reliability of funding will enable projects to be less expensive.

Creating a clean energy investment fund or corporation, owned by the government, directly addresses the cost of capital and securing funding. Essentially, this creates a subsidy. This would allow solar and other emerging RETs to access a pool of low cost and reliable funding to plan and construct projects. The fund could enter into partial ownership agreements or loan repayment agreements to minimize cost to government. It will be easier for developers to interact with a lender/investor that is designed around clean energy and very familiar with development, as opposed to an all-purpose bank lender. A bank could achieve similar outcomes, but would require loan guarantees from the government or other means to secure its lending.

4.2.3. Policy 5: micro SOP expansion - cost of feasibility studies / solar specific regulations

As noted above, BC Hydro's regulatory process puts a high burden on small projects, costing SunMine nearly $1.2 million of their $5.6 million construction budget. The two sources of cost are redundant equipment purchases and study costs. Expanding the Micro SOP to be more inclusive allows more IPPs and projects to benefit from study cost savings. Accumulating solar knowledge and using the knowledge to create better regulations will help avoid unneeded equipment purchases for future development.

Given these potential benefits, in depth studies should not be required for smaller projects. Additionally, regulations and the permitting process should not be over burdening. A policy goal is to streamline the regulatory process and reduce the costs of development. The Micro SOP goes part way to achieving this goal, but as noted, does not apply to private sector IPPs.

Proposed changes to the Micro SOP program include: (1) increasing the generation size to 5MWs to allow for proposed projects to actually benefit from the program; (2) exemption from the SOP generation pool quota to allow more projects to be developed and not require potential applicants to wait to develop when there is will and means to do so; and (3) expanding the eligible participants to include commercial or industrial IPPs.

Baseline regulations - unnecessary equipment

As noted above, SunMine bought unnecessary equipment in response to regulations from BC Hydro. The unnecessary equipment costs were caused by BC Hydro not being familiar with solar and over prescribing regulations to ensure safety of their infrastructure. With greater solar technical knowledge, a solar specific regulatory framework can be developed. Once these regulations are created, BC Hydro will not have to over prescribe regulations and the unnecessary equipment costs will be eliminated.

4.3. Mandated development policies

Policy 6: renewable portfolio standards, renewable portfolio standards with PV requirements, sustainable-building requirements

The government has the ability to require utilities to install renewable technologies. BC already has one of these policies in place – the renewable portfolio standard placed on BC Hydro to ensure that over 90% of electricity generated in BC is generated from non-emitting sources. Under this policy, in order to operate, projects or entities' will have to build or invest a certain amount in solar or other renewables. This policy could be applied to solar. For example, an RPS could require that 5% of generation has to come from solar for new developments. So a 100GWh contract would have 5GWhs provided by solar.

Another mandated program could be a sustainable building requirement. This policy is similar to an RPS but instead of being tied to energy projects, they are tied to new building developments. The requirements could be a certain amount of generation per size or just require that new buildings be outfitted with solar panels where possible. These policies usually target large buildings like warehouses, manufacturing buildings, large residential towers and large commercial developments, all which tend to have significant roof space and large budgets that can absorb the cost.

4.4. Policy screening

In order to streamline and focus the analysis on options that are the most feasible in BC, some attributes of policies can be used to screen out policies that are likely not well-suited to BC. These attributes indicate unacceptable or undesired consequences of policies. Two screening attributes are used. One is used to remove a type of policy from analysis. The other is used to indicate undesirable consequences of the policy type, but it is still included in the bundle analysis.

Policies that mandate the development of expensive solar against the wishes of those who have to pay for it will result in stakeholder opposition to the process. BC Hydro has shown that stakeholder acceptance is crucial to their decision making process. When evaluating IPP projects, BC Hydro uses stakeholder and community acceptance as a factor in deciding if the project will receive an EPA. If the stakeholders do not want the energy project, it will be challenging, if not impossible to build it. Policies that force development are thus screened out. While it is best to start the solar industry earlier, forcing people to build it against their perceived best interests is not warranted at this time. Additionally, these kinds of policies do not properly address identified barriers and will result in expensive development. Both outcomes are undesirable.

The other screening attribute, used to identify undesirable consequences of policy, becomes a criterion in the policy analysis but does not completely screen out the policy from the analysis. Policies that subsidize solar development can be inefficient due to free riding[6] (Rivers and Shiell 2015, p. 23), are often too targeted at specific

[6] The company would have undertaken the investment without the subsidy.

technologies[7] (Roberts, 2015, p. 23), or have unintentional negative impacts to the energy market like a greatly altered price (Stagnaro, 2012, p. 4). These subsidies include: feed-in-tariffs or preferential pricing, capital subsidies, and tax credits. These policies are included in the analysis of options because they are the major tools that the largest solar markets have utilized to grow to their current state.

Substitutability of policies

There are many different policies that solve the same or similar issues faced by solar and other renewables. They may have different methods of implementation, different target groups, or different mechanisms, but result in similar outcomes. For this reason the policy bundles for solar energy are somewhat modular. Certain policies can be swapped out for others that have similar benefits and tradeoffs. The options I present to develop solar are not the only methods to do so in BC. I select options that I believe deliver the desired outcomes.

[7] For example, government tries to pick winners.

Chapter 5. Proposed Policy Bundles

The overall objective of policies is to remove existing barriers to the development of solar and foster its development. Each option is modeled around outcomes rather than modeled around policy inputs. The options look at three broad bundles that differentiate how they approach solar development, with the goal to develop different levels of solar with different levels of tradeoffs.

