PEMBINA institute

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Re: Comments on Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity

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The Pembina Institute welcomes the opportunity to comment on the Government of Canada's Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity (gas regulations).

Summary of the Pembina Institute's comments

The role of natural gas in the electricity sector will likely change with greater integration of renewables, storage, demand-side management and grid optimization. As new gas units are built in the wake of coal plant retirements, this standard sets a good precedent for regulating their performance.

- The gas standards should either be regularly and automatically ratcheted down to reflect the emissions performance of the best available technologies that are economically feasible, or be periodically reviewed and adjusted appropriately.
- The different categories of exemptions to the regulations should be reviewed in three years time (2021) to determine whether they need to be adjusted in response to climate targets and evolution of technology and the electricity market.
- To ensure that the GHG reduction goals are not compromised when units need to use the emergency clause, they should be required to compensate for their emissions above the applicable standard through some mechanism such as purchasing allowances or offsets. The process for applying for and granting temporary exemptions in such cases should be transparent.
- Performance test results for coal-to-gas conversions, and annual emissions and generation data for all units, should be made available to the public at the unit level.
- Early conversions of coal units to gas can deliver significant benefits. But the stringency of the term for life extensions of converted units is critical to ensuring that emissions-intensive generation is phased out and replaced by non-emitting resources.

Context

Deep decarbonization of the electricity sector is critical to decarbonizing Canada's economy both through direct emission reductions and through electrification of various economic sectors — actions that can further support reducing Canada's GHG emissions and meeting its climate commitments. With the continued fall in price of renewable energy technologies and batteries, plus improvements in grid management, the electricity sector has viable and cost-effective alternatives to fossil fuel generation.

Natural gas and climate

In order to meet the Paris Agreement targets, natural gas must play the role of a short and narrow bridge to cleaner generation. While natural gas emissions from power generation are significantly less than those of coal, the life cycle emissions for gas power plants may be greater due to emissions associated with extraction and transport of gas. As Figure 1 shows, methane leakage can create scenarios where using gas is more emissions-intensive than using coal. Empirical studies recently conducted in Alberta shows that some extraction sites have a leakage rate greater than 3%, confirming the significant underestimation of methane emissions in official data.[1] In fact, methane emissions reduction is a critical component of any climate policy.

In addition, Canada has committed to a target of 90% emissions-free electricity by 2030. So gas should be used only when there are no viable alternatives, and in those cases the most efficient technologies must be applied.

[1] Daniel Zavala-Araiza, *Super-emitters at Canadian Production Sites: From Measurements to Mitigation*, presentation to the EERL Methane Symposium, Carleton University, Ottawa, Canada, November 21, 2017. https://carleton.ca/methanesymposium/wp-content/uploads/2-Zavala-MethaneSymposium.pdf. Slide 7 shows a leakage rate of 3.3% for the Red Deer region.

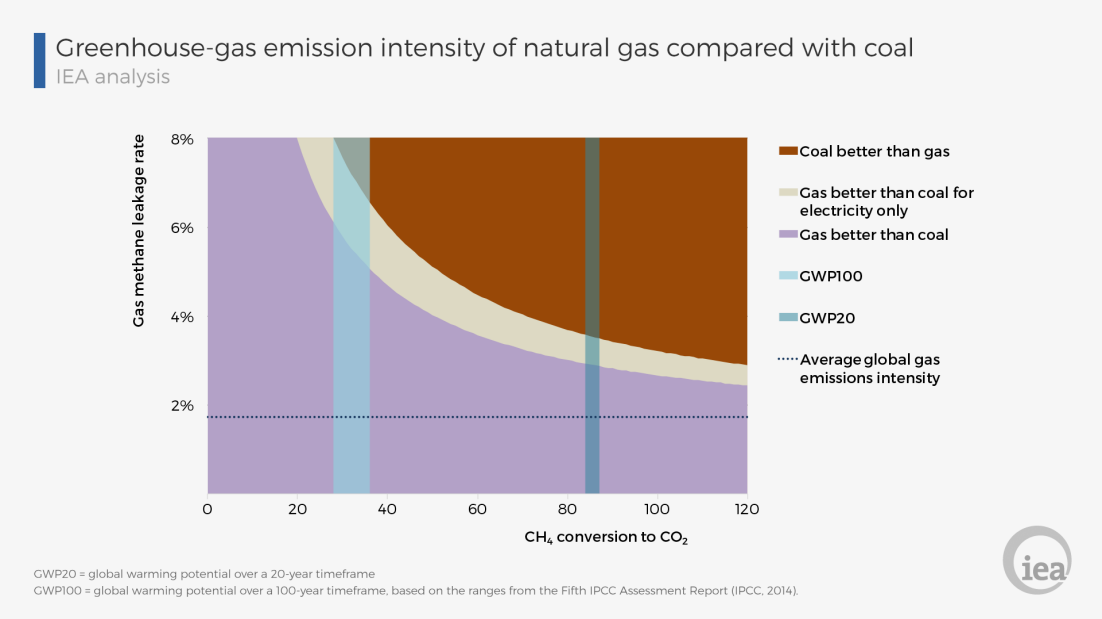

Figure 1. Greenhouse gas emission intensity of natural gas compared with coal

SOURCE: IEA[2]

