Overview

This report was prepared by a team of researchers led by UBC's Program on Water Governance, including Dr. Karen Bakker, Dr. Gordon Christie, and Richard Hendriks.

- This report finds that the number and scope of significant adverse environmental effects arising from the Site C Project are unprecedented in the history of environmental assessment in Canada.
- The Joint Review Panel (commissioned by the federal and provincial governments) for the Site C Project determined that there were significant adverse environmental effects for dozens of species, as well as for aquatics, vegetation, wildlife, Aboriginal use of lands and resources, and cultural heritage.
- The alternative portfolio proposed by BC Hydro for meeting the needs for electrical energy and capacity in British Columbia would have no significant adverse environmental effects (and a lower overall level of adverse environmental effects), including in relation to greenhouse gas emissions.
- The sources of the data used in this analysis are public documents, including those provided by BC Hydro and the environmental assessment Joint Review Panel, as well as documents from the Canadian Environmental Assessment Agency.

Contents

Our analysis is presented as follows:

2.1 *Regulatory context*

The determination of whether or not a proposed project is likely to result in "significant adverse environmental effects" is fundamental to environmental assessment in Canada. The Canadian Environmental Assessment Agency defines environmental assessment as a process that:

- identifies potential adverse environmental effects;
- proposes measures to mitigate those adverse environmental effects;
- predicts whether there will be significant adverse environmental effects, including cumulative environmental effects, after mitigation measures are implemented; and
- uses follow-up programs to verify the accuracy of the environmental assessment and the effectiveness of the mitigation measures.

The purpose of this process is to minimize or avoid adverse environmental effects before they occur and to incorporate environmental factors into decision-making.[1]

For its part, the BC Environmental Assessment Office views environmental assessment as:

> …an integrated process for identifying, mitigating and evaluating the potential significant adverse environmental, economic, social, heritage, and health effects that may occur during the life of a reviewable project.[2]

Significance is determined in relation to residual environmental effects, which are those adverse effects that remain following implementation of mitigation measures. The environmental effects are broadly assessed to be inclusive of biophysical, socioeconomic, cultural heritage and health effects. Significance is determined on the basis of key criteria, including: magnitude, geographic extent, timing, frequency, duration, and reversibility. If it is determined that one or more residual environmental effects are significant, the likelihood of those effects occurring is also evaluated.[3]

2.2 *Significant adverse environmental effects of the Site C Project*

2.2.1 Environmental Assessment of the Site C Project

In May 2011, BC Hydro submitted a project description for the Site C Project to the Canadian Environmental Assessment Agency and the BC Environmental Assessment Office, initiating

[1] Canadian Environmental Assessment Agency. Undated. Basics of Environmental Assessment. Available at: http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=B053F859-1)
[2] BC EAO. 2015. Environmental Assessment User Guide: An Overview of Environmental Assessment in British Columbia, p.3.
[3] Canadian Environmental Assessment Agency. 2015. Operational Policy Statement. Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the *Canadian Environmental Assessment Act*, 2012. Available at: http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=363DF0E1-1.

federal and provincial environmental assessments. Several months later, in February 2012, the federal Minister of the Environment and the provincial Minister of Environment finalized terms of reference for a Joint Review Panel (JRP), establishing the scope, procedures and methods for conducting the environmental assessment.[4]

In August 2013, following review of BC Hydro's environmental impact statement by the government agencies, Aboriginal groups and the public, the Ministers appointed the JRP. The three-person Panel consisted of a former senior-level federal government deputy minister as Chairperson and joint appointee, a former senior-level provincial assistant deputy minister as the provincial government appointee, and a communications consultant with prior experience as a panel member, including for a large-scale hydroelectric project, as the federal appointee.

Following a series of information requests, public hearings, and a 90-day period for synthesis and report drafting, the JRP released its final report[5] in May 2014. The report makes a number of recommendations and draws a number of conclusions respecting the environmental effects of the Site C Project, mitigation measures designed to address some of those effects, and the significance of residual effects following mitigation.

2.2.2 The findings of the JRP in context

The findings of the JRP with respect to significant adverse environmental effects of the Site C Project are summarized below.

