



Canada's Energy Outlook

CURRENT REALITIES AND IMPLICATIONS FOR A CARBON-CONSTRAINED FUTURE

CHAPTER 4: EMISSIONS REDUCTION TARGETS & IMPLICATIONS FOR AN ENERGY STRATEGY

Full report available at energyoutlook.ca

By J. David Hughes

MAY 2018



CCPA
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This paper is part of the Corporate Mapping Project (CMP), a research and public engagement initiative investigating the power of the fossil fuel industry. The CMP is jointly led by the University of Victoria, the Canadian Centre for Policy Alternatives and the Parkland Institute. This research was supported by the Social Science and Humanities Research Council of Canada (SSHRC).



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Introduction to Part 4

Canadian emissions by sector are illustrated in Figure 131. Upstream oil and gas production was the largest emissions source in 2015 at 26%, followed by transportation (24%), buildings (11.9%), electricity (10.9%), heavy industry (10.4%), agriculture (10.1%) and other (6.6%).¹

In January 2017 Canada implemented a “Pan-Canadian Framework on Clean Growth and Climate Change” designed to “enable Canada to meet or exceed its target to reduce emissions to 30% below 2005 levels by 2030” as a signatory to the Paris Agreement.² Canada also submitted the aforementioned mid-century strategy to the United Nations Framework Convention on Climate Change (UNFCCC) in November 2016, which presents several scenarios to reduce emissions by approximately 80% by 2050 (these scenarios were reviewed by generation source in the previous discussion of electricity).

Figure 131: Greenhouse gas emissions by sector in Canada from 1990 to 2015.³

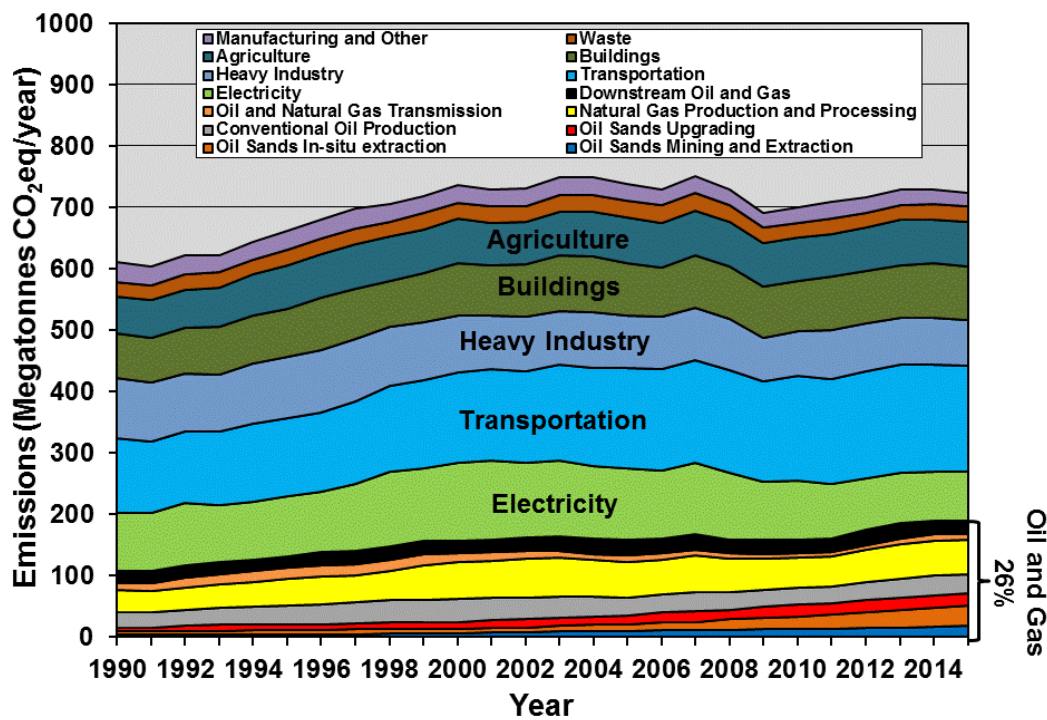


Figure 132 illustrates these emissions-reduction goals compared to planned growth in oil and gas production given the National Energy Board’s “reference case” production forecast, and including the 100-megatonne per year emissions cap on oil sands under Alberta’s Climate Leadership Plan. Oil sands production would grow until 2024 before being constrained by the cap.