Role of gas in the electricity sector

The electricity sector is undergoing an unprecedented shift across the world as renewables become economically competitive with fossil fuels. The grid is evolving to be more flexible and sophisticated in its operation as more renewables come online. Renewables add to the reliability of the grid due to their often distributed nature and the fact that they don't have to rely on a supply of fuel.

The variable nature of wind and solar is often misrepresented in determining how much natural gas generation is required in the grid. Solar generation is predictable and system operators are getting better at forecasting wind generation.[3] Capacity factors are also substantially greater now (40 % for wind[4] and 14-28% for solar in some regions[5]). Depending on their relative locations on the grid, different renewable facilities can provide a certain degree of backup for each other. In addition, the costs of storage are decreasing rapidly, and interconnections improve the ability of grids to integrate renewables. Greater integration of demand side

[2] International Energy Agency, "Commentary: The environmental case for natural gas," October 23, 2017. https://www.iea.org/newsroom/news/2017/october/commentary-the-environmental-case-for-natural-gas.html

[3] Amory Lovins, *Amory's Angle: Ramping up Renewable Electricity*, 2. https://www.rmi.org/wp-content/uploads/2017/05/2014%E2%80%94Amorys-Angle-Ramping-Up-Renewable-Electricity.pdf

[4] Canadian Wind Energy Association, *Alberta Wind Vision Technical Overview Report*.

[5] National Renewable Energy Laboratories, "2016 Annual Technology Baseline." http://www.nrel.gov/analysis/data_tech_baseline.html. These values are for facilities in the U.S.

management mechanisms and energy efficiency will also assist with higher penetration of renewables.

Renewables and storage can also provide other services – such as frequency regulation - for which we have traditionally relied on conventional generators.

However, as we wait for storage solutions to further evolve (in terms of cost and discharge time) and for additional interconnections to be constructed, natural gas can play an important interim role. Gas generators have faster ramping capacity than coal — this is an important feature in a grid that will require greater flexibility. Currently, gas is also very cheap in North America, although, in the U.S., wind and solar are expected to be competitive with gas by 2020.[6] There may remain a limited role for natural gas in the grid in a carbon-constrained world, but the generators will then require some form of carbon capture.

With the phase-out of coal, most GHG emissions in Canada's electricity sector from 2030[7] onwards will be from the use of gas. It is critical then that all new gas generation brought online meet the most stringent standards for emissions.

Role of coal-to-gas converted units

TransAlta[8] and ATCO[9] have announced their plans to convert some of their coal units to gas-fired units. The converted units have higher emissions than new units (up to 800 tonnes CO_2e/GWh (tCO_2e/GWh)) and are unable to ramp like gas generators. The actual emissions and ramping performance of the units depend on the scope and extent of the conversion. For example, expansion of the gas infrastructure and changing of the burner with minimum modifications to the boiler will result in a converted unit that operates very similar to a coal plant, but also needs minimal capital investment. On the other end of the spectrum the addition of a gas turbine and further reconfiguration of the plant can greatly increase the efficiency of the unit, but it will require much greater capital. In our analysis we assume that most units will undergo only minimal changes.

[6] McKinsey & Company, *Global Energy Perspective: Reference Case 2018* (2017), 17.

[7] There may be some GHG emissions from coal-fired generation depending on the use of coal with carbon capture and storage, and the nature of the equivalency agreements with the provinces of Nova Scotia and Saskatchewan.

[8] TransAlta, *TransAlta announces Accelerated Transition to Clean Energy,* media release, December 6, 2017. https://www.transalta.com/newsroom/news-releases/transalta-announces-accelerated-transition-clean-energy/

[9] Geoffrey Morgan, "Alberta could be coal-free years ahead of deadline as ATCO plans transition to natural gas by 2020," *Financial Post*, May 10, 201.7 http://business.financialpost.com/g00/commodities/energy/alberta-could-be-coal-free-years-ahead-of-deadline-as-atco-plans-transition-to-natural-gas-by-2020?i10c.encReferrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNhLw%3D%3D&i10c.ua=1

These conversions present a unique opportunity in the electricity sector. Due to the typically small capital investment ($50-60 million[10]) required for these conversions, they have a short payback period. This allows their short-term use while non-emitting technologies evolve to replace them.