The bundles represent levels of effort that the BC government can commit to the development of solar. The first option is low effort. It is a status quo option. Policies that exist or are planned by government are updated with results from this analysis, but no additional policies are proposed. There are two medium bundles. The first medium effort bundle (2.A) attempts to maximize cost savings while minimizing cost to government or taxpayers. It implements an expanded Micro SOP to improve development. Bundle 2.B implements any other identified cost reductions, and then a small price incentive to fill the viability gap. The third bundle has government intervene to greatly accelerate the development of the solar industry. In the third bundle government or ratepayers absorb significant costs of solar development that results in large amount of development. It emulates other successful jurisdictions to create a mature market quickly with a generous Feed-In-Tariff.

The bundles are created this way because there are so many different solar policies, most of which are flexible in their size and what they do. Creating a frame to create bundles allows for narrower bundles to be created, and allows more defined and different bundles to be made.

Policies should be applied to all emerging energy sources, not just solar. This ensures a level playing field and the government is not choosing the winner. Removal of barriers should be done with cost effective policy, and none should receive overly preferential treatment from government. To find the most efficient of the potential technologies, there needs to be a level field for competition and development. Many interviewees maintained this view. Analogous policies to those I recommend are applicable to other energy sources and the policies should be implemented in a way that other emerging RETs benefit.

5.1. Option 1: status quo

Status quo plus takes the policy actions currently underway in BC and applies recent and planned developments to understand what the current path will do to improve the clean energy industry development prospects. Specially, this bundle looks at the cost reductions implemented from the recent Micro SOP and the cost reductions that will be experienced after the creation of solar specific regulations and accumulation of expert knowledge within BC Hydro.

5.1.1. Summary of policies

1. Create solar specific regulations – eliminating redundant equipment costs
2. Apply the savings of the new Micro SOP to solar – reduced study costs

The Micro SOP has one major benefit, reduction of cost to develop solar and other small renewables. These reductions are the result of replacing expensive studies costing hundreds of thousands at a minimum with a $5000 study. This type of study already exists in the Micro SOP applied to First Nations and communities. While the ceiling on the study costs reduces costs for developers, under the current Micro SOP there is limited room for development in the next few years, as the pool of GWhs is shared with the regular SOP and it is has already been or is nearly exhausted for the next few years. And the size limits may be too small for solar, as proposed projects are too large to qualify for this.

Formalization of solar specific regulations that incorporate its unique technologies makes development easier and addresses unnecessary equipment costs. The provincial government can develop baseline regulations through their experience with SunMine and learning from other jurisdictions. There needs to be additional work on the requirements for solar so developers don't have to navigate an incomplete system and not know if they will face additional costs or delays, like SunMine did. The technical details that the regulations would prescribe are beyond the scope of this analysis.

Measuring the impact of the Micro SOP is the second half of the policy. It is to showcase how the current energy regime will impact the cost of solar. If SunMine were built today, they would likely be able to make use of the cost savings associated with the new Micro SOP. The Micro SOP as defined in Chapter 1 allows developers to avoid expensive study fees and have more certainty in development.

5.2. Option 2: medium effort

The goal of this bundle is to allow solar to reach grid parity. Option 2 is split into two variant bundles. This bundle first seeks to maximize cost reductions and make efficient changes to the development environment. This portion of the bundle represents purely cost-effective improving policies, similar to bundle 1 but expanded. It is dubbed 2.A. The second portion of the bundle, 2.B, then looks at steps to fill in any viability gaps to allow solar to reach grid parity. Policy Bundle 2.B builds upon previous cost savings and program changes to explore how to subsidize solar in the most acceptable way to evaluate what it would look like if solar were to reach grid parity through policy. These policies are conceived to be the more acceptable forms of subsidies. Bundle 2.A is evaluated on its own. Bundle 2.B has 2.A incorporated into it when evaluated to show the effects of subsidies in an environment that has been improved as much as possible without subsidies.

5.2.1. Summary of policies

A - 1. Create solar specific regulations – eliminating redundant equipment costs, same as option 1

A - 2. Expand the Micro SOP – exemption from the SOP generation pool limits, reduce study costs, and increase Micro SOP access

B - 3. Commercial bank activities/creation of a clean technology investment corporation to reduce the cost of capital and make funding more reliable

B - 4. Voluntary Green Electricity Pricing Scheme – increase price of solar by ratepayers voluntarily absorbing excess cost of development with minimal negative consequences

5.2.2. Option A - Micro SOP expansion

The Micro SOP program has been in the works for a few years and has been recently implemented. However, the current form of the Micro SOP has significant drawbacks as explained in previous chapters. There are three main changes that should be made to the Micro SOP to significantly increase solar and other renewable development. 1) Increase size limit, 2) exempt the Micro SOP from the SOP generation pool, and 3) expand the Micro SOP to include business IPPs. This policy, combined with expanding solar regulations and accumulating solar knowledge, explored in the previous bundle, make up bundle 2.A.

The outcomes of the Micro SOP only are accessible for projects 1MW or under. The current size is too small to accommodate past and proposed solar projects, preventing them from making use of the cost reductions that will make the projects more viable. The policy is ineffective at addressing cost barriers in its current state. Increasing the size requirements by a few MWs to around 5 MWs of capacity allow for sizeable projects to make use of the benefits of the program.

Belonging to the SOP generation pool means that large energy projects can take the space in the pool and edge out solar and other small renewable projects. To prevent this from happening, the expanded Micro SOP should be exempt from the general SOP pool. The pool exists so that BC Hydro can properly manage the amount of IPP development, to prevent more development than is desirable from happening. But, the Micro SOP projects are so small that they will have a negligible negative impact on BC Hydro's budget and generation capacity. Allowing large, established energy types to edge out emerging energy types hampers the creation of a diverse clean energy industry.