¹ Environment and Climate Change Canada, April 2017, National Inventory Report, Volume 3, see Table A10-2, page 44, http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/can-2017-nir-13apr17.zip

² Environment and Climate Change Canada, Pan-Canadian Framework on Clean Growth and Climate Change, January 2017, <https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html>

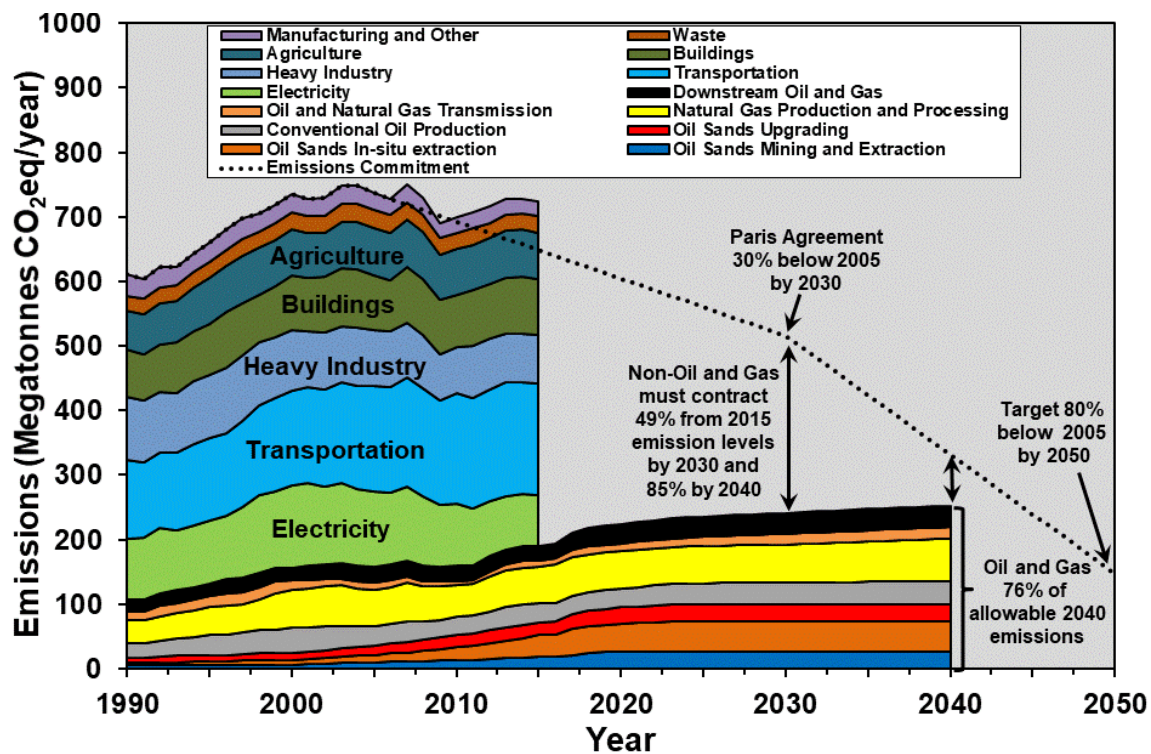
³ Data from ECCC National Inventory Report 2017

The magnitude of emissions reductions required to meet these aspirational targets is daunting. In the NEB's reference scenario, including the Alberta oil sands emissions cap, oil and gas production would constitute 76% of all Canadian emissions in 2040, requiring emissions from the rest of the economy to contract by 85% from 2015 levels at that time. By 2050, if oil and gas production remained constant at 2040 levels, emissions from the rest of the economy would have to contract by more than 100%. Given the options to reduce and replace energy use in non-oil and gas sectors of the economy, which in 2015 were responsible for 74% of Canada's emissions, negative emissions are likely impossible by 2050, even with massive adoption of technologies like carbon capture and storage that have yet to be proven at scale.