Impact of carbon pricing and market changes

Changes in the electricity sector are not limited to the economics of renewables. External costs of GHG emissions are being internalized through carbon pricing schemes around the world.[11] As more renewable generation comes online at negligible operating costs, it will exert a downward pressure on electricity prices. Changes in market structure are needed to ensure that generators have reasonable revenue streams. There are several ways to do this (each with their own risks and advantages). These changes make it difficult to predict how different units will be operated to optimize economic returns and reduce costs. Generators are entering a new era where they need to include new costs such as that of carbon and need to compete with disruptive technologies.

In these changing dynamics, emissions standards should send a clear signal and offer certainty on performance expectations. They should be set with environmental and health impacts as primary drivers, while ensuring that the industry remains economically viable. This can be done by benchmarking the standards against best available technologies that are economically achievable (similar to BATEA standards used by Alberta's Clean Air Strategic Alliance for criteria air contaminants).

Analysis of the regulations

The introduction of a standard for gas plants sets a good precedent for regulating emissions from what will be the largest source of emissions in Canada's electricity grid after 2030.

New gas standard

- The performance standards of 420 tCO_2e/GWh for large units and 550 tCO_2e/GWh for smaller units are not representative of the best-in-class gas technologies currently available.
- Since units are not expected to run in ideal baseload conditions, we understand that the performance standard cannot be the same as the design performance of units. The data presented by ECCC at the Technical Working Group last year (see Figure 2) show that even older units that came into operation in 2003 are able to operate below the performance standard even at low capacity factors. Newer plants should be able to stay

[10] *Canada Gazette Part I*, Vol. 152, No. 7, page 608, footnote 17.

[11] Carbon Pricing Leadership Coalition, *Carbon pricing in action.* https://www.carbonpricingleadership.org/who/

well below the 420 tCO_2e/GWh standard. For instance, the Shepard Energy Centre commissioned in 2015 achieved an emissions intensity of 388 tCO_2e/GWh at a 45% capacity factor for its first year of operation.[12,13] Similarly, the data sampled shows that smaller units are able to stay below the standard of 550 tCO_2e/GWh (Figure 3).

- The thermal efficiency of gas turbines has improved in recent decades and may continue to improve in the future. More efficient turbines will have lower emissions intensities. The standard for new gas units should reflect the best available technology that is economically achievable at the time the unit is licensed, not at the time the regulation is promulgated. Therefore, the standard should be ratcheted down periodically to reflect the actual performance of recently commissioned gas units. For example, the standard for new gas units installed in future years could be automatically adjusted (without amending the regulations) based on the top quartile of emissions performance for new units installed in a defined preceding period.
- Even if some commercially available gas units cannot meet the standards, this alone is not sufficient reason to relax the standards. There needs to be adequate evidence that the vast majority of available gas technologies can not meet the standard. The number has to be large enough to demonstrate impacts on reliability or significant costs to consumer.
- If there is ample evidence for such an exemption, one could be designed for very specific conditions (to be crafted with stakeholder input before finalization of the regulation) allowing operators to offset or generate some other equivalency for the GHG benefits lost. An exemption of this kind has the potential to significantly weaken the regulation and to send a weak signal to developers, hence it should only be included if the need has been clearly established; our research to date has not produced adequate data to demonstrate this need.

[12] ECCC, *Greenhouse Gas Reporting Program data search: facility information*. https://climate-change.canada.ca/facility-emissions/. Based on 2015 data downloaded in 2017.

[13] Alberta Environment and Parks, *2006 to 2017 Annual Reports of Generators*. http://www.environment.alberta.ca/apps/etr/Documents.aspx