The current Micro SOP applies only to communities and First Nations. Hence, business IPPs cannot apply to it. This is unfair to them and goes against developing a robust clean energy industry. That is why this policy bundle allows businesses to access the Micro SOP program. First Nations and community IPPs should have priority when EPAs are awarded because they often build projects to provide social benefits beyond the revenue from energy sales.

5.2.3. Option B - clean technology innovation fund

This policy utilizes a clean technology investment corporation managed by a public sector entity. This policy was selected for this bundle because it enables government to evaluate projects and decide which should receive cheaper capital, ensuring the more worthwhile projects are constructed. By providing these services to solar, the cost of capital is reduced. This corporation would invest in projects at a low cost of capital in return for a proportional ownership share or payment plan on a project-by-project basis. Comparatively, solar is not a risky investment, it has the lowest average rates of budget overruns compared to other energy investments (Sovacool et Al. 2014, p. 6) and when it does go over budget it is usually by only a few percent of the total budget (Sovacool et Al. 2014, p. 6). This policy is similar to the government's Innovative Clean Energy fund, but expects a payback. This model can be applied to other emerging renewables as government pursues actions to promote the development of a robust clean energy industry. This policy can realize savings of up to $14/MWh.

5.2.4. Option B - green pricing scheme analysis

A green pricing scheme is utilized to fill the $57/MWh hole left after all identified cost savings are applied. It was chosen over other alternatives that could have filled the viability gap because it fills it through voluntary means. No one is subject to additional costs that they do not opt in for. The following analysis explains in more detail how the scheme would work, and uses American data to make an approximation of the size of the policy.

Green pricing has been utilized in the USA to great success in boosting renewable markets without having the government absorb large amounts of cost. They have been around since 1997 (US DOE, 2014) and are now used in every US State. Approximately 3.9 million Americans participate in green pricing schemes; this represents 1.2% of the entire customer population, buying 74 million MWhs annually (O'Shaughnessy et Al., 2015). These programs are almost always administered through private utility companies.

Rates in the US depend on the type of program and type of energy, and by location. Some offer a partial renewable (e.g. 50% of energy supplied is renewable), some are a subscription (e.g.: extra $10/mo), and most are $/KWh premiums paid on top of regular rates. Rates range from $0.009 USE per KWh to $0.06 USD/KWh ($11.5-77/MWh CAN). With a green pricing option of $57 CAN/MWh[8], solar would reach grid parity in BC after all cost savings are realized. If we assume BC will have similar buying habits as the US, BC could have a market size up to 433 GWh/yr[9]. Based on the growth of these programs in the US, it will take several years for the program to grow to this size (O'Shaughnessy et Al. 2015, p. 12). It is a very small amount of total demand, but provides enough funds for a substantial amount of solar and other experimental renewables. In the short term at least, there is likely more demand for this kind of program than there is ability to supply, for solar and likely all renewable energy technologies besides hydro in BC.

While this policy solution falls under cost shifting, it is different from government absorbing the costs. It is individual electricity consumers making the choice to support green energy or not. Consumers are making decisions that are optimal given their set value beliefs. Thus, this subsidy results in a new benefit to those who pay it. The price incentive used would be priced at the point that makes solar reach grid parity under a 6% interest rate. Under this option solar will develop at an accelerated rate compared to the status quo option.

[8] After all identified cost barriers are removed.

[9] (1.2% * 1.9 million BC Hydro customers) = 22800 potential customers
(22800*19mwh/yr) = 433200 MWh/YR = 433GWh/yr
(433/57000GWh/yr) = 0.0076% of total demand
This is nough room for 240mw of solar development (at 1mw of solar = 1.8GWh/yr).
Numbers are sourced from USA data (O'Shaughnessy et Al. 2015.), (US DOE, 2014.)

This policy would be administered by BC Hydro and would just add an option for the existing billing system. The money would go to a green fund that is associated with the Micro SOP and would amend EPAs of new clean energy developments that are eligible for the expanded Micro SOP, based on first come first serve. After this policy, solar energy in BC is able to reach grid parity, allowing for meaningful First Nations, community, and business development of the solar industry.

5.3. Option 3: major changes to favour the development of solar and other RETs

The goal of this policy bundle is to aggressively develop the solar industry. This option shows what would happen if BC were to emulate the policies of other mature solar markets. There are several methods that could be used including FITs, subsidies, tax breaks, or large shifts in the market. The mechanisms of the policy are always the same: price is increased significantly and this allows solar to become an economically viable investment leading to significant development. The price increase shifts the costs of development onto government and/or ratepayers. It goes beyond just reaching grid parity, ensuring solar is netting significant benefits to the developers allowing society to benefit from solar's positive externalities. Specifically, this bundle implements a large FIT. It would make use of the expanded cost saving policies in bundle 2.A for fair comparison between bundles. While not explicitly measured, the policies in 2.A would be made more inclusive to reflect the development bundle 3 would encourage.

5.3.1. Summary of policies

1. Create solar specific regulations – eliminating redundant equipment costs, same as option 1
2. Expand the Micro SOP – solar exemption from the SOP generation pool limits, reduce study costs, and increase who has access to the Micro SOP, similar to option 2
3. $100/MWh additional FIT over SOP payment – ensures that development is a net financial benefit

The effects of the expanded Micro SOP from the second bundle are expanded even more to include large-scale utility solar to encourage more development. The study cost savings would remain only for projects under 5MW. Larger projects don't need to access the savings because the regular SOP fees would have negligible impacts on the large budget of these projects. The potential projects under this bundle are much larger installations and the more rigorous studies should be done to ensure each is a good project and to protect BC Hydro infrastructure. The generation pool would be opened up for solar even more to allow the development for large solar facilities. And business IPPs would of course be allowed to access everything non-business IPPs can. The Expanded Micro SOP would benefit solar similarly in this option as in the previous option to ensure solar is provided as cost effectively as possible. All available cost savings should be applied where appropriate before the FIT is implemented.