Under the NEB's higher carbon price and technology scenarios, upstream oil and gas would, under Alberta's oil sands emissions cap, still constitute 70–72% of allowable emissions in 2040, and emissions from the rest of the economy would have to contract by 82–83% from 2015 levels (and contract by more than 100% by 2050).

Figure 132: Canadian emissions by sector including a projection to 2040 for upstream oil and gas emissions, assuming Alberta's 100-megatonne cap on oil sands emissions and the National Energy Board's reference case production projection.

Emissions per unit of production are based on the latest Environment and Climate Change Canada emissions report and NEB production data averaged over the 2012–2015 period.⁴



⁴ National Energy Board Energy Future October 2017, <https://www.neb-one.gc.ca/nrg/ntgrtd/fttr/2017/2017nrgftr-eng.pdf> appendices <https://apps.neb-one.gc.ca/fttrpndc/dflt.aspx?GoCTemplateCulture=en-CA> retrieved Oct 29, 2017. Emissions are from Environment and Climate Change Canada, National Inventory Report, released April, 2017. See Table A10-2 for emissions by economic sector, http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/can-2017-nir-13apr17.zip.

4.1 ECCC's Pan-Canadian Framework on Clean Growth and Climate Change

Environment and Climate Change Canada's pan-Canadian framework is the federal government's plan to reduce emissions by 30% from 2005 levels by 2030, as committed to when Canada signed the Paris Agreement in late 2015. Under its reference case, which includes emissions-reduction measures announced up to November 2016, ECCC projects that emissions will fall from 2005 levels by only 0.7% by 2030, and will be 21.4% above 1990 levels, with emissions in the oil and gas sector rising by 46.5% (see Table 29).⁵

Table 29: Emissions by sector in Canada projected by Environment and Climate Change Canada's reference case to 2020 and 2030.

Sector	Historical		2016 projection		Change	
	1990	2005	2020	2030	1990–2030	2005–2030
Oil and gas	108	159	201	233	115.7%	46.5%
Electricity	94	118	64	34	-63.8%	-71.2%
Transportation	122	171	168	157	28.7%	-8.2%
Heavy industry	97	88	85	97	0.0%	10.2%
Buildings	73	85	89	94	28.8%	10.6%
Agriculture	60	70	72	74	23.3%	5.7%
Waste and others	57	56	51	53	-7.0%	-5.4%
Total	611	747	731	742	21.4%	-0.7%

The pan-Canadian framework provides few specifics on how much emissions will be reduced by each of its measures and in which sectors, and it appears to have double-counted the impact of certain mitigation strategies. For example, in its 2016 reference case projection (see Table 29), ECCC indicates that greenhouse gas emissions measures in place as of November 2016 were included,⁶ yet the pan-Canadian framework claims further reductions of 89 megatonnes per year from “announced measures as of November 1, 2016,” as well as “international cap and trade credits.”⁷ There is no mention of the split between “announced measures” and “international cap and trade credits,” which amount to buying credits rather than reducing emissions. The pan-Canadian framework claims a further 86 megatonnes of reductions will be achieved from the phasing out of coal-fired power (although all but eight megatonnes of coal phase-out are already accounted for in the ECCC projection in Table 29), along with buildings, transportation and industry (the ECCC projection included extensive measures implemented at the provincial and federal levels as of November 2016).

The probability of the pan-Canadian framework's success is difficult to evaluate without specifics on how much emissions can be cut by sector using new incentives, funding and technologies, and therefore it is largely an aspirational document. In contrast, ECCC's mid-century strategy offers specifics for a number of scenarios to reduce emissions by approximately 80% below 2005 levels by 2050, which can be used to assess their potential viability and cost.

⁵ Environment and Climate Change Canada, 2017, Canada's 2016 greenhouse gas emissions Reference case, <https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=1F24D9EE-1>; note that ECCC revised 2005 emissions downward to 738 megatonnes which makes its reference case projection in 2030 actually higher than 2005, not lower as indicated in Table 29 and the text above.