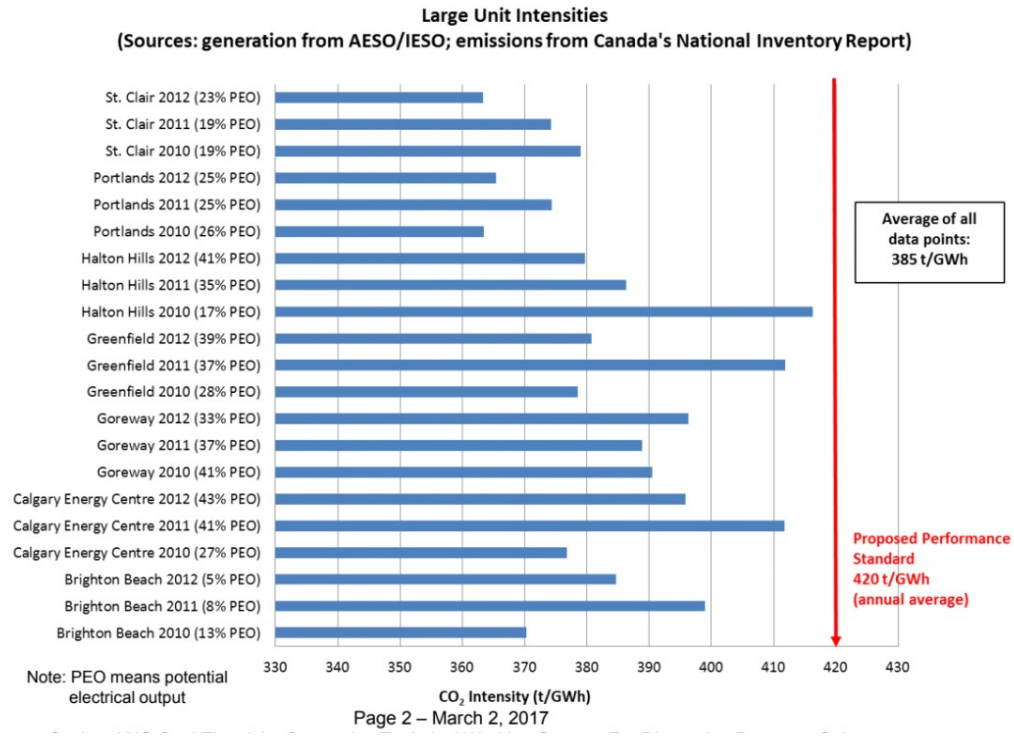

Figure 2. GHG emissions performance data for large existing gas units.

SOURCE: ECCC[14]

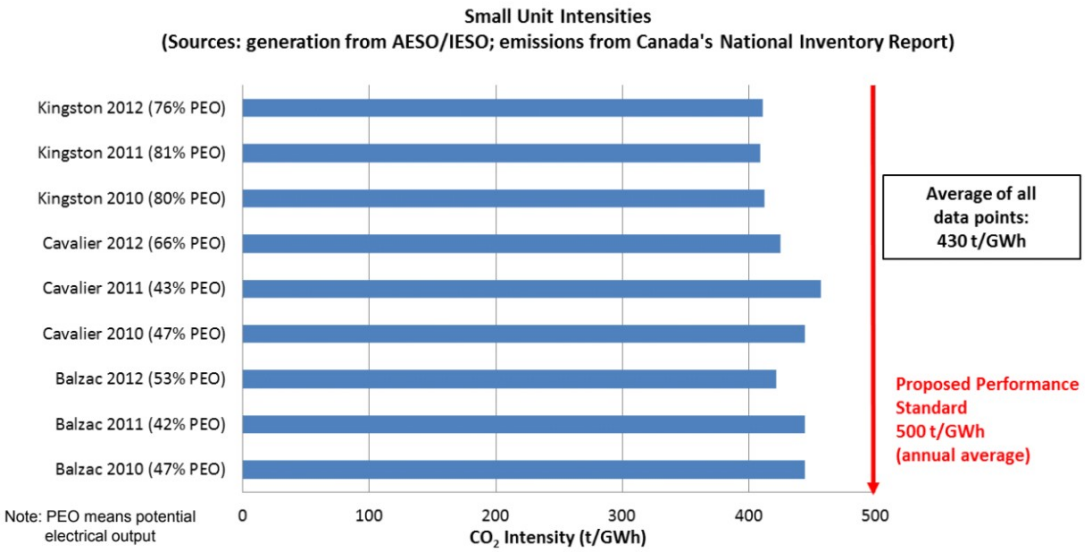

Figure 3. GHG emissions performance data for small existing gas units.

Source: ECCC[15]

[14] ECCC, Informal Technical Working Group – Meeting #3, March 2, 2017.

[15] Ibid.