There are a lot of ways to implement a FIT. Some jurisdictions change prices paid depending on the size, type of energy, length of contract, or have floating rates. For simplicity, the FIT used here would be a flat rate for all sizes of utility solar. If this option were chosen, likely the price point would change and a stepping system would be used as more research is conducted and an optimal FIT is identified. A simple FIT is used for ease of analysis and for comparison to the other options. BC Hydro would just tack a flat additional payment onto the purchase of each solar MWh.

The size of FIT has been informed by Ontario. Ontario has been consistently reducing the size of its FIT and now pays $275/MWh of large solar supplied to the grid, with rates as high as $380 per MWh for small rooftop solar. The Ontario FIT, while successfully creating a mature solar market, has been criticized for being too generous and driving up electricity rates for consumers. BC does not need to implement a FIT nearly that high and instead should implement one that is large enough to create enough incentive for IPPs to develop solar.

The previous cost reductions mean that solar will be able to achieve a net cost of $-57/MWh. The FIT thus needs to be $57/MWh to reach grid parity. But we want to beat grid parity. The goal is to make solar a suitably good investment. A FIT of approximately $100 per MWh above the SOP price will achieve significant net benefits for solar developers. The result is a net profit of $43 per MWh supplied, at r=6%, which should be ample incentive for the development of solar in BC. It is larger than the profits seen by wind projects in BC[10]. The FIT would be paid for ratepayers; rates increased evenly for all energy consumers. This size of FIT will allow solar to have higher net benefits than established wind projects. Under this policy BC Hydro would pay $200/MWh supplied by solar. It is significantly lower than other jurisdictions, but makes solar a viable investment and thus ensures considerable development.

[10] $135/MWh of wind has costs between $90-300/MWh. It is a 2013 estimate.Cost reductions have happened, but are not large. Wind has access to the same price of electricity and time horizons as solar, receiving a LBOE of $139/MWh. Wind has not reduced costs to a point where they make more than $50/MWh. If wind were able to make this much with policy intervention, then it would be the clear leader in energy technologies and be significantly cheaper than Site C.

Chapter 6. Criteria and Measures

This section outlines the societal and governmental goals that policies seek to fulfill and the measures that will differentiate the options to allow for comparison and selection of a recommended policy. General criteria for a good policy are outlined. Each criterion is measured by a comparative measure of high, medium, or low for each policy bundle. After each bundle has been evaluated for each criterion, they are compared in a matrix to identify the recommended policy option.

6.1. Objective 1: sustainably

Sustainability is a societal objective that I define in this analysis as the ability to produce energy with minimal impact on the environment. Minimal impact means lowest possible emissions of pollutants and adverse impacts on the natural environment (e.g., land disturbance, impacts on species and ecosystems). Sustainability is the root reason behind wanting to further develop a clean energy industry and solar in BC.

An important measure when comparing energy alternatives are the negative externalities generated per MWh. This measure would include land disturbances, impacts on species and ecosystems, pollutants generated and their impacts. However, the different types of solar options I assess have virtually the same impacts on the environment, thus negative externality minimization is an objective, but does not lead to a direct assessment criterion for the solar options.

Sustainability: sustainable power generation

Expected generation is the ideal measure, it is the expected growth profile for BC Solar caused by the policy bundles. It is a measure of amount of sustainable power generation. Ideally, GWh/yr would measure this, but that estimation would be very speculative at best. Instead a proxy measure will be used to indicate the level of solar development that each bundle can be expected to create.

The net of cost and benefit of solar will determine how much production a bundle will result in. The higher the net benefits of construction and the more IPPs that can access high net benefit projects will indicate that higher solar development will occur. A low scoring policy will be measured by IPPs building solar under grid parity ($-25/MWh and lower financial net benefits of solar at 6%). A low scoring policy will result in a low level of development, with development coming mostly from community and First Nation IPPs. A medium scoring policy will enable IPPs to build solar at grid parity, the benefits of solar balances out the costs at this point (between $-25/MWh and +25/MWh). A medium scoring policy will enable some economical business IPPs to start to develop solar. A high scoring policy will enable solar developments to beat grid parity by enough to significantly encourage development (solar projects net $25/MWh and over). A high scoring policy will enable businesses to make a significant return, resulting in a lot of development.

6.2. Objective 2: stakeholder buy-in

People want to avoid disruption of their social order or when they are told to do something against their wishes. The development of new energy sources should not adversely impact or discriminate against groups that are involved or want to be involved in solar. There should be stakeholder buy-in for the best policy. The simplified list of impacted groups is: First Nation IPPs, residents/ratepayers of BC, community IPPs, business IPPs, and BC Hydro. It is assumed that BC Hydro will not allow projects that are protested by local community interests to be built, so they are not considered as a stakeholder that buy-in must be obtained from.

Ideally the measure that would be used here is how much engagement, consultation, lack of coercion and alignment with community values per specific project. This is difficult to do. Instead, this is measured by how many core stakeholders are in support of the policy bundle. A high scoring policy will have buy in from all stakeholder groups. A medium scoring policy will have buy in from a majority of groups, only one broad group would not buy in. A low scoring policy is determined if more than 2 major groups do not support the policy. Not all stakeholder group are weighted the same. Ratepayer support is given a higher weight than the other groups due to the need to have the broad province on board. If there were a provincial wide campaign against any solar policy, that policy would not be implemented.