⁶ Environment and Climate Change Canada, 2017, Canada's 2016 greenhouse gas emissions Reference case, see Table A30, <https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=1F24D9EE-1>

⁷ Environment and Climate Change Canada, 2017, Pan-Canadian Framework on Clean Growth and Climate Change, see page 44, <https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170125-en.pdf>

4.2 ECCC's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy

Environment and Climate Change Canada's mid-century strategy provides several scenarios to reduce emissions by 67% to 89% below 2005 levels by 2050, all of which project some reduction in overall energy consumption by 2050.⁸ Target emissions in 2050 and percentage reduction by scenario are given in Table 30.

Table 30: Target 2050 emissions and emissions reductions by scenario in Environment and Climate Change Canada's mid-century strategy.⁹

Scenario	CO ₂ eq emissions in 2050 (megatonnes per year)	% CO ₂ eq reduction by 2050 from 2005 without emissions credits	% CO ₂ eq reduction by 2050 from 2005 with emissions credits
DDPP 2050	78	89.4%	89.4%
Trottier Current Tech 2050	244	66.9%	66.9%
Trottier New Tech 2050	244	66.9%	66.9%
ECCC High Nuclear 2050	147.4	65.0%	80.0%
ECCC High Hydro 2050	147.4	65.0%	80.0%
ECCC High Demand Response 2050	147.4	65.0%	80.0%

⁸ Environment and Climate Change Canada, 2016, Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy, http://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

⁹ Environment and Climate Change Canada, 2016, Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy, see pages 21-22 and Figure 7 page 34, note that target emissions are calculated based on ECCC's revised estimate of 2005 emissions of 738 megatonnes http://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

Scenarios in the mid-century strategy call for a major increase in electrification, from 17% of delivered energy in 2015 to as much as 65% in 2050. In all of the scenarios electricity, as a portion of total delivered energy, at least doubles and in some cases more than triples, as illustrated in Table 31. Consumption of natural gas and oil as a proportion of total delivered energy are projected to decrease markedly. By contrast, the National Energy Board's projection to 2040 forecasts an increase in energy consumption with oil and gas as a proportion of total consumption comparable to 2015 levels, and electricity increasing only slightly to 19% of delivered energy in 2040. The "other" category in the following tables includes biofuels, biomass, geothermal and hydrogen. The DDPP 2050 scenario also assumes that most coal and natural gas consumption would incorporate carbon capture and storage.

Table 31: Delivered energy supplied by fuel according to the National Energy Board reference scenario in 2015 and 2040, and in the six 2050 scenarios in Environment and Climate Change Canada's mid-century strategy.¹⁰

RPP=refined petroleum products

Scenario and % of supply	Natural gas	RPP	Electricity	Other
NEB Reference 2015	35.2%	41.0%	16.8%	6.9%
DDPP 2050	17.6%	13.0%	48.1%	21.3%
Current Tech Trottier 2050	6.7%	15.3%	65.3%	12.8%
New Tech Trottier 2050	5.4%	16.5%	58.3%	19.8%
ECCC High Nuclear 2050	12.5%	20.5%	57.2%	9.9%
ECCC High Hydro 2050	12.5%	20.5%	57.2%	9.9%
ECCC High Demand Response 2050	20.9%	0.0%	33.2%	45.8%
NEB Reference in 2040	37.8%	36.9%	19.1%	6.2%

The change in delivered energy consumption by fuel compared to 2015 levels in the NEB 2040 reference forecast and the 2050 levels in the various scenarios of the mid-century strategy is given in Table 32. In all scenarios, except the NEB reference case, consumption of oil and gas decreases radically, and electricity generation in most scenarios more than doubles from 2015 levels.

Table 32: Change in delivered energy supplied by fuel in 2050 compared to 2015 consumption in the scenarios in Environment and Climate Change Canada's mid-century strategy.

