University of Alberta Future Energy Systems

British Columbia Energy Market Profile

Measuring the Costs and Benefits of Energy Transitions

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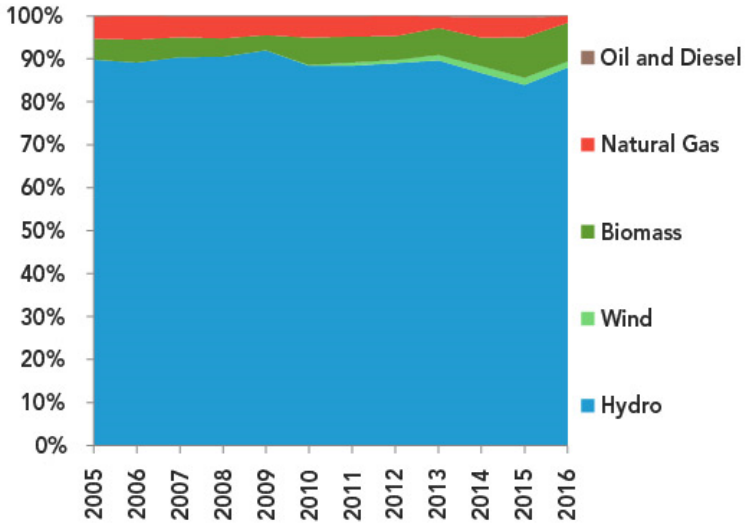
Context

Located between the Pacific coast and the Rocky Mountains, British Columbia has an abundance of rivers, allowing the majority of energy to be generated through renewable hydroelectric sources. Based on the National Energy Board (NEB) Renewable Power - Energy Market Analysis, 98.4% of electricity in BC is being produced from renewable sources, accounting for ~73,000 GWh of generation and ~17,000 MW of capacity. Run of river and storage hydro lead electricity generation (~88%), followed by biomass (~9%), with a small but growing wind sector with high potential, especially offshore projects (National Energy Board (NEB), 2017). New projects targeting geothermal and tidal are currently in exploration and/or demonstration phases, also demonstrating ample potential (Government of BC (BC), 2018).



Electricity Generation by Source in British Columbia (NEB, 2017)

Electricity in BC is supplied to most consumers via BC Hydro (majority supplier, publicly-owned) and Fortis BC (minority supplier, private ownership, subsidiary of Fortis Inc. based in Newfoundland), with about 70 communities in remote regions that are not connected to the grid (BC, 2018). From the NEB's Provincial and Territorial Energy Profile, BC is ranked 9th in annual per capita electricity consumption at 11.2 MWh. Industry is the largest consumer of electricity at 23.8 TWh in 2016, followed by residential (16.8 TWh) and commercial (12.6 TWh) (NEB, 2018). BC is a net electricity exporter, although it does occasionally import from the United States, with a positive trade revenue. An interconnected electricity system allowed BC to trade 5.5 TWh to the United States and Alberta in 2016 (NEB, 2018).

Renewable energy in British Columbia is produced through large scale heritage hydro projects, Independent Power Producers (IPPs), and private household generation.

In 2008, BC Hydro launched the Standing Offer Program (SOP) in support of the 2007 BC Energy Plan to encourage small scale renewable production. The program regulates commercial energy projects over 100 kWh up to 15 MW. Participants sell their energy as an IPP with an Electricity Purchase Agreement (EPA) through BC Hydro. In 2014, BC Hydro launched a Micro-SOP program for First Nations and Communities, targeting projects between 100 kWh and 1 MW, with the conditions that a community group or First Nation have beneficial ownership (at least 50% for community groups) and participate in development. Approximately 125 IPP projects are in operation and 10 in development. Five new IPP projects are underway with First Nations involvement, but since August 2017, all other agreements are on hold while a program review is completed with the provincial government and Clean Energy BC (BC Hydro, 2018).