6.3. Objective 3: efficiency of systems

Efficient provision of goods and services minimizes resource inputs for a given output, allowing society to achieve more with a given set of resources. For solar, the goal is to maximize energy generated while minimizing costs and other negative externalities. A simplification is minimizing the cost per MWh supplied to the grid. This would be the ideal measure to compare policies. The policy bundles have been modeled to make use of cost reductions as much as possible to ensure that the options are the most effective and best options to compare. Cost itself cannot be used as a good differentiator between the policies because it is nearly the same among all the options. The options make use of the cost reductions identified in previous analysis.

Changes to price and cost have an equal impact to the decision to build solar, but they are not inherently equal in their value as a policy tool. It would be preferable to not use price mechanisms or subsidies, as they are more costly. But these kinds of policies are often required to allow solar to become economically viable. If subsidies are used they should only be used to bridge the final small gap to make solar viable to begin the industry in earnest. Limiting price increases to a small size is emphasized in several interviews.

The size of subsidies can be measured to indicate how efficiently solar is being provided. Price increases (or other cost shifting policies) indicate that solar can not be developed efficiently and thus needs a subsidy to be developed. The exact measure for this objective is the size of a subsidy received by solar above what developers would receive. A policy with no subsidy receives a high score. Medium scoring subsidy incentive will be between $0/MWh and $50/MWh. A policy scores low on efficiency if it has a subsidy, over $50/MWh. Who pays for the price increase is also important.

Ratepayers or government financing the price increase is less desirable because it will be unpopular and divert resources from other activities. A price increase that can be financed through voluntary measures receives a more favourable scoring.

6.4. Objective 4: government budget/ administrative ease

This criterion represents the level of administrative ease relative to the status quo. It can include increased staffing costs, government adopting new practices and technologies, or creating new programs that are costly or difficult. Ease will be separated into three categories: low, medium, and high. A policy bundle that is easy to implement and manage scores high. Medium will require a small amount of changes to budgets or responsibilities or the creation of new programs. A low scoring policy will have high costs or highly complex administration.

Table 7 Criteria and measures summary table

Objective	Criterion	Measure
Stakeholder Buy-in	Level of support from impacted groups	Buy-in from: FN IPPs, community IPPs, business IPPs, BC Hydro, Ratepayers using high, medium, low indicators
Efficiency of System	Minimal Subsidy	$/MWh, size of subsidy
Administrative Ease	Minimal impact on government budget/ administrative complexity	High, medium, low indicators to represent the requirements for new programs, new responsibilities
Sustainability	Minimal ecosystem impact	Emissions and ecosystem impact per MWh (not measured due to similarity between the options)
	Amount of expected energy provided	Proxy measure of cost to supply a MWh. $/MWh

Factors that impact or influence recommendations, but are not reflected in the criteria and measures

Timing is very important to how the province will make its decision. We don't want too much development too fast or not enough too late. Technology is continually developing and in 10 years the current technology might be obsolete. Timing is not explicitly included because it is implicit in many of the policies. Policies could be implemented now or later, but the analysis assumes development begins after 2017. The values used in this analysis are what the expected prices and costs will be in 2017. This allows analysis to take advantage of technological cost savings and gives ample time for implementation. This is especially relevant for the economic viability measures. The case for solar will continue to get better between now and when generation is needed. Ideally, in 10 years the emerging renewables will have enough experience to be able to begin playing a key role in new generation portfolios and there will be enough experience to know if certain renewables are viable.

Chapter 7. Evaluation of Policy Options

Each policy bundle is evaluated following the order set out in the options. A bullet point summary of each bundle is provided, and then is assessed using the criteria and measures indicated above. After the policies have been evaluated on their own, a summary of the individual effects will be compiled to compare options and recommend the most suitable policy for solar in BC.

This report only evaluates policies on how they impact solar energy in BC. It is beyond the scope of my analysis to assess the other potentially viable energy sources BC may be able to rely upon in the future. However the government should apply comparable policy bundles to all potential renewable sources to create a level playing field for each energy sources and policy should not significantly raise one energy source over another.

7.1. Option 1: Low effort

Policy Summary:

1. Create solar specific regulations – eliminating redundant equipment costs
2. Apply the savings of the new Micro SOP to solar – reduced study costs

Sustainability:

Development of baseline regulations reduces costs for all IPP types by reducing the impact of cost barriers. The policy eliminates unnecessary equipment costs by the amount indicated in the cost-effectiveness analysis.

Table 8 Savings as a result of a knowledgeable regulator not over prescribing regulations

$(2014)/MWh	V1 r = 6%	V2 r=3%	V3 R=0 (nominal)
Unexpected connection equipment	11.42	8.47	5.96

Savings as a result of a knowledgeable regulator not over prescribing regulations

The current Micro SOP enables savings for First Nations and community projects by requiring appropriately detailed and priced studies before development can occur. However this cost reduction does not occur for business IPPs.

Table 9 Savings as a result of the current Micro SOP

Barrier savings $(2014)/MWh	V1 r = 6%	V2 r=3%	V3 R=0 (nominal)
Feasibility and connection studies completely removed for solar. Applies to First Nations and Communities only	36.27	26.89	18.93

Economic viability improves, but not by much. If an organization is operating under a low discount rate, for example when the goal is to provide generation to remote communities, it is likely a net benefit investment. But my analysis shows that business solar developments have negative net benefits if their discount rates are positive. Under this policy, only First Nations and communities will build projects. And they will only be able to access cost savings for small projects, which may be smaller than they wish to develop. They also are subject to the existing pool, and the pool is exhausted for 2016 and nearly exhausted for 2017, further limiting development opportunity. For all these reasons, this option scores low for the amount of expected energy provided due to the high cost of development. A further danger here is that a few potential solar projects are too large to be eligible for the cost savings. So either those projects are larger and don't get the barrier cost reductions, or are down sized and don't get access to the Micro SOP. Either way, development is costly and there is a low level of development in this option.