Also shown is the National Energy Board's reference case projection to 2040.¹¹

(RPP=refined petroleum products)

Scenario and % change from 2015	Natural gas	RPP	Electricity	Other	Total
DDPP 2050	-57.1%	-72.9%	139.0%	153.5%	-14.9%
Current Tech Trottier 2050	-87.9%	-76.4%	141.0%	13.2%	-36.7%
New Tech Trottier 2050	-88.4%	-69.9%	153.3%	106.8%	-25.5%
ECCC High Nuclear 2050	-73.3%	-62.6%	149.2%	3.4%	-25.3%
ECCC High Hydro 2050	-73.3%	-62.6%	149.2%	3.4%	-25.3%
ECCC High Demand Response 2050	-44.0%	-100.0%	80.5%	498.1%	-6.8%
NEB Reference in 2040	16.6%	-2.3%	23.6%	-2.8%	8.7%

¹⁰ National Energy Board Energy Future 2017 for 2015 delivered energy by fuel and 2040 reference case forecast; and Environment and Climate Change Canada, 2016, Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy, see Figure 7 http://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

¹¹ Ibid.

Table 33 illustrates the change in electricity generation by renewable and nuclear sources through 2050 compared to 2015 levels for scenarios in the mid-century strategy. The scale-up in nuclear power in most scenarios required to meet emissions-reduction targets strains credibility. The slow growth in nuclear energy worldwide, given retirements of aging reactors, along with unresolved issues such as waste disposal, make it hard to believe that Canada's nuclear capacity will be scaled up by two-fold to eight-fold by 2050, as called for in five of the six scenarios. As discussed in the nuclear section above, Canada will have no nuclear capacity after 2036 without the expenditure of \$26 billion to extend the lives of eight Bruce and Darlington reactors. In the "Current Tech Trottier" and "ECCC High Nuclear" scenarios, Canada would require 108 new one-gigawatt reactors by 2050 (see nuclear section above for a more detailed discussion).

Table 33: Change in electricity generation provided by renewable and nuclear sources by 2050 compared to 2015 in Environment and Climate Change Canada's mid-century strategy scenarios.

Also shown is the National Energy Board's reference case projection to 2040.¹²

Scenario and % change from 2015	Nuclear	Hydro	Wind	Solar	Biomass
DDPP 2050	-18.1%	103.9%	779.1%	2361.6%	0.0%
Current Tech Trottier 2050	706.6%	114.8%	1791.7%	713.8%	67.7%
New Tech Trottier 2050	563.9%	113.7%	352.4%	0.0%	0.0%
ECCC High Nuclear 2050	706.6%	36.5%	439.2%	498.6%	872.5%
ECCC High Hydro 2050	184.4%	150.7%	698.3%	3192.3%	369.5%
ECCC High Demand Response 2050	65.0%	124.3%	12.0%	0.0%	34.1%
NEB Reference in 2040	-9.1%	10.4%	145.1%	332.6%	22.6%

Similarly, the scale-up in large hydro required by Canada's mid-century scenarios also strains credibility. Between 33 and 101 new "Site C"-sized dams (1.1 gigawatts) would be required, as discussed in the hydropower section above. Even the NEB's much more modest hydro expansion would require eight major new dams by 2040. Given the protests, backlash and cost-overruns associated with two hydro dams currently under construction—Site C and Muskrat Falls—it would be challenging to build eight new dams by 2050, let alone 101 dams.

¹² National Energy Board Energy Future 2017 for 2015 delivered energy by fuel and 2040 reference scenario forecast; and Environment and Climate Change Canada, 2016, Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy, see Figure 2 http://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

Table 34 gives estimated costs for new renewable, hydro and nuclear generation capacity by 2050 in the mid-century strategy's scenarios. Between US\$710 billion and US\$1,688 billion are required, based on 2016 capital costs (see Table 20), which corresponds to \$C30–70 billion each year between 2017 and 2050 (cost calculations for each electricity generation source can be found in previous sections). Somewhere between 67–99% of these costs are directed at nuclear and large hydro in ECCC's mid-century scenarios. The spending rates range from four to ten times higher than that required for the NEB's much more modest reference case scenario through 2040, which would see a considerable increase in emissions.