Table 2.1. Significant adverse environmental effects – Site C Project[6]

Aquatic	Vegetation	Wildlife	Aboriginal Use	Cultural Heritage	Other
fish and fish habitat	at-risk and sensitive ecological communities	- 16 breeding bird species - western toad - broad-winged hawk - short-eared owl - eastern red bat - little brown myotis - northern myotis	fishing opportunities and practices for Treaty 8 First Nations	physical heritage resources	loss of agricultural production of the Peace River valley bottomlands to the farmers who would

[4] The Minister of the Environment, Canada – The Minister of Environment, British Columbia. February 2012. Agreement to Conduct a Cooperative Environmental Assessment, including the Establishment of a Joint Review Panel, of the Site C Clean Energy Project, (CEAR #63919-130) ['Panel Agreement'].
[5] Site C Joint Review Panel. May 2014. Report of the Joint Review Panel: Site C Clean Energy Project BC Hydro (CEAR #63919-2771).
[6] Ibid., Appendix 1 List of Panel's Conclusions and Recommendations.

					bear the loss
cumulative effects on fish	wetlands, in particular valley bottom wetlands	migratory birds relying on valley bottom habitat during their life cycle	hunting and non-tenured trapping for Treaty 8 First Nations	cultural heritage resources for both Aboriginal and non-Aboriginal people	loss of navigation use for the small number of people who traverse the dam site
	rare plants	cumulative effects on all wildlife species listed above	other traditional uses of the land for Treaty 8 First Nations	cumulative adverse effects on heritage resources	
	cumulative effects on vegetation and ecological communities	possible cumulative effects on fisher	cumulative effects on current use of lands and resources for traditional purposes	visual resources	

For those less familiar with environmental assessment in Canada, Table 2.1 may appear unremarkable. In the federal context, however, a determination by the Canadian Environmental Assessment Agency or a review panel of one or more significant adverse environmental effects is neither a trivial matter nor a common occurrence. Such a finding requires the Minister of Environment to decide whether she concurs with this determination and, if so, she must then refer to the Governor in Council (i.e. Cabinet) for a decision on whether those significant adverse environmental effects are justified in the circumstances.

Since the enactment of the *Canadian Environmental Assessment Act* in 1992, over 120 major projects have been assessed either through i) comprehensive study under the prior *Act* ("CEAA 1992"), ii) as designated projects under the current *Act* ("CEAA 2012"), or iii) through review panels established solely by the federal government or jointly with a provincial government.[7] Of these projects, only a total of ten (10), in addition to the Site C Project, have been determined to have significant adverse environmental effects. These projects are listed below in Table 2.2, and

[7] Canadian Environmental Assessment Agency. 1996 to 2014. Departmental Performance Reports. Available at: http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=C5C19E38-1.

their significant effects are described.

In addition to the projects listed in Table 2.2, several other large-scale (> 200 MW) new-build hydroelectric projects have been reviewed under the *Canadian Environmental Assessment Act* and been predicted to have no significant adverse environmental effects. These projects include (total installed capacity; year assessment completed):

- Eastmain 1-A and Rupert Diversion Project (893 MW; 2006)[8]
- Keeyask Generation Project (695 MW; 2014)[9]
- Romaine Hydroelectric Complex (1550 MW; 2009)[10]
- Wuskwatim Generation Project (200 MW, 2005)[11]

Within this context, the findings of significant adverse environmental effects by the Site C JRP are unprecedented in the history of environmental assessment under the *Canadian Environmental Assessment Act*.

[8] Federal Review Panel for the Eastmain-1-A and Rupert Diversion Project. 2006. Environmental Assessment of the Eastmain-1-A and Rupert Diversion Project Panel Report.
[9] Canadian Environmental Assessment Agency. 2014. Keeyask Generation Project Comprehensive Study Report.
[10] Canadian Environmental Assessment Agency – Bureau d'audiences publiques sur l'environnement. 2009. Romaine River Hydroelectric Complex Development Project: Investigation and Public Hearing Report (Translation).
[11] Canadian Environmental Assessment Agency. 2005. Wuskwatim Generation Project Comprehensive Study Report.