Table 10 Cost of development from option 1

$(2014)/MWh	V1 r = 6%	V2 r=3%	V3 R=0 (nominal)
Net benefit after low effort option (only for FN IPPs and community IPPs)	-71.07	-28.83	7.7
Net benefit after low effort option (Business IPPs)	107.34	55.72	11.23

Stakeholder buy in:

This policy has buy-in from all stakeholders but one, the clean energy business IPP stakeholders. Business stakeholders in the clean energy industry unfairly face harder and more expensive development processes. I assign a medium ranking for stakeholder impact because an important group is not happy with the policy, but it is not multiple groups or the most important stakeholder group, the public. There is limited impact on the public, so their buy-in is expected.

This policy has buy-in from First Nation and community IPPs because they are able to build small solar projects at less expense and through an easier process than before. BC Hydro is in favour of this option because it is what they are currently doing and planning on doing. Ratepayers like the policy because there are no increases in their hydro charges to cover the cost of the policy.

Ease of administration:

This policy is what the government is currently planning on doing. There is no change required so this policy rates as high under ease of administration.

Efficiency of systems:

This policy implements some cost reduction policies and does not impose any price increases or use subsides. It rates high in efficiency because while there is only a small amount of solar energy produced, it is produced efficiently. Likely those who do not qualify for the Micro SOP will not build solar, and only small projects will be undertaken.

Table 11 Summary for option 1: low effort

Criteria	Measure	Option 1
Maximize impacted groups that support policies	Buy-in from: FN, communities, businesses, BC Hydro, Ratepayers,	Medium, Business IPPs discriminated against
Minimal Subsidy	$/MWh, size of subsidy	High, No price increase
Minimal impact on government budget/ minimal new costs/administrative complexity	$, new programs, new responsibilities	High, No change to administration
Amount of expected energy provided	$/MWh	Low, -28.83 (3%)/MWh for FN and Communities. -107.34 /MWh for businesses

The end result of this policy bundle is that the governmental sources of cost inefficiency for solar are addressed for some groups. It results in a better development environment than exists now and covers necessary changes that a responsible regulator needs to make given the emergence of new technology. First Nations and community-based projects are especially encouraged. Prices remain the same and government costs are minimized.

7.2. Option 2A: medium effort option policy evaluation

Summary of policies:

A - 1. Create solar specific regulations – eliminating redundant equipment costs, same as option 1

A - 2. Expand the Micro SOP – exemption from the SOP generation pool limits, reduce study costs, and increase Micro SOP access

Sustainability:

Baseline regulations implemented are the same as bundle 1 and have the same impact, removing redundant equipment costs at a very low cost. Option 2.A effectively has the same level of cost savings as option 1. But, it significantly expands who can access the pool and prevents small projects from being edged out. These actions allow more solar development than option 1. Thus, 2.A scores medium-low on sustainability.

Stakeholder buy-in:

All stakeholders have buy-in for this option, resulting in a high score. All types of IPPs are free to develop solar in fair and more favourable conditions. In Bundle 2.A, BC Hydro is just expanding existing programs to address issues. The discrimination from Bundle 1 is removed, improving the score of the bundle. Ratepayers are not impacted, and thus do not object.

Ease of administration:

This option only alters existing programs, and expands them in ways that reduce costs by reducing administrative duties and having a net zero impact on budget. Bundle 2.A gets a high rating for ease of administration.

Efficiency of systems:

This bundle does not use any subsidies. For this reason it rates high on efficiency of systems.

Table 12 Summary for option 2.A: medium effort

Criteria	Measure	Option 2.A
Maximize impacted groups that support policies	Buy-in from: FN, communities, businesses, BC Hydro, Ratepayers,	High, full buy-in
Minimal Subsidy	$/MWh, size of subsidy	High, no subsidy
Minimal impact on government budget/ minimal new costs/administrative complexity	$, new programs, new responsibilities	High, reduced responsibilities
Amount of expected energy provided	$/MWh	Medium-low, same costs as bundle 1 but more access to cost reductions

Overall, this policy does well in the analysis. This bundle makes significant improvements over the current regulatory environment. 2.A does not seek to implement any subsidy, and just tries to maximize cost savings to projects and parties where it makes sense. Essentially it is making easy improvements over the regulatory environment. It allows more development of solar by allowing more projects to access the Micro SOP and prevents other forms of energy from edging solar out. It is strictly better than bundle 1. But, it doesn't do much to encourage solar above expanding the limited benefits of the Micro SOP. The next bundle will explore improvements upon this bundle to evaluate polices that will result in solar reaching grid parity.

7.3. Option 2B: medium effort option policy evaluation

Summary of policies:

A - 1. Create solar specific regulations – eliminating redundant equipment costs, same as option 1

A - 2. Expand the Micro SOP – exemption from the SOP generation pool limits, reduce study costs, and increase Micro SOP access

B - 3. Commercial bank activities/creation of a clean technology investment corporation – reduce the cost of capital and make funding more reliable

B - 4. Voluntary Green Electricity Pricing Scheme – increase price of solar by ratepayers voluntarily absorbing excess cost of development with minimal negative consequences

Sustainability:

2.A implements the expanded Micro SOP and other cost saving regulations. The last cost barrier identified is solved in this bundle to lower the cost of solar development as much as possible without subsidies.

The cost of capital for large scale solar in BC is a significant portion of the cost to produce. Creating an investment fund, funded by government, is the most direct way to reduce the cost of capital. It also encourages development by creating a more stable source of financing from a lender that understands the needs and constraints of emerging renewable energy sources.