Table 34: Investment required to generate 2050 levels of electricity for renewable and nuclear sources in Environment and Climate Change Canada's mid-century strategy scenarios (and 2040 in the case of the National Energy Board's reference case forecast).

Also shown is the average expenditure per year required over the 2017–2050 period in Canadian dollars.

Scenario and 2016–2050 cost (\$US2016 billion)	TWh	Nuclear	Hydro	Wind	Solar	Biomass	Total	\$Cbillion/year 2017–2050
NEB 2015 Generation	646							
DDPP 2050	1,477	17.8	576.8	158.9	136.9	0.0	890.5	37.0
Current Tech Trottier 2050	2,257	642.1	630.8	365.5	41.4	8.1	1,687.9	70.1
New Tech Trottier 2050	1,622	517.2	630.8	71.9	0.0	0.0	1,219.9	50.6
ECCC High Nuclear 2050	1,648	642.1	204.6	89.6	28.9	104.8	1,070.0	44.4
ECCC High Hydro 2050	1,648	190.2	738.8	142.4	185.1	44.4	1,301.0	54.0
ECCC High Demand Response 2050	1,215	89.2	613.8	2.5	0.0	4.1	709.5	29.5
NEB Reference in 2040	732	23.8	47.0	29.3	19.2	2.8	122.1	7.3

The NEB's reference case forecast to 2040 calls for little change in the basic energy mix and significant increases in emissions from oil and gas production, such that by 2040 76% of Canada's emissions would come from upstream oil and gas production in a scenario where emissions-reduction targets were met, even with Alberta's oil sands emissions cap (see Figure 131). Canada's mid-century strategy scenarios, on the other hand, strain credibility with their call for major scale-ups in large hydro and nuclear. Even given this credibility problem, the scenarios still call for reduced but significant amounts of oil and gas consumption.

4.3 Key considerations for a long-term energy plan

The following are key findings of this report that should be considered in formulating a long-term energy plan to maintain long-term energy security for Canadians and minimize environmental impacts:

- Canada has very high per capita energy consumption—more than five times the world average. Primary energy consumption is based 65% on fossil fuels and 7% on nuclear energy. Delivered energy consumption is 83% non-electric, and 92% of non-electric delivered energy is fossil fuels.
- Although the “energy intensity” of the economy is decreasing somewhat, gross domestic product (GDP) remains highly correlated with energy consumption. Canada's energy consumption per dollar of GDP is nearly double the world average and considerably higher than even China's (the next-highest) and the US's (the third-highest). Greenhouse gas emissions per unit of energy consumed are flat to slightly declining.
- Canada's electricity consumption is among the highest in the world—more than five times the world average on a per capita basis. Although Canada is the second-largest generator of

hydropower in the world, it is considerably below the world average in per capita generation of non-hydro renewable energy from solar, wind, biomass and geothermal sources.