Table 2.2. Significant adverse environmental effects of all other Projects reviewed under CEAA since its enactment in 1992

Name	Air	Aquatic	Vegetation	Wildlife	Aboriginal Use	Cultural Heritage
Cheviot Coal Project[12] EA Decision – 2001 Approved Currently in operation		fish and fish habitat			traditional uses and sites	
Encana Shallow Gas Infill Development Project[13] EA Decision – 2012 Not approved			three species: - tiny cryptanthe - small-flowered sand verbena - slender mouse-ear-cress	cumulative effects on - Ord's kangaroo rat - Sprague's pipit		
Jackpine [Oilsands] Mine Expansion Project[14] EA Decision – 2013 Approved Pending investment decision			wetlands, traditional plant potential areas, wetland-reliant species at risk cumulative environmental effects on wetlands, traditional plant potential areas, old-growth forests	migratory birds that are wetland-reliant or species at risk, biodiversity cumulative environmental effects on wetland-reliant species at risk and migratory birds, old-growth forest reliant species at risk and migratory birds, caribou, biodiversity	cumulative environmental effects on Aboriginal traditional land use, rights, and culture	
Kemess North Copper - Gold Mine Project[15] EA Decision – 2008 Not approved		possibly on downstream hydrological regimes, water quality and aquatic systems; possibly on fish and fish habitat			loss of Duncan (Amazay) Lake as culturally and socially detrimental for Aboriginal people	

[12] Alberta Energy and Utilities Board – Canadian Environmental Assessment Agency. 2000. Report of the EUB-CEAA Joint Review Panel: Cheviot Coal Project Mountain Park Area, Alberta Cardinal River Coals Ltd.
[13] Joint Review Panel Established by the Federal Minister of the Environment and the Alberta Energy and Utilities Board. 2009. Report of the Joint Review Panel: Encana Shallow Gas Infill Development Project Canadian Forces Base Suffield National Wildlife Area, Alberta.
[14] Joint Review Panel Established by the Federal Minister of the Environment and the Energy Resources Conservation Board. 2013. Report of the Joint Review Panel: Shell Canada Energy Jackpine Mine Expansion Project.
[15] Kemess North Copper-Gold Mine Project Joint Review Panel. 2007. Kemess North Copper-Gold Mine Project Joint Review Panel Report.

Labrador Island Transmission Link[16] EA Decision – 2013 Approved Under construction				caribou		
LNG Canada [17] EA Decision – 2015 Approved Pending investment decision	GHGs					
Lower Churchill Hydroelectric Generation Project[18] EA Decision – 2012 Approved Under construction		fish habitat and the final fish assemblage	the overall loss of terrestrial habitat; wetlands and riparian habitats	caribou	fishing and seal hunting in the event of new consumption advisories as a result of elevated methylmercury	culture and heritage, particularly with respect to the "loss of the river" as a highly valued cultural and spiritual landscape
New Prosperity Gold-Copper Mine Project[19] EA Decision – 2014 Not approved		fish and fish habitat; water quality in Fish Lake (Teztan Biny); water quality in Wasp Lake; water quality in the down gradient receiving environment	wetland and riparian ecosystems	cumulative effect on the South Chilcotin grizzly bear population; cumulative effect on the regional moose population	Tsilhqot'in current use of lands and resources for traditional purposes	Tsilhqot'in cultural heritage; Tsilhqot'in archaeological and historical resources
Northern Gateway Project[20] EA Decision – 2014 Approved Pending investment decision				cumulative effects for certain populations of woodland caribou and grizzly bear		
Whites Point Quarry and Marine Terminal Project[21] EA Decision – 2007 Not approved						valued environmental component represented by the "core values" of the affected communities

2.3 *Significant adverse environmental effects of the alternatives to Site C*

In light of the determinations of the JRP with respect to the significant adverse environmental

[16] Canadian Environmental Assessment Agency. 2013. Labrador-Island Transmission Link Comprehensive Study Report.
[17] British Columbia Environmental Assessment Office. 2015. LNG Canada Export Terminal Project Assessment Report.
[18] Joint Review Panel established by Canada's Minister of the Environment, the Minister of Environment and Conservation for Newfoundland and Labrador, and the Minister for Intergovernmental Affairs for Newfoundland and Labrador. 2011. Report of the Joint Review Panel: Lower Churchill Hydroelectric Generation Project Nalcor Energy Newfoundland and Labrador.
[19] Review Panel Established by the Federal Minister of the Environment. 2013. Report of the Federal Review Panel New Prosperity Gold-Copper Mine Project Taseko Mines Ltd. British Columbia.
[20] National Energy Board – Canadian Environmental Assessment Agency. 2013. Connections: Report of the Joint Review Panel for the Enbridge Northern Gateway Project Volumes 1 and 2.
[21] Whites Point Quarry and Marine Terminal Project Joint Review Panel. 2007. Environmental Assessment of the Whites Point Quarry and Marine Terminal Project Joint Review Panel Report.