Table 13 Costs reduced by mitigating the cost of capital

Barrier savings $/MWh	V1 r = 6%	V2 r=3%	V3 R=0 (nominal)
Cost to borrow/acquire capital	13.68	12.53	11.24

This policy implements cost reductions allowing solar to become more viable. It is viable under pure service provision (r=0%) and is approaching grid parity under the medium return scenario. These policies reduce the cost to develop solar from an r=6% value by $114/MWh, which is significant savings.

The other expanded Micro SOP changes continue to make development easier. Private sector businesses are able to access the Micro SOP. Development, especially in the short term, will not be constrained by the SOP pool. And larger, more cost effective projects can be built at low cost.

Table 14 Cost to develop solar after technological developments and cost barriers removed

$/MWh	V1 r = 6%	V2 r=3%	V3 R=0 (nominal)
Net cost to develop solar with all identified cost barriers removed (cost of capital, unexpected equipment costs, study costs removed)	-57.39	-16.3	18.94

After all of the easy economic viability barriers and other regulatory barriers to the development of solar are addressed, there is still an economic viability gap. There is still approximately a $57 deficit per MWh under r=6% for developers. The voluntary green pricing scheme allows solar to reach grid parity in the r=6% scenario. These policies should create a significant amount of development and the true beginning of the solar energy industry in BC. Bundle 2.B has a medium score for sustainable energy development. More development will happen than bundle 2.A alone and bundle 1.

Stakeholder buy-in:

All stakeholders have buy-in for bundle 2.B, resulting in a high score. All types of IPPs are free to develop solar in favourable conditions and none are discriminated against. BC Hydro, while having to create new programs, should not have a significant increase in their administrative work. They implement new programs, but the funding for these programs is provided by another source, the ratepayers. As far as subsidies go, this is a good one, assuming the BC Utilities Commission allows the rate structure for green electricity to occur. While some ratepayers are paying more, they are doing so voluntarily.

Ease of administration:

This bundle requires BC Hydro to create two new programs and do a major overhaul of another. While these are not expensive to BC Hydro, funding for them comes from ratepayers or the projects are approximately revenue neutral after enough time, they do create more administrative burden. For this reason this bundle is rated medium-high for ease of administration. It is more responsibility than bundle 1, but the resources to provide that responsibility are provided.

Efficiency of systems:

This bundle utilizes subsidies, and so cannot rate a high. However, the funding of the price increase comes from voluntary ratepayers. Because there is willingness to pay for solar, this bundle rates better than if a similarly sized price incentive that was financed involuntarily was implemented. The other subsidy, the investment fund, is paid by government, but can be expected to make returns as good projects are funded. This bundle scores medium in efficiency. It uses subsidies to achieve grid parity, but does so in a responsible way to minimize government costs.

Table 15 Summary for option 2.B: medium effort

Criteria	Measure	Option 2.B
Maximize impacted groups that support policies	Buy-in from: FN, communities, businesses, BC Hydro, Ratepayers,	High, full buy-in
Minimal Subsidy	$/MWh, size of subsidy	Medium, small and voluntary
Minimal impact on government budget/ minimal new costs/administrative complexity	$, new programs, new responsibilities	Medium-high, new programs, new resources
Amount of expected energy provided	$/MWh	Medium, grid parity

This policy efficiently minimizes the costs of solar in BC and then bridges the economic viability gap with a voluntary subsidy, allowing solar to reach grid parity. Development is not constrained by the SOP and Micro SOP. Small and experimental energy projects are especially encouraged. It is acceptable to stakeholders. The price increase is acceptable because it is done voluntarily and is applicable to other forms of energy ensuring a level playing field. The price increase is also relatively minor in size when compared to other similar policies, such as FITs in other jurisdictions. There is creation of two new programs, the investment fund and the green energy scheme. Grid parity is reached for solar without significant costs or burdens imposed on government or ratepayers.

7.4. Option 3: aggressive solar development

Summary of policies:

1. Create solar specific regulations – eliminating redundant equipment costs, same as bundle 1
2. Expand the Micro SOP – solar exemption from the SOP generation pool limits, reduce study costs, and increase who has access to the Micro SOP, similar to bundle 2.A
3. $100/MWh additional FIT over SOP payment – ensures that development is a net financial benefit

Sustainability:

The baseline regulations implemented are the same as option 1 and have the same impact, removing redundant equipment costs at a very low cost. The further expansion of the Micro SOP program enables the savings from it to be realized for all solar. The clean investment fund is implemented for eligible solar. Together these three actions realize cost savings for all eligible solar. The FIT pushes the viability of solar up to +$50/MWh, meaning many more IPPs will want to invest in solar projects. This project has the highest amount of environmentally sustainable energy development and rates high in this criterion.

Stakeholder buy-in:

This policy does not have full stakeholder buy-in. It has buy-in from IPPs, as they are all able to make use of all cost savings and are essentially guaranteed to make a significant return on investment. BC Hydro will likely have buy-in as well. They are administering the programs, but they are not directly paying for them, although there may be BC Hydro buy-in issues due to the size and complexity of the bundle. Ratepayers absorb the costs of expensive development. Effectively, the general public would absorb these costs given most of BC is supplied electricity by BC Hydro. Ratepayers in other jurisdictions where FITS have been used and rates increased are not happy with the program, and it is expected the same reaction would occur in BC. This bundle thus has a low score for stakeholder buy-in because ratepayers, the general public, will likely dislike this policy. They are the largest and most important stakeholder group, hence the low rating.

Ease of administration:

This bundle is more difficult to implement compared to the other two bundles due to the inclusion of the FIT. There would be a flurry of development, which may strain BC Hydro's administrative capacity. And these programs require huge budgets, staffs, and continual analysis to ensure it is being done responsibly. This bundle scores medium-low for administrative ease. It does not score low because there are other policies, like electrification, that are more complex and difficult to implement properly in a cost effective manner.