In addition to the SOP program, a Metering program was launched through BC Hydro in 2014 allowing customers who are already connected to the grid to produce their own renewable electricity generation and sell back any excess at a rate of 9.99 cents per kWh. Today the program has ~1,300 participants, 95% of which produce energy using solar photovoltaic systems. As of April 2018, program eligibility had changed to accept only generation projects sized to annual usage, with an application for amendment sent to the B.C. Utilities Commission to formalize this change, along with a full program review due at the end of 2018 (BC Hydro, 2018).

Selected Timeline of Renewable Energy Projects and Goals

1985: First run of river commercial operation
1989: First Call for Power
1991: The Independent Power Producers Association of British Columbia (IPPBC) formed, changed named to Clean Energy BC (CEBC) in 2010
1993: First biomass commercial operation
2007: BC Energy Plan - building on the 2002 BC Energy Plan, outlines key policies and targets:
- Keep at least 90% of electricity generation renewable with no nuclear and zero net GHG for all coal, new electricity, and existing thermal generation (by 2016 for thermal generation).
- Acquire 50 percent of BC Hydro's incremental resource needs through conservation by 2020
- Achieve electricity self-sufficiency by 2016, make small power part of the solution through a set purchase price for electricity generated from projects up to 10 megawatts
- Establish an Innovative Clean Energy Fund of $25 million
- Implement the BC Bioenergy Strategy to generate electricity from mountain pine beetle wood by turning wood waste into energy

2008: BC Bioenergy Strategy - support 2007 Energy Plan and address mountain pine beetle infestation, includes key policies and targets
- Issue a two-part Bioenergy Call for Power, focusing on existing biomass inventory in the forest industry
- Aim for B.C biofuel production to meet 50 percent or more of the province's renewable fuel requirements by 2020
- Develop at least 10 community energy projects that convert local biomass into energy by 2020

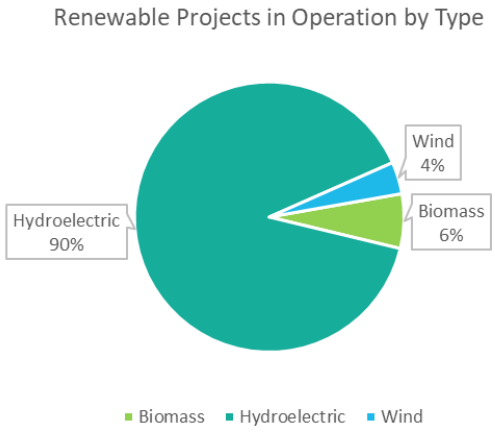
2009: First wind farm commercial operation
2010: *2010 Clean Energy Act* - the Act outlines and formalizes many of the 2007 Energy Plan objectives including
- Electricity self-sufficiency
- Reduce energy demand by 66% through conservation, by 2020
- Generate at least 93% of electricity from renewable sources and develop the infrastructure for transport
- Ensure rates remain competitive
- Encourage switching from one energy source to another with a lower GHG footprint
- Become a net exporter of clean and renewable electricity
- Achieve BC's energy objectives without using nuclear power

2015: First solar commercial operation

Renewable Energy Overview

A dataset of over 200 large and small commercial and community-based renewable energy projects, both in operation and in development, has been compiled from four main sources:

- BC Hydro In Operation and In Development IPP List
- Government of Canada - Renewable Energy Powerplants, 1 MW or more
- Atlas of Canada - Clean Energy Resources Project
- Atlas of Canada - Remote Community Energy Database



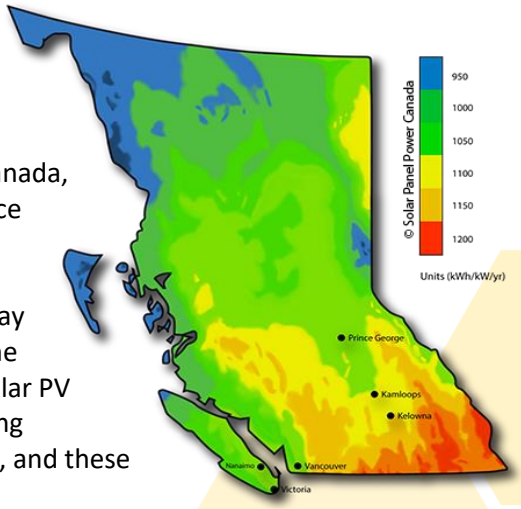
Of the 17,642.65 MW of operational renewable projects, 90% (15,817.10 MW) are hydroelectric projects, 6% (1,150.85 MW) are biomass projects, and 4% (673.70 MW) are wind projects. This list does not include Net Metering participants who produce renewable energy to offset their individual use.