effects of the Site C Project, the issue arises as to whether the alternative portfolios of electricity resources for meeting the electricity needs identified by BC Hydro could also result in significant adverse environmental effects. To the extent that these alternatives to the Site C Project would also impose significant adverse environmental effects, the relative environmental costs of the Site C Project would be reduced, and approval of the Project more justifiable.

2.3.1 Alternatives to the Site C Project

In its Integrated Resource Plan (IRP) and in its environmental impact statement (EIS) for the Site C Project, BC Hydro compared three alternative portfolios of resources for meeting the needs for electrical energy and dependable capacity. These portfolios all make up approximately the same 5,100 GWh of annual energy and 1,100 MW of dependable capacity as the Site C Project, as shown in Table 2.3.

Table 2.3. BC Hydro's Integrated Resource Plan Portfolios

Portfolios	Clean		Clean + Thermal #1		Clean + Thermal #2		Site C	
	Dependable Capacity	Annual Energy	Dependable Capacity	Annual Energy	Dependable Capacity	Annual Energy	Dependable Capacity	Annual Energy
Supply-side Resources	MW	GWh/year	MW	GWh/year	MW	GWh/year	MW	GWh/year
Site C							1100	5100
GM Shrum	220	0			220			
Revelstoke 6	488	26	488	26	488	26		
Municipal Solid Waste	36	312	36	312	36	312		
Natural Gas (SCGT)			588	924	392	616		
Pumped Storage	500	-364						
Wind		5126		3839		4148		
Totals	1244	5100	1112	5101	1136	5102	1100	5100

The resources included in these portfolios consist of available resources for meeting the needs within regulatory, planning and technical constraints, including the provincial energy objectives in the *Clean Energy Act*.

- Clean portfolio – wind resources for energy, additional capacity at Revelstoke 6, capacity upgrades at G.M. Shrum, municipal solid waste generation, and pumped storage hydro
- Clean + Thermal #1 – wind resources for energy, Revelstoke 6, municipal solid waste generation, and natural gas generation (6 simple cycle gas turbines)
- Clean + Thermal #2 – wind resources for energy, Revelstoke 6, G.M. Shrum, municipal solid waste generation and natural gas generation (4 simple cycle gas turbines)
- Site C portfolio includes the Site C Project for an in-service date of F2024

The objectives of the *Clean Energy Act*, discussed further in Briefing Note #3 *The Regulatory*

Process for the Site C Project, include that BC Hydro's rates "remain among the most competitive of rates charged by public utilities in North America."[22] As such, the comparative costs of the portfolios are also relevant to the consideration of the justification of environmental effects. The following table illustrates the present value (PV) cost differences determined by BC Hydro in its IRP.

Table 2.4. Portfolio present value for Site C base case analysis[23]

Portfolio Type	Site C Timing	Portfolios without Site C Portfolio PV (M$)	Portfolios with Site C Portfolio PV (M$)	PV Difference (M$) (Portfolio without Site C minus Portfolio with Site C)
Clean Generation	F2024	6,766	6,138	630
	F2026	6,741	5,864	880
Clean + Thermal Generation	F2024	6,030	5,883	150
	F2026	6,001	5,608	390

Some observations:

- Developing all clean generation without Site C is about $500 million more expensive than similar portfolios with some thermal generation (i.e. natural gas);
- Developing all clean generation without Site C or natural gas is at least $600 million more costly than portfolios with Site C, natural gas or both; and
- The benefit of Site C compared to the clean + thermal alternative in 2024 is $150 million, which represents 1.7% of the current estimated cost of Site C of $8.8 billion.

The most recent project cost estimate for Site C is a Class 2 cost estimate as defined by AACE International, which means that the expected accuracy range in the estimate is -5% to -15% low to +5% to +20% high, which is much greater than the cost difference between the alternative portfolios.[24, 25] The clean + thermal portfolios therefore provide the most likely alternatives to the Site C Project, while still meeting the requirements of the *Clean Energy Act*, including with respect to greenhouse gas emissions and competitive electricity rates.