Efficiency:

In order for the large amount of development to occur in this policy, there must be a tradeoff. That tradeoff is the large cost that must be incurred to develop solar. The large FIT that is needed to make this policy work, or any other similar subsidy policy could be substituted, results in high cost development of solar. While this generation might still be worthwhile because of unvalued extra benefits and costs avoided, there is a large subsidy given, resulting in a low efficiency score.

Note: There are other policies that could be implemented that have similar effects: aggressive development of the solar and other clean energy industries through significant cost to government or ratepayers. Other policies that could have similar effects are fundamental changes to the current energy regime, such as how price is managed, pursuit of provincial electrification, and similar policies to encourage rapid solar and other clean energy development at significant cost. They are numerous in form but have similar outcomes to option 3 and thus are not analyzed.

Table 16 Summary for option 3: high effort

Criteria	Measure	Option 3
Maximize impacted groups that support policies	Buy-in from: FN, communities, businesses, BC Hydro, Ratepayers,	Low, ratepayers dislike
Minimal Subsidy	$/MWh, size of subsidy	Low, large and everyone pays for it
Minimal impact on government budget/ minimal new costs/administrative complexity	$, new programs, new responsibilities	Medium-low, bigger new programs
Amount of expected energy	$/MWh	High, +40/MWh

provided		

Overall, this policy has the same outcomes that have been seen in all the other jurisdictions that have implemented it. A lot of solar development occurs very quickly, but at significant cost to government or ratepayers. The policy is useful if the goal is to quickly develop solar to replace old generation or meet quickly growing demand in a sustainable way, like Germany, Ontario, or California.

Table 17 Criteria and measures of all three policies

Objective	Criteria	Option 1	Option 2.A	Option 2.B	Option 3
Stakeholder Buy-in	Maximize impacted groups that support policies	Medium, Business IPPs discriminated against	High, full buy-in	High, full buy-in	Low, ratepayers dislike
Efficiency of System	Minimal Subsidy	High, No subsidy	High, No subsidy	Medium, small and voluntary	Low, large and everyone pays for it
Administrative Ease	Minimal impact on government budget/ minimal new costs/administrative complexity	High, No change to administration	High, minor improvements administration	Medium-high, new programs, new resources	Medium-low, bigger new programs
Sustainability	Amount of expected energy provided	Low, -28.83 (3%)/MWh for FN and Communities. -107.34 /MWh for businesses	Medium-low, same costs as bundle 1 but more access to cost reductions	Medium, grid parity	High, +40/MWh

7.5. Results of policy evaluation

Option 1 does a good job keeping externalities low. This is because it results in small amount of development at a high cost per MWh and does not really develop the solar industry. It would take a long time for solar to become economically viable under this policy, potentially too late for solar to be seriously considered as an option for future development needs.

Option 3 does a good job of developing the solar industry, but does so at direct and significant cost to government and ratepayers. For this reason it is not chosen as the recommended option. The high level of GWhs is desirable, but comes at a high cost and may lead to too much inefficient solar development in place much before it is needed.

Chapter 8. Recommended Policy

Solar has previously been thought to be far away or completely unfeasible without serious government intervention in BC. This report finds that solar fares better than expected and in a few years could be close to, if not at grid parity, with limited government intervention. Solar is a rapidly changing and improving energy technology that BC should investigate and develop further. Through a relatively small amount of effort, the BC government can significantly improve the prospect of solar generation in BC.

Option 2.A and 2.B are the policies this report recommends to encourage solar development in BC. Option 2.A improves the current regulatory regime by increasing solar knowledge, and expanding the Micro SOP. By reducing redundant costs and increasing development opportunities, this option increases solar's economic viability. Option 2.A should be implemented because it results in better outcomes for all IPPs, for solar, and for other small energy projects in BC. However, it still does not do much to further encourage solar development. If the government wants to develop a robust solar industry, both 2.A and 2.B should be implemented. They balance goals of government cost management while beginning development of a solar industry on a timeline that is reasonable and flexible based on economic conditions. They avoid excess negative externalities associated with the rapid development experienced by other jurisdictions.

Ultimately there is a tradeoff between cost and the amount of sustainable energy generation from solar (or any other emerging energy alternative). The tradeoff needs to be understood and competing interests balanced when making decisions about the future of energy generation in BC. Allowing development to proceed at an appropriate pace and volume will allow clean energy industries to be appropriately sized when they are needed. When BC needs to start building additional generation after Site C, the industry should be sufficiently developed to be able to rely on solar to a significant extent to help meet energy demand along with other clean energy technologies. Under 2.A and 2.B, solar development will expand, but at a reasonable pace.

While I have attempted to make the policies and bundles optimal for comparison in BC, there are many bundles and assortments of policies that could be implemented other than those explored here. These less explored alternatives may deserve more attention in future work.

Option 2.A and 2.B should be implemented for all other types of emerging energy source to ensure a level playing field and an optimal future generation portfolio. The analyses here are very applicable to other emerging renewables. They face similar barriers, and the solutions to those barriers are similar, and sometimes exactly the same. In order to maintain a fair playing field to have an optimal future portfolio, all renewable energy types should be able to access these policies. This requires further research to understand energy specific barriers, costs, benefits, and optimal policies.

Solar can play a significant role in future energy development in BC, especially as the technology continues to improve at a breakneck pace and if the government makes the effort to create an environment conducive to solar and the clean energy industry as a whole. As this research shows, a serious attempt at encouraging the development of solar does not necessarily mean it will be expensive or be ineffective, and this may be true of other alternative energy sources as well – there should be much more exploration, analysis and experimentation of emerging options. The BC government needs to evaluate and compare solar, and other energy technologies in an informed way when planning BC's energy future to ensure BC's electricity continues to be low-cost and low emissions.

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