Life extension for coal-to-gas conversions

- Coal units that are given five or ten years to operate as a converted gas unit will end up emitting between 23 Mt and 32 Mt of extra greenhouse gas over the analysis period of 2017–2055 (Figure 4). There is a high degree of uncertainty associated with the capacity factors of the coal-to-gas converted units. Any further extensions for the coal-to-gas conversions could significantly impact the GHG reductions. For example, if units were granted a fifteen-year life extension, the resulting extra emissions would amount to 49 Mt over the analysis period of 2017–2055 compared with a coal phase-out that does not allow for conversions (Figure 4).
- Early conversions of coal units to gas can result in significant emissions reductions. If TransAlta and ATCO follow the conversion timeline they recently announced, emissions would be reduced by an additional 52 Mt of CO_2e[16] over the 2017–2055 period (see Figure 4). We estimate that an accelerated schedule of coal unit retirements and conversions to gas in Alberta could prevent between 530 and 670 premature mortalities premature mortalities from 2017 to 2055 compared with the RIAS policy scenario.[17] It should be noted, however, that there have been several cases of utilities and generation owners who express interest in, study, and even make plans for unit conversions, but don't follow through with those plans. With each passing year, the costs of renewable energy and bulk energy storage get lower, and coal-to-gas conversions look less and less economical.

[16] Based on Pembina calculations as detailed in the Appendix, assuming a capacity factor of 30% for converted units. It includes the impact of units being mothballed 1-2 years before conversion to gas, as well as conversions prior to end of life. Most units are assumed to operate for 5 years after conversion; Keephills 3 and Genesee 3 are assumed to operate for 10 years after conversion.

[17] The timeline of the modelled early conversions follows the announcements from TransAlta and ATCO. Health benefits were calculated over the same period as the RIAS (2017–2055). The range exists because the RIAS does not the model reduction in coal emissions alone, but the reduction in emissions from phasing coal out *and* building natural gas. Pembina estimated the reduction in emissions from coal alone using two different methodologies that are reflected in the range.

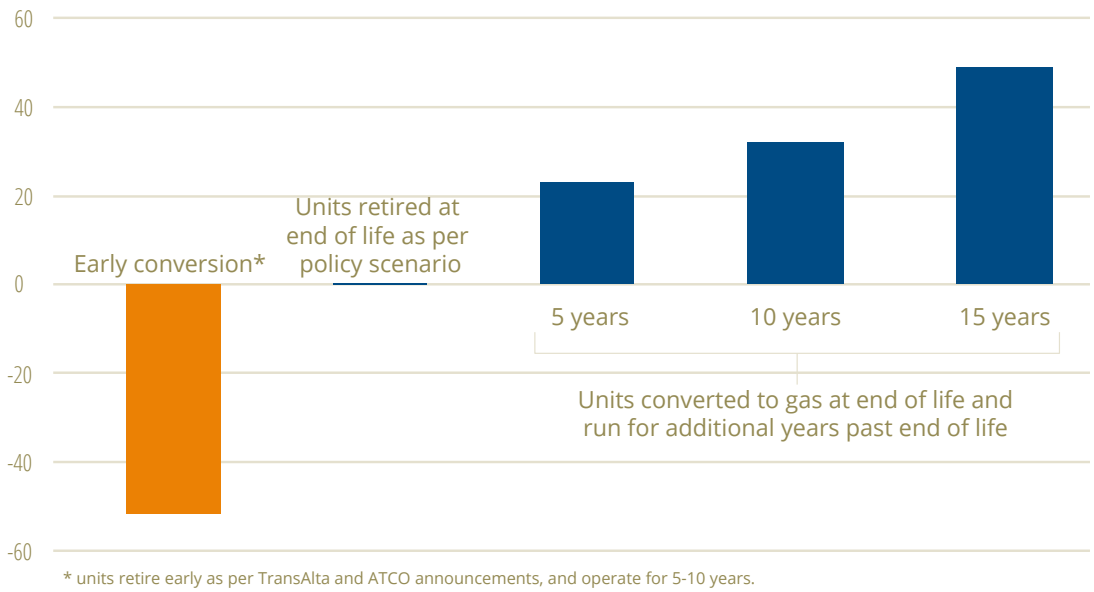

Figure 4. Emissions impacts of converting coal units to gas

Data source: Pembina calculations as detailed in the Appendix

- The performance-based life extensions allowed for coal-to-gas conversions can ensure that more emissions-intensive plants operate for fewer years.
- The baseload performance test determines the life extension period for the converted coal units. Since the test will be conducted at baseload and very likely under favourable operating and ambient conditions, the units' annual emissions are expected to exceed the performance test. It is difficult to determine what is an acceptable exceedance level given that no data exists in Canada for such conversions. So it is critical that the performance test data as well as the unit annual emissions data are available publicly, to determine the effectiveness of the regulation in managing GHG emissions.
- Most projections indicate that storage and renewables will outcompete natural gas generation before 2030. So the timeline for the extension (5 to 10 years) for coal-to-gas conversions is towards the high end of the range of timelines for significant development of emissions-free facilities such as storage. However, we understand that these timelines might be necessary to allow for some capital investment in the conversions. But, any further extensions of the timeline could prevent cost-effective non-emitting technologies from entering into the market once they are cost-competitive.