2.3.2 Environmental effects of the alternatives to Site C Project

In light of the determinations of the JRP respecting the significant adverse environmental effects

[22] *Clean Energy Act*, SBC 2010, c22, s.2(f).
[23] BC Hydro. 2013. BC Hydro Integrated Resource Plan, Appendix 6A Portfolio Results, p.6A-36.
[24] United States Society on Dams. 2012. Guidelines for Construction Cost Estimating for Dam Engineers and Owners.
[25] AACE International. 2016. Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries, p.3.

of the Site C Project, the issue arises as to whether the clean + thermal alternative portfolios could also result in significant adverse environmental effects, including in relation to greenhouse gas emissions. The resources composing the Clean + Thermal #2 portfolio are considered below in terms of the likelihood they could result in significant adverse environmental effects that would require justification in a manner similar to the Site C Project.

GM Shrum and Revelstoke 6 capacity upgrades

In recent years, BC Hydro has implemented several upgrades to existing heritage hydroelectric facilities as part of its Resource Smart program, including upgrades at the Revelstoke, Mica and GM Shrum generating stations. The largest remaining Resource Smart projects available for development are Revelstoke 6 (with a dependable capacity of 488 MW) and GM Shrum Units 1-5 (with a capacity increase of 220 MW).

Revelstoke 6 would involve the addition of a 500 MW turbine inside an existing generating station. The project would be identical to Revelstoke 5, a capacity upgrade undertaken recently at the same generating station. An environmental assessment of Revelstoke 5 was completed in 2007 by each of the federal and provincial governments. Each assessment reached similar conclusions:

> The general conclusion of the environmental assessment is that there are no likely significant adverse effects as a result of the Project, with the implementation of proposed commitments, including effects monitoring and follow-up measures.[26] [emphasis added]

A capacity increase at GM Shrum Units 1-5 would be identical to capacity upgrades previously undertaken at GM Shrum Units 6-8. On March 12, 2007, the BC Environmental Assessment Office determined that the GM Shrum Units 6-8 upgrades did not require an environmental assessment certificate for the following reason:

> …the Project will not have a significant adverse environmental, economic, social, heritage or health effect after taking into account practical means of preventing or reducing to an acceptable level any potential adverse effects of the Project."[27] [emphasis added]

On the basis of these prior identical projects, the potential for significant environmental effects

[26] BC Environmental Assessment Office and Fisheries and Oceans Canada. 2007. Revelstoke Generating Station Unit 5 Project Assessment Report, p.97.
[27] BC EAO. 2007. Letter of March 12, 2007 from Joan Hesketh, Associate Deputy Minister to Benjamin Sparrow, BC Hydro.

from Revelstoke 6 and GM Shrum Units 1-5 capacity upgrades is considered to be nil.

Municipal Solid Waste (MSW)

MSW refers to the mass burn incineration of municipal solid waste into usable electricity, following pre-processing of waste to remove oversized, non-combustible, hazardous or explosive materials. Considered a form of "clean energy" under the *Clean Energy Act*, MSW is generally promoted by the province as part of a strategy to manage municipal solid waste in BC. Recently reviewed MSW projects include the 100 MW Gold River Power Project, which did not trigger federal environmental assessment and was exempted from the requirement to obtain a provincial environmental assessment certificate after the EAO "concluded that the proposed Project will not cause significant adverse effects after mitigation."[28]

The MSW projects contemplated as part of the alternative portfolio are smaller in size than the approved Gold River Power Project, and presuming that similar mitigation measures are employed and the MSW projects are appropriately sited, the likelihood of significant adverse environmental effects is considered to be nil.

Wind

Wind power technologies, appropriately designed and sited, are generally considered to be one of the lowest overall impact forms of electricity generation available. According to BC Hydro, land impacts total about 100 ha for a typical 100 MW wind facility in British Columbia.[29] Freshwater impacts from on-shore wind development are temporary in nature, resulting from construction of access roads or from clearing of transmission interconnections near wetlands or lakes. Atmospheric emissions are limited to turbine manufacture and construction activities, with no emissions during actual operations.