British Columbia Renewable Energy Potential Summary

While British Columbia has predominantly developed its hydroelectric sector, with remaining potential, other renewables have recently come into development with large and untapped potentials. Wind and biomass are increasing commercial development thanks to large wind resources and a Bioenergy Policy to address fuel overload following mountain pine beetle infestation. Ocean and geothermal have impressive potential but are currently under investigation with no commercial development in place. This report summarizes the geographic potential of solar, wind, geothermal, ocean, biomass, and hydroelectric energy in addition to identifying some of the social, environmental, and economic concerns associated with each energy type.

Solar

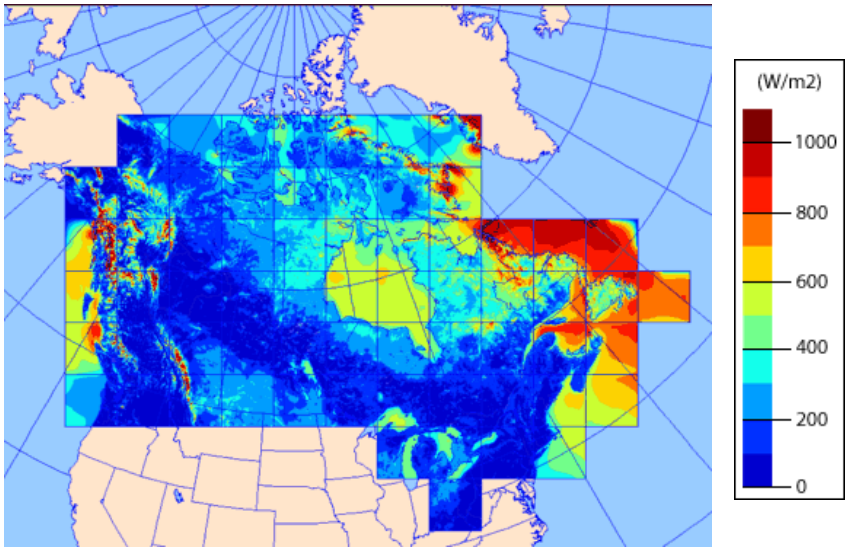
British Columbia is given a #1 ranking in terms of solar acceptability and utility adoption, however raw solar potential receives a 'Grade D' from Solar Panel Power Canada, with the average solar system (5 kW) expected to produce approximately 5,320 kWh of energy per year. This solar potential is variable throughout the province with the highest potential in the southwest mainland and Kootenay region; British Columbia's only commercial solar farm, the Kimberley SunMine (1 MW) is located here. However, solar PV systems are a popular choice for many home net metering programs and community/First Nation micro-generation, and these small roof-top solar PV systems can be found throughout the province.



Average Annual Solar Energy Generation per kW Installed
Source: https://solarpanelpower.ca/solar-power-maps-canada/

Wind

While British Columbia has been characterized as having excellent wind resources, the province was slow to introduce commercial development until 2009, when the first turbines became operational. Today several large wind projects exist producing at least 100 MW each. Estimates put British Columbia's land-based wind capacity at 16,425 MW (BC Hydro), with 5,250 MW economically feasible with costs less than $105/MW by 20205 (CanWEA). The Peace Region, Kootenays, Okanagan, and Vancouver Island are identified as favourable for wind development as each experiences appropriate wind speeds, are fairly remote, and thus likely to receive public approval and connect to a provincial power grid.