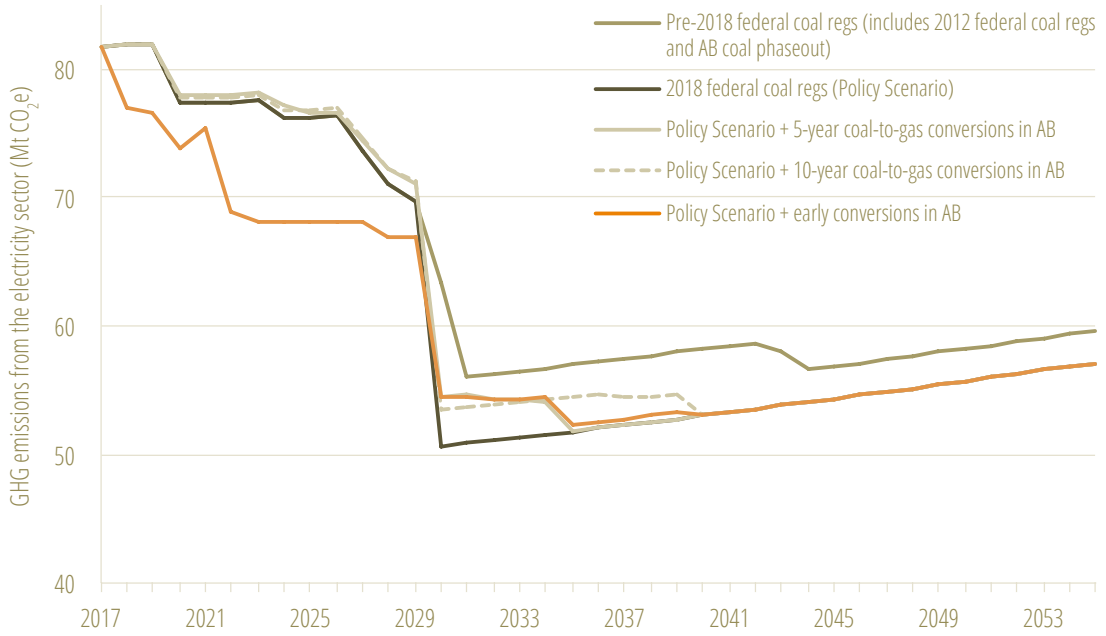

Figure 5. Projected annual greenhouse gas emissions from the Canadian electricity sector under different scenarios

Data source: Pembina calculations as detailed in the Appendix

Exemptions

There are several units for which these regulations will not apply, making up a significant portion of gas-fired electricity. These exemptions should be reviewed in the future and adjusted if needed to continue to drive down emissions, particularly as more non-emitting sources (including storage) come online. However, for the first iteration of regulating gas emissions, these exemptions are reasonable.

- Existing gas units (approximately 13.5 GW of capacity) are not covered by these regulations. This is a fair approach for, as these units could not anticipate such standards could be applied to them retroactively.
- Units smaller than 25 MW are exempted under the current draft regulations. This exemption intends to protect smaller electricity generators that have higher emissions intensities.
- Behind-the-fence generation (approximately 10% of gas-fired generation) is also exempted. We acknowledge that recording data for emissions resulting from electricity that is not sold to the grid could be challenging.
- Combustion engines with a capacity factor less than 33% are exempted in order to provide reprieve to peaking plants, which can play an important role on the grid but have higher emissions intensities.
- Cogeneration units with a heat-to-electricity ratio of 0.9 or more are also exempted. The primary purpose of such units is steam generation.

Reliability and exemption for emergency circumstances

- Maintaining the reliability of the electric power system is of paramount importance. Temporary excursions from emissions limitations for a pollutant such as CO_2, which has no short-term or acute public health impacts, can and should be tolerated. The accumulation of CO_2 in the atmosphere over long periods of time is more critical for climate change and is the appropriate focus for emissions standards.
- The implication then is that while units can be allowed to temporarily exceed emissions performance standards under emergency circumstances, they should later offset or compensate for those excess emissions. In other words, if a unit must run under emergency circumstances in such a way that its emissions are 100 tonnes greater than compliance with the performance standard would dictate, the owner of that unit should be required to take actions within a defined time period (e.g., 12 months) to reduce CO_2 emissions by 100 tonnes in a verifiable and enforceable way. This could be done through a purchase of offsets or allowances from a carbon trading program, for example.
- It is also critical that there be a transparent process by which generators apply for and are granted temporary exemptions.