Nonetheless, wind turbines have the potential to affect wildlife, particularly birds and bats. Environment Canada recently assessed the geographic, seasonal, and taxonomic variation in the magnitude of national-scale bird mortality and in population-level effects on species and groups across Canada.[30] Combined, cat predation and collisions with windows, vehicles, and transmission lines caused > 95% of all mortality; the highest industrial causes of mortality were the electrical power and agriculture sectors. The electric power sector examined by Environment Canada included transmission-line collisions, hydro reservoirs, electrocutions, transmission-line

[28] BC EAO. 2009. The Gold River Power Project Order Under Section 10(1)(b), p.2.
[29] BC Hydro. November 2013. Integrated Resource Plan, Appendix 3A-4 2013 Resource Options Report Update, Resources Options Database (RODAT) Summary Sheets, p.227.
[30] Calvert, A.M. et al. 2013. A Synthesis of Human-related Avian Mortality in Canada. Avian Conservation and Ecology 8(2):11.

maintenance, and wind energy. However, it was not wind energy but transmission line collisions that composed the dominant cause of bird deaths within this sector, and transmission lines would be common to all supply-side electricity resources, and not only wind energy.

During the past 15 years, environmental assessments of several dozen wind projects totaling more than 10,000 MW have been completed in seven provinces, including BC,[31] Ontario[32] and Quebec.[33] To date, not a single project has required justification of significant adverse environmental effects as part of project approval. Post-construction monitoring of birds and bats is typically required as part of licencing. With proper turbine siting and avoidance of development in areas known or determined to have significant bird, bat or other wildlife populations, adverse effects can be minimized, and no significant adverse environmental effects would be expected.

Natural Gas

The natural gas resources contemplated in the clean + thermal portfolios consist of simple cycle gas turbines (SCGTs) developed in 100 MW increments, only as necessary to meet peak capacity requirements. A new natural gas facility has not been commissioned in BC for many years, and so there are no recent examples of environmental assessments for these facilities in the Province.

The total area of land impacted by a typical 100-MW natural gas facility is on the order of 30 ha, with no expected freshwater impacts.[34] This compares to over 5,000 ha each of impacted land and freshwater areas for the Site C Project.[35]

The air emissions of principal concern from SCGTs are nitrogen oxides (NO_x), carbon monoxide and to a lesser extent volatile organic compounds and particulate matter. Nitrogen oxide formation and emissions are controlled using low-NO_x combustors, water injection, and selective catalytic reduction (SCR) systems. Carbon monoxide and unburned hydrocarbons originate from incomplete fuel combustion, and formation is reduced by "good combustion practices" (proper air/fuel ratio, temperature, and residence times), and by an oxidation catalyst in the exhaust

[31] BC EAO. Undated. Project List Report. Available at: http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_list_report.html.
[32] Government of Ontario. Undated. Renewable Energy Projects Listing. Available at: https://www.ontario.ca/environment-and-energy/renewable-energy-projects-listing.
[33] Hydro Quebec. Undated. Wind farms and generating stations covered by supply contracts. Available at: http://www.hydroquebec.com/distribution/en/marchequebecois/parc_eoliens.html.
[34] BC Hydro. 2013. Integrated Resource Plan, Appendix 3A-4 2013 Resource Options Report Update, Resources Options Database (RODAT) Summary Sheets, p.475.
[35] *Ibid*., p.469.

system.[36] With these mitigations, the limited hours of operation of natural gas peaking facilities, and appropriate facility siting, the air contaminant emissions from a typical SCGT would not be considered significant.

Greenhouse gas emissions

Of additional concern in light of the requirements under the *Clean Energy Act*, the resources in the Clean + Thermal #2 portfolio, including MSW generation and SCGTs, produce carbon dioxide as a product of complete combustion of carbon, as well as methane from upstream natural gas infrastructure. Though technology for separating CO_2 from the plant exhaust is available, it is unlikely that CO_2 removal technology would be employed for an SCGT because of its relatively small size and limited hours of operation. In addition, wind resources produce greenhouse gas emissions as a result of construction activities and materials manufacture.