- Canada's nuclear fleet is aging and capacity will be reduced to zero by 2037 without refurbishing eight reactors at Bruce and Darlington at a cost of \$26 billion. Even with refurbishment of these reactors, there will be a 39% reduction from 2015 levels of nuclear capacity by 2037, if new reactors are not built. Aside from the largely unresolved issue of long-term storage of nuclear wastes, the cost of a major nuclear scale-up is very high. The National Energy Board's reference case would require construction of four new reactors, in addition to the refurbishments, although overall nuclear output would still decline 9% from 2015 levels by 2040.
- Canada's per capita emissions of greenhouse gases are among the highest in the world—3.2 times the world average, more than double that of China (the world's highest total emitter) and eight times that of India.
- Although on paper Canada has the third-largest resource of oil in the world, in practice 97.4% of proven reserves are low-quality oil sands that are energy- and emissions-intensive to extract and costly to refine. Some 80% of the remaining recoverable resources in the oil sands are too deep for mining and thus require even more energy- and emissions-intensive in situ methods to extract. Furthermore, industry invariably extracts the highest-quality, most economic resources first, which means that much of Canada's remaining oil resource will cost more to extract than current operations and will produce higher levels of emissions.
- The NEB has more than tripled its estimates of marketable natural gas in Canada since 2010 based on a series of brief studies with speculative assumptions. Although estimates of conventional gas have declined, estimates of tight gas and shale gas have vastly increased, due to the assumed widespread viability of horizontal drilling in combination with high-volume hydraulic fracturing (fracking). As with oil, the gas industry extracts the highest-quality, most economic resources first. Hence, even if these resources prove to be extractable, which is by no means assured, the bulk of them are in lower-quality parts of the resource, which will require higher prices to extract and mean higher environmental impacts given the number of wells required to produce them.
- The revenues in terms of royalties and corporate taxes from oil and gas extraction have plummeted and are now relatively minor in terms of total government revenue. Even though oil and gas production has grown by 27% since 2000, royalty revenue is down by 63%. Royalties as a share of total oil and gas sales have declined from nearly 18% in 2000 to 4.5% in 2015. In Alberta, Canada's largest oil and gas producer, production has doubled since 1980 and royalty revenues are down 90% in real terms—resource revenue constituted 80% of Alberta government revenue in 1980 and just 3.3% in 2016. In BC, Canada's second-largest gas producer, resource revenue from natural gas, coal and minerals is down 84% since 2005 while gas production has doubled.
- Corporate taxes paid for oil and gas extraction and refining are down more than 50% since 2006 despite growing production, and amounted to less than \$4 billion in 2015, which is less than the royalty revenue in that year. Employment in oil and gas extraction amounted to less than 3% of total Canadian employment in 2015, and more than half of that was in construction, which is temporary. The highest provincial employment in the oil and gas sector in 2015 was in Alberta at 13%, more than half of which were temporary construction jobs. Claims of higher employment and revenues relate to "spin-off" jobs not directly related to the oil and gas industry, and assume that these workers would not otherwise be employed.
- Greenhouse gas emissions from oil and gas extraction amounted to 26% of Canada's total in 2015 and will rise to 76% by 2040, given the NEB's reference case production projection and Alberta's 100-megatonne oil sands emissions cap, under a scenario where Canada's emissions-reduction

targets are achieved. This would require emissions from the rest of the Canadian economy to contract by 85% in 23 years.

- Environment and Climate Change Canada's pan-Canadian framework for emissions reduction by 2030 is an aspirational document with little quantitative information on how much individual measures will cut emissions. ECCC's mid-century strategy for emissions reduction contains several scenarios that would require an increase in annual spending on new energy infrastructure of four to ten times the amount in the NEB's reference case, 67–99% of which would be spent on new hydropower and nuclear plants. Development of up to 101 new "Site C" sized dams and 108 new reactors, as called for in some of these scenarios, indicates the scale of the problem in reducing emissions by 80% (and several of the scenarios require substantial purchases of international emissions credits, which were not included in cost estimates). Construction of new dams and reactors on this scale is highly unlikely given cost and public opposition to the environmental impacts.
- Renewable energy from solar and wind can be scaled up many-fold but there are limits due to intermittency and seasonal variations in output. Even the most aggressive scenarios in Canada's mid-century strategy don't see wind growing to more than 24% of total generation and solar to more than 6% (which would require an 18-fold increase in wind and a 32-fold increase in solar from current levels).
- Renewable energy from biomass can be scaled up also, bearing in mind that when initially burned it releases greenhouse gas emissions comparable to coal, and it takes decades to neutralize these emissions through regrowth. Biofuels have a low energy return on investment (EROI) and therefore do little to reduce overall emissions impact.
- Renewable energy from geothermal sources could be a major source of heat, displacing fossil fuels for heating buildings, but is unlikely to be scalable to replace much electricity generation by 2050.
- In terms of fossil fuels, Canada is a well-explored and intensively developed petroleum province. These fuels remain a reliable backup to other energy sources should the scale of alternatives prove to be unachievable. These resources are non-renewable and finite, and production of oil and gas is the largest source of Canadian emissions, yet current policy is to extract them as fast as possible and sell them at rock-bottom prices with diminishing returns for the Canadian economy. This compromises emissions-reduction commitments and imposes long-term risks for Canadian energy security.

Further reading

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