Recommendations

- **Predictable ratcheting down of standard:** The standard should be ratcheted down periodically to reflect the actual performance of recently commissioned gas units. For example, the standard for new gas units installed in future years could be automatically adjusted (without amending the regulations) based on the top quartile of emissions performance for new units installed in a defined preceding period.
- **GHG compensation for emergency exemptions:** There should be a mechanism (offset etc.) for when units need to use the emergency clause to ensure that GHG reductions are not compromised. The process for applying for and granting temporary exemptions in such cases should be transparent.
- **Other exemptions:** The different categories of exemptions to the regulations should be in three years time (2021) and to determine whether they need to be adjusted in response to climate targets and evolution of technology and the electricity market.
- **Data:** Performance test results for coal-to-gas conversions, and annual emissions and generation data for all units, should be made available to the public at the unit level to ensure transparency and allow for public scrutiny.
- **Stringency of coal-to-gas life extensions:** The stringency of the term for life extensions of converted units is critical to ensuring that emissions-intensive generation is phased out and replaced by non-emitting resources.

Appendix A: Modelling impacts of the regulation

The Pembina Institute modeled the emissions from coal plants and the replacement generation over the period of analysis in the RIAS, 2017 to 2055. Although the initial intent was to try to replicate RIAS's modelling, Pembina's model also includes the health and climate impacts of different scenarios for how plants might be retired and converted to gas.

Model Results

Table 1: GHG emissions in the business-as-usual scenario

	GHG emissions in 2030 (Mt CO_2e)	**Cumulative GHG emissions between 2017 and 2055 (Mt CO_2e)**
Business As Usual (includes 2012 Federal coal regulations and Alberta's coal phase out by the end of 2030)	63	2,506

Table 2: GHG benefits of different scenarios (with business-as-usual scenario as a baseline)

	In 2030 (Mt CO_2e)	**Over the 2017 – 2055 period (Mt CO_2e)**
Policy scenario	- 13	- 109
Coal phase out with coal-to-gas conversions (5 years life)	- 9	- 86
Coal phase out with coal-to-gas conversions (10 years life)	- 10	- 77
Coal phase out with coal-to-gas conversions (15 years life)	- 10	- 60
Early coal-to-gas conversions in AB	- 9	- 161

Table 4: Avoided premature deaths additional to the BAU scenario

	2017 – 2055
2018 Amended federal coal regulations	264
2018 Amended federal coal regulations with phase-out by December 2030	[193 – 209]
Early coal-to-gas conversions in AB	[804 – 993]

Scenarios

Business As Usual / Baseline scenario: It includes retirement of coal plants as per the 2012 federal regulation, "Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations," and the phase-out of coal in Alberta by 2030 as per Alberta's Climate Leadership Plan[18] (that is, Alberta coal plants are retired in December 2030).

National coal phase-out / Policy / 2018 federal regulations scenario: This models the scenario in the Regulatory Impact Assessment Statement (RIAS). It includes the baseline scenario together with 2018 amendment to the federal coal regulations. Its schedule follows the same schedule as the baseline scenario, except that all plants with an end of life after December 2029 are retired in December 2029.

Coal-to-gas conversion scenarios: These build on the policy scenario, and include the conversion of coal units in Alberta to gas-fired units. The variations of the scenario modeled are:

- Coal phase out with coal-to-gas conversions (5/10/15 years) – These scenarios include the conversion of coal plants to gas at their scheduled end of life, with the units assumed to operate for 5/10/15 years beyond their end of life.
- Early coal-to-gas conversions in Alberta – This scenario models the TransAlta and ATCO announcements for mothballing and conversion of units.

[18] Government of Alberta, "Phasing out coal pollution." https://www.alberta.ca/climate-coal-electricity.aspx

Methodology and assumptions

Emissions intensity and capacity factor for coal-to-gas conversions

These depended on the scenario considered:

- Coal-to-gas conversions with five-year extension: 700 t CO_2e / GWh annual intensity for five years at a 30% capacity factor
- Coal-to-gas conversions with ten-year extension: 610 t CO_2e / GWh intensity for ten years at a 30% capacity factor
- Coal-to-gas conversions with fifteen-year extension: 610 t CO_2e / GWh intensity for fifteen years at a 30% capacity factor
- Early coal-to-gas conversions in Alberta: All units are assumed to operate at 30% capacity factor and follow the schedule below as per the conversion announcements by TransAlta and ATCO.