In its IRP, BC Hydro determined greenhouse gas emission rates (in CO_2e/GWh) specific to each supply-side resource.[37] BC Hydro initially based these rates only on direct emissions from fuel combustion, and excluded emissions from other phases of the resource life cycle, including construction, land clearing, emissions embedded in materials, etc. BC Hydro notes that these emissions are "generally small in comparison to emissions from fuel combustion at a power plant".[38] While this is true for MSW and natural gas facilities, since the emissions occur almost exclusively during operations, the relatively large quantity of wind resources in the alternative portfolios does sum to a measurable level of greenhouse gas emissions resulting from construction and embedded emissions in materials, as shown in the following table summarizing the greenhouse gas emissions for the Clean + Thermal #2 portfolio.

Table 2.5. GHG emission estimates – Clean + Thermal #2 Portfolio[39]

Resources	Clean + Thermal #2 (kt CO_2e/year)
GM Shrum	0
Revelstoke 6	0
MSW	217
Natural Gas (SCGTs)	294

[36] US EPA. 1995. Compilation of Air Pollutant Emission Factors, Section 3.1 Stationary Gas Turbines.
[37] BC Hydro. 2013. Integrated Resource Plan Appendix 3A-4: 2013 Resource Options Report Update Appendix 3.
[38] BC Hydro. 2013. Integrated Resource Plan Appendix 3A-3: 2013 Resource Options Report Update Appendix 2, p.53.
[39] BC Hydro. September 13, 2013. Site C Clean Energy Project Evidentiary Update, p.37.

Wind[40]	58
Totals	**569**

The Site C Project also produces greenhouse gas emissions, including construction-related emissions, life-cycle emissions from manufacturing of materials and equipment, and reservoir-related emissions. In preparing its emissions estimate for the Site C Project, BC Hydro considered both "likely" (lower emission) and "conservative" (higher emission) scenarios.[41] In order to assess the uncertainty of these estimates, BC Hydro also undertook a sensitivity analysis of various input parameters in order to develop "minimum likely" and "maximum conservative" estimates.

The resulting total Site C greenhouse gas emissions, including construction-related emissions, for the 108-year construction and operation period are summarized below.

Table 2.6. Range of GHG emission estimates – Site C Project[42]

	Minimum	**Likely**	**Conservative**	**Maximum**
	(kt CO_2e)	**(kt CO_2e)**	**(kt CO_2e)**	**(kt CO_2e)**
Operations	2,713	4,344	5,825	6,970
Construction - Materials	628	628	1,060	1,060
Construction - Fuel	363	363	417	417
Construction - Electricity	6	6	7	7
TOTAL	**3,710**	**5,341**	**7,309**	**8,454**
Annual (over 108 years)	**34.4**	**49.5**	**67.7**	**78.3**

The Clean + Thermal #2 portfolio (569 kt $C0_2e$/year) differs from the Site C portfolio (34.4 to 78.3 kt $C0_2e$/year) by on the order of 500 kt CO_2e/year. To place this difference in context, it represents less than 1% of BC's current emissions, 1.25% of BC's 2030 target emissions and 3.7% of the BC's 2050 target emissions under BC Hydro's assumptions.

The ~500 kt CO_2e/year difference between Site C and the Clean + Thermal #2 portfolio can also be considered in the context of other existing, recently approved, and potential future emission

[40] BC Hydro. 2013. Site C Clean Energy Project EIS, Volume 2, Section 15: Greenhouse Gases, Table 15.11 Emissions Intensity – Project Compared with other Generation.
[41] BC Hydro. 2013. Site C Clean Energy Project Environmental Impact Statement. Volume 2 Appendix S: Site C Clean Energy Project: Greenhouse Gases Technical Report. Prepared for BC Hydro by Stantec Consulting Ltd., p.84.
[42] CO_2 equivalents (CO_2e) calculated on a 100-year global warming potential of 21 for CH_4 and 310 for N_2O.