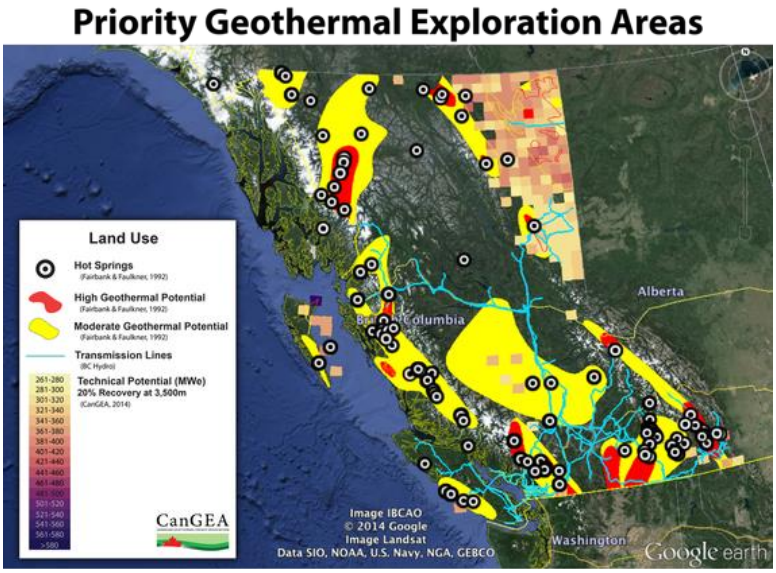
Annual Mean Wind Speed at 50 m Height
Source: http://www.windatlas.ca/maps-en.php

In a 2015 national study by Barrington-Leigh & Ouliaris, wind potentials across the nation were measured to determine the feasible generation. Using GIS, high wind potentials were identified using wind speeds of 7 m/s at a height of 80 m. The study excluded protected lands, inland water bodies, First Nations land, and a 5 km buffer around population centres. The remaining lands were then amended to only include lands near transmission lines (Barrington-Leigh & Ouliaris, 2015). Assuming that 25% of the remaining high potential areas are utilised, which accounts for competing land uses, British Columbia could generate 26 TWh per year. Of BC's total 2015 energy demand of 238 TWh per year, onshore wind energy could account for 10% of BC's total energy demand (Barrington-Leigh & Ouliaris, 2015).

BC also has some potential for offshore wind energy as well. Barrington-Leigh & Ouliaris (2015) evaluated the potential for offshore wind across the nation. Offshore wind benefits from higher wind speeds, but is challenged by higher construction costs, higher maintenance costs due to seawater corrosion, and higher transmission costs (Barrington-Leigh & Ouliaris, 2015). Most commercial offshore wind occurs at shallow depths. When examining feasible lands for offshore wind, areas near the shore and water bodies near population centres or transmission lines were considered feasible. Areas with high potential were off the coast of British Columbia, on the Great Lakes, on the Gulf of St. Lawrence, and Bay of Fundy. High potential sites do not account for shipping lanes and environmentally sensitive areas. Assuming a 50% utilization of high potential areas, it was determined that offshore wind farms in British Columbia could produce 196 TWh per year, meeting 82% of the total energy demand in BC of 238 TWh per year (Barrington-Leigh & Ouliaris, 2015).

Geothermal

Geothermal exploration has been ongoing in British Columbia since the 1970s, with interest from both the public and private sector, however, no geothermal electricity projects are currently in operation. While high heat resources exist throughout the Coast Mountains and the Garibaldi volcanic belt, permeability is considered an issue with many sites. Estimates from 2007 put geothermal resource potentials between 3,000-5,000 MW (Helston, 2012), while a more recent planning study published in 2016 (Kerr Wood Leidal, GeothermEx) put the combined potential of 18 economically 'favourable' sites at just 400 MW. Further, the Canadian Geothermal Energy Association (CanGEA) estimates the technical potential of geothermal at 5% recovery between 133 and ~5,700 MW at depts of 1.5 and 2.5 km respectively (nd). While no MW estimates are given, the Geological Survey of Canada recognizes British Columbia as a region of high geothermal energy potential for both electrical and direct-heat use (Grasby et al., 2012).