Table 3: Schedule and assumptions for early conversions of coal units to gas

Unit	End of Life	Year mothballed	Year converted to gas	Years of operation of converted unit	Average emissions intensity (t CO_2e/GWh)
Milner 1	2019		2020	7	700
Battle River 3	2019		2019	5	700
Battle River 4	2019		2020	10	700
Sundance 1	2019	2018 (retired)	N/A	0	700
Sundance 2	2019	2018 + 2019	2023	5	700
Sundance 3	2023	2018 + 2019	2022	9	700
Sundance 4	2026	2019	2022	10	700
Sundance 5	2026	2018	2022	11	700
Sundance 6	2027		2022	13	700
Battle River 5	2028		2020	15	700
Keephills 1	2029		2022	13	700
Keephills 2	2029		2022	13	700
Sheerness 1	2029		2020	15	700
Sheerness 2	2029		2020	15	700
Genesee 2	2029		2029	5	700
Genesee 1	2029		2029	5	700
Genesee 3	2029		2029	10	610
Keephills 3	2029		2029	10	610

Replacement of retired coal capacity

The assumptions around replacement capacity are the same as the ones used in the RIAS. In the Pembina model coal-fired electricity is replaced with 12 % of zero-emission renewable electricity. The remaining 88 % of retiring coal-fired generation is replaced with natural gas-fired electricity (at a 460 t CO_2e / GWh emissions intensity, national average in 2015[19]). This ratio is based on the following details from the RIAS:

- New Brunswick replaces its coal capacity with hydro imports.
- Nova Scotia replaces half of its coal capacity with hydro imports, the rest with natural gas-fired electricity.
- Alberta and Saskatchewan replace 100 % of their coal-fired electricity with natural gas-fired generation. This assumption is not representative of our current reality in which provinces have renewables targets.

The model takes into account a 0.9 % increase per year in electricity demand as predicted in National Energy Board's Canada's Energy Future.[20] The additional demand is assumed to be met by the same generation mix of 12 % renewables and 88 % gas.

We have not made the distinction between electricity coming from new and efficient gas-fired power stations and increased generation coming from existing plants when coal-fired power stations retire. This makes our analysis conservative as new gas-fired generation will likely emit less than the current national average intensity of 460 t CO_2e / GWh.

Excluded units

The Boundary Dam unit 3 (SK) plant is not included in the calculations because it is equipped with carbon capture technologies. The Coleson Cove (NB) plant is not included in the calculations because it burns a mix of heavy oil and petcoke, not coal. The Brandon Power plant (MB) is not included in the calculations because it is considered as a backup plant.

Health impact estimates

The emissions and health impacts of electricity generated from supercritical coal units were assumed to be the same as from subcritical units. This assumption is expected to have little impact on the analysis given the small number of supercritical coal-fired power stations in Canada (e.g. in Alberta they account for 15% of provincial coal capacity).

[19] Environment and Climate Change Canada, *National Inventory Report 1990 – 2015 Greenhouse Gas Sources and Sinks in Canada*, 2017.

[20] National Energy Board, *Canada Energy Futures 2017*, 2017.

To estimate the number of saved lives due to the retirement of coal power plants, results from the RIAS were extrapolated. The relationship between electricity generation from coal and the number of related premature mortalities was assumed to be linear. Instead of taking a national average, our model differentiates the magnitude of the health impacts from coal for each province.

Data sources

The model uses data from the following sources:

- Environment Canada, Regulatory Impact Analysis Statement (RIAS), Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations (2012). Available in Canada Gazette Part II, Vol. 146, No. 19. http://publications.gc.ca/collections/collection_2012/gazette/SP2-2-146-19.pdf
- Environment Canada, Regulatory Impact Analysis Statement (RIAS), Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations (2018). Available in Canada Gazette Part I, Vol. 152 (2018). http://gazette.gc.ca/rp-pr/p1/2018/2018-02-17/html/reg3-eng.html
- TransAlta, TransAlta announces Accelerated Transition to Clean Energy, media release, December 6, 2017. https://www.transalta.com/newsroom/news-releases/transalta-announces-accelerated-transition-clean-energy/
- Geoffrey Morgan, "Alberta could be coal-free years ahead of deadline as ATCO plans transition to natural gas by 2020," Financial Post, May 10, 201.7 http://business.financialpost.com/g00/commodities/energy/alberta-could-be-coal-free-years-ahead-of-deadline-as-atco-plans-transition-to-natural-gas-by-2020?i10c.encReferrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNhLw%3D%3D&i10c.ua=1
- Government of Alberta, "Phasing out coal pollution." https://www.alberta.ca/climate-coal-electricity.aspx
- Nova Scotia Power, "Total System Emissions (All Plants)." https://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx
- Pembina Institute, Out with the coal, in with the new: National benefits of an accelerated phase-out of coal-fired power (2016). http://www.pembina.org/reports/out-with-the-coal-in-with-the-new.pdf