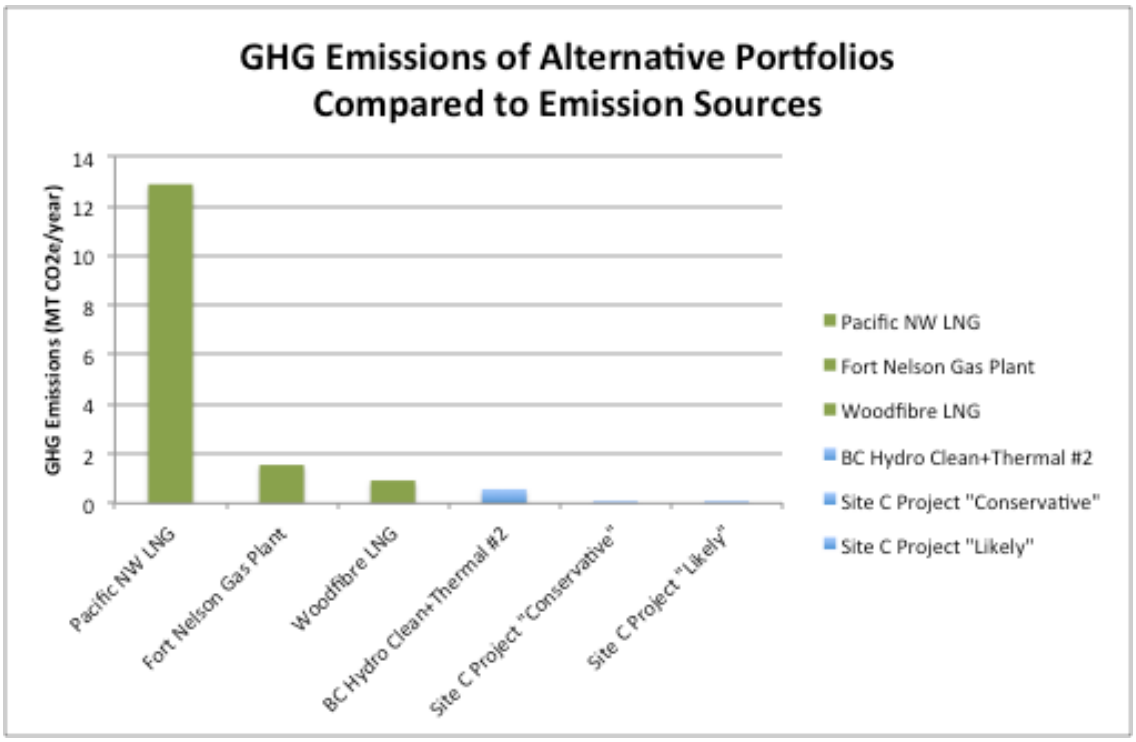
sources in British Columbia, as shown below in Figure 2.1. For example, the potential greenhouse gas emission reduction benefits of Site C are about 30% of the emissions of the largest single emitter in the Province, the Spectra Energy Fort Nelson Gas Plant.

Were the Pacific Northwest LNG export facility to be approved, its emissions would be more than 20 times the potential greenhouse gas emissions benefits of Site C, and would also represent over 95% of British Columbia's 2050 emissions reduction target set out in the *Clean Energy Act*.

The recently-approved Woodfibre LNG Project, even with its relatively low emissions intensity per tonne of LNG as a result of the use of electric drives, produces double the annual emissions of the Clean + Thermal #2 portfolio. The federal Minister of the Environment determined in March 2016 that the Woodfibre LNG Project is not likely to cause significant adverse environmental effects, including in relation to greenhouse gas emissions. On the basis of this very recent decision it is reasonable to conclude that the greenhouse gas emissions of the Clean + Thermal #2 portfolio would also not be considered a significant adverse environmental effect.

Figure 2.1 Portfolio GHG emissions compared to emission sources[43,44,45]

[43] Stantec. 2014. Pacific NW LNG Environmental Impact Statement and Environmental Assessment Certificate Application Section 7: Greenhouse Gas Management, p. 7-14.
[44] Environment Canada. 2014. Greenhouse Gas Emissions Reporting Program Online Data Search – Facility Reported Data.
[45] Canadian Environmental Assessment Agency. February 1, 2016. Woodfibre Liquefied Natural Gas (LNG) Project Review of Related Upstream Greenhouse Gas (GHG) Emission Estimates.


GHG Emissions of Alternative Portfolios
Compared to Emission Sources
GHG Emissions (MT CO2e/year)
14
12
10
8
6
4
2
0
Pacific NW LNG
Fort Nelson Gas Plant
Woodfibre LNG
BC Hydro Clean+Thermal #2
Site C Project "Conservative"
Site C Project "Likely"
Pacific NW LNG
Fort Nelson Gas Plant
Woodfibre LNG
BC Hydro Clean+Thermal #2
Site C Project "Conservative"
Site C Project "Likely"