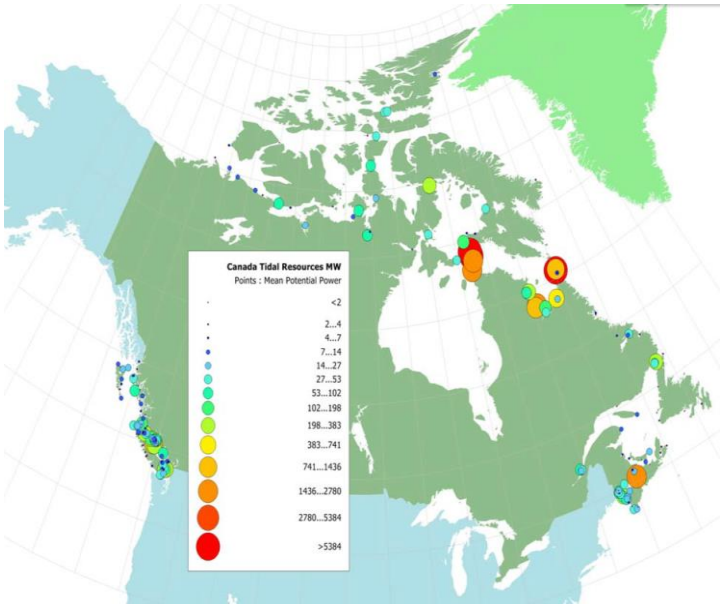


Geothermal Exploration
Source: https://www.cangea.ca/bc-geothermal-resource-estimate-maps.html

Ocean

Due to its coastline and many narrow fjords and channels, British Columbia has excellent ocean energy potential, including both wave and tidal. Wave energy is essentially the kinetic energy from large scale wind collection, gathered over the broad ocean, and harnessed near shore. Five main wave energy technologies are used including: buoys, surface following, oscillating water column, terminators, and overtopping. Wave power is firm/predictable with seasonal highs in the winter. Tidal is subdivided into stream and range projects; range projects are similar to dams and capture gravitational kinetic energy, while tidal stream projects function like an underwater wind turbine. Tidal power is also firm/predictable with regular variation. Estimates from the Government of British Columbia put development opportunities and potential energy at 6,000 MW wave and 2,000 MW tidal (nd), while

Clean Energy British Columbia estimates tidal potential at 4,000 MW over 89 sites, mostly in the south of the province (Farris & Helston, 2017). British Columbia had been a leader in tidal development, with the Race Rocks Tidal Stream Project in 2006, but has fallen behind with little further development and the removal of the Rack Rocks turbine in 2011 however (British Columbia Sustainable Energy Association (BCSEA)), the West Coast Wave Initiative is a promising new joint government and industry project to develop wave power in the province (Robertson, Bailey & Buckham, nd). While the energy potential of ocean projects is high, so are the potential environmental harms and further research is suggested as conflicting accounts are given.



Canadian Tidal Resources
Source: http://www.energybc.ca/cache/tidal/www.oreg.ca/docs/OREG_presentations/JJ_Alaska_Jan.pdf

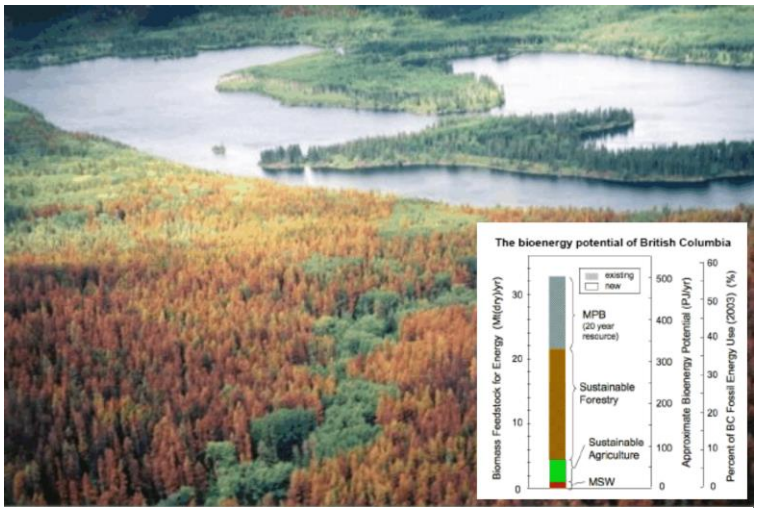
Tidal energy is still in its infancy, and technology is still in the process of being developed. As such, it is hard to have a realistic estimate of how much energy can be feasibly generated from tidal sources. Barrington-Leigh & Ouliaris (2015) assumed 15% of the tidal potential on the shores of British Columbia can be realistically captured. Under this parameter, British Columbia could generate 3.10 TWh per year, or 1.3% of the total energy demand of 238 TWh per year.

Wave energy is another growing technology and is also difficult to determine the true potential of wave powers. Waves are faster further from the shore, but floating wave converters have high transmission and maintenance costs. Barrington-Leigh & Ouliaris (2015) found that British Columbia has a wave generation potential of 16 TWh/year.

Biomass

Biomass resources in British Columbia include wood and wood residues from mills, roadside debris, and mountain pine beetle. Total potential estimates for all current wood sources are approximately 2,300 MW and suggest the need for a future biomass crop industry (Clean Energy BC, 2018). Landfill gas (LFG) is also utilized as a biomass resource, currently being captured by municipalities throughout the province. Estimating potential from these projects is difficult due to variation in waste mix, however the province of British Columbia does regulate the capture of LFG from all landfills producing more than 1,000 tonnes of methane (CH_4) per year, suggesting the number of projects may rise if population

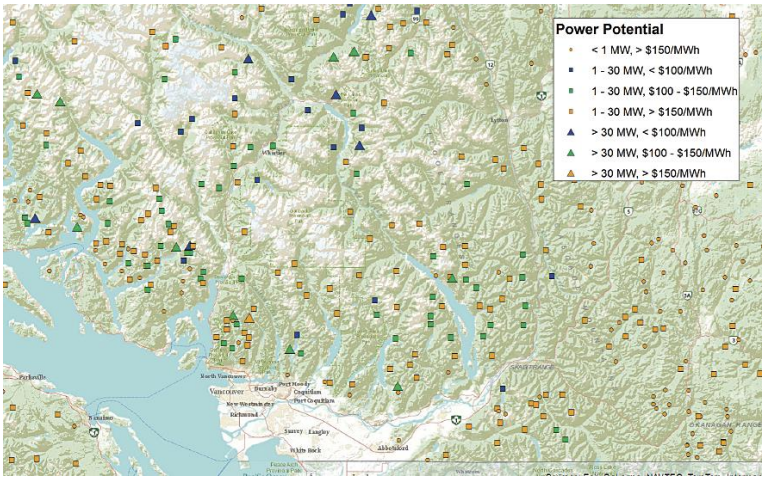
increases and waste diversion does not (Hallbar Consulting, 2017). Previous estimates (2006) put total biomass potentials for the province, from all sources, at 920 PJ/year (Ralevic & Layzell). While LFG projects can be prohibitively expensive, upgrading to wood-based biomass is considered a more affordable and attractive option for small and rural communities to replace fossil fuels, both for heating and electricity production, as long as sustainable feedstocks can be acquired (BIOCAP, 2008). Funding to support certain biomass project development is available through the BC Bioenergy Network (Government of British Columbia, 2018).



The Bioenergy Potential of British Columbia
Image Source: https://www.enfor.com/?Page=/energy/bioenergy/
Graph Source: An Inventory of the Bioenergy Potential of British Columbia, Biocap Canada Foundation, November 2006.

Hydroelectric

Hydroelectric energy in British Columbia is produced through both large-scale storage projects, using dams and reservoirs and smaller scale run-of-river projects that utilize natural elevation changes. While large hydro projects are mostly legacy builds and out of favour due to environmental impacts, small run-of-river projects have seen a boom in British Columbia following the 2008 Clean Energy Plan. A 2013 case study identified over 8,000 run-of-river sites with the potential to produce a collective 12,000 MW of hydropower (ESRI Canada), while EnergyBC suggests 5,500 potential sites with no MW estimate (2018).



Hydroelectric Power Potential in BC
Source: https://esri.ca/sites/default/files/resources/cr/EC1_0134_1201_6B_Kerr_Wood_0.pdf

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