Canada's Carbon Roadmap to 2030:
Accelerating Canadian Decarbonization Beyond the 2030 Paris Target

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Executive Summary

This policy package delivers a solution that limits Canada's CO2 emissions to 515 MT by 2030. This is 44 MT lower than the PCF base case, and 2 MT lower than Canada's committed Paris Climate Accord target. The approach to achieving this result was using the web interface EPS, and targeting areas with the greatest emission reduction potential. It was observed that increasing the carbon tax from $50 in 2022 to $75 by 2030 would achieve the desired result, but was too political fraught. Thus, alternative policy levers within each sector were optimized to achieve the same emissions reduction without changing the tax level. These main policy changes are highlighted in terms of their output, feasibility, cost effectiveness, and impact on emissions. The proposed policy package achieves a cost-effectiveness of $21.94/tonne of emissions abated, as opposed to the PCF benchmark of $23.88/tonne. In addition, the social and political aspects of this package were informed so as to provide a strategic basis that could advance Canada as an international leader in climate change policy.

Current State

According to the Pembina Institute's State of the Framework report, Canada is not on track to meet its Paris Climate Accord target of 517 MT of emissions by 2030.[1] National emissions increased by 5% from 2009 to 2015, and achieving the target will require policy action that go beyond the Pan-Canadian Framework on Clean Growth and Climate Change.

Simulation Methodology

Using the web-based interface, the optimal policy package was determined by achieving, at maximum, 517 MT of emissions in 2030 while considering political, social, and economic feasibility. The PCF is used as the base case, as it presents changes already on schedule for implementation. Analyzing the PCF-extended scenario, it was noted that the carbon tax has the most significant impact of any individual policy, as shown in Figure 1.

From this base case, using the PCF and increasing the carbon tax policy from $50 to $75 at the same implementation schedule would achieve emissions of 515 MT in 2030. However, Alberta's current carbon tax at ~$22/tonne falls at the global carbon tax average2, and is already scheduled to increase to $50/tonne by 2022. Increasing the tax even further was deemed too politically fraught to guarantee the desired emissions reductions. Instead, this package evaluates the largest drivers for emission reductions in the four carbon tax sectors - transportation, electricity, buildings, and industry. The objective was to achieve the same impact as a $25 increase in the carbon tax between 2022 and 2030, but through alternative policy measures. Using this approach, a policy package was designed to reduce emissions to 515 MT by 2030 using the case without land use (to align with the measurement of the emissions target). This output improves the PCF base case by 44 MT as shown in Figure 2, and furthermore exceeds even the 517 MT Paris Accord target by 2 MT. Key additions to the PCF in this package are shown in the Table 1 overleaf. Additional changes were made (such as decreased R&D costs in renewable energy, etc.) to adjust for anticipated market realities.

[1] Flanagan, Erin et al., "State of the Framework Tracking Implementation of the Pan-Canadian Framework on Clean Growth and Climate Change."
[2] The World Bank, "Carbon Pricing Dashboard | Up-to-Date Overview of Carbon Pricing Initiatives."

Table 1: Highlights of Proposed Policy, in Addition to Current PCF Package

Highlight #	Sector	Policy	Change from PCF (2030 unless noted)	Impact (MT reduced)	Cost ($/tonne)
1	Industry	Cogen + Waste heat recovery	0% to 50%	7	-161.17
2	Electricity	Renewable Portfolio Standard	0% to 20% by 2050	2	Negligible
3	Electricity	Ban new NG nonpeaker power plants	"On" by 2050	24	-54.10
4	Transportation	Feebate	0% to 76%	6	-149.05
5	Transportation	Low carbon fuel standard	13% to 26%	10	-2.76
6	Cross Sector	Carbon Capture & Sequestration	0% to 20% by 2050	2	37.39

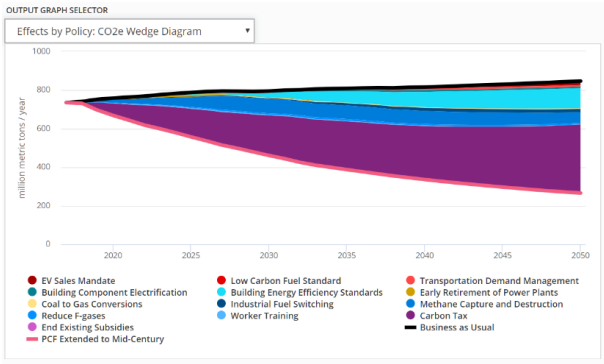

Figure 1: Extending the PCF through to 2050 shows that a slowly ramped up a cross-sector carbon tax overwhelming drives emissions reductions. However, increasing carbon

Figure 2: The proposed policy package reduces emissions to 515 MT by 2030, outperforming the PCF by 44 MT and beating the Paris target by 2MT

Highlights of the Proposed Policy Package

Highlight #1: Industrial Cogeneration and Waste Heat Recovery

This policy reduces fuel consumption in the industrial sector by leveraging combined heat and power production, and redirecting waste heat to perform useful work. Implementing this policy would also lower operating costs from electricity purchases. This package targets 50% of total cogeneration and waste heat recovery potential in Canada by 2030, resulting in 7 MT of emission reductions. The 50% target is realistic if heat-intensive industrial sectors are targeted, such as oil and gas production, oil refining and upgrading, and cement production. CHP-enabling initiatives in the US have proven that guaranteed grid interconnections are useful in bringing new CHP capacity online.[3] Furthermore, a positive technology outlook on distributed energy resources (DERs) means renewable energy resources, distributed CHP, and district heating have potential synergies.[4] This is especially useful for cases such as upgrading small-scale active and orphaned oil wells in Alberta, several of which can be retrofitted for geothermal heat and electricity cogeneration.[5]

Highlight #2: Enhanced Renewable Portfolio Standard

A Renewable Portfolio Standard (RPS) legislates electricity production from the sources of solar, wind, and biomass. Under the BAU case, the nationwide RPS is expected to fulfill 14% of Canada's electricity load from renewable sources. The proposed policy package increases this to 20% by 2050, specifically targeting the high-emitting electricity grids of Alberta, Saskatchewan, Nova Scotia and New Brunswick.[6] To attract cost-competitive

[3] Joskow and Jones, "The Simple Economics of Industrial Cogeneration."
[4] Simchak and Davis, "Combined Heat and Power for Industrial Revitalization."
[5] Bentein, "Hinton Exploring the Viability of Capturing Geothermal Heat from Re-Purposed Oil and Gas Wells."
[6] Energy and Mines Ministers' Conference, *Canada - a Global Leader in Renewable Energy*.

renewable energy investments, an Indexed Renewable Energy Credit (IREC) auction mechanism can be used, similar to the process used in Alberta's Renewable Electricity Program. The auction design can be further modified to optimize renewable energy procurement by time-of-day and location,[7] and to overcome barriers to entry experienced by community-scale or distribution-connected generators.[8] To complement this policy, grid scale energy storage at 5% annual growth to 2050 can mitigate market volatility that renewables may cause. Finally, Indigenous equity stakes can be legislated to meet national goals for reconciliation with Canada's Indigenous peoples, in partnership with renewable energy developers.[9] An important synergy for new renewable energy development is the 20% decline in wind and solar capital costs, based on reductions in their LCOE.[10]

Highlight #3: Banning New Natural Gas Non-Peaker Power Plants After 2050

The proposed package bans the construction of new natural gas non-peaker power plants by 2050. This policy could cut 24 MT of emissions, with this impact likely due to the effectiveness of long-term policies in asset planning. In tandem with the accelerated coal phase-out in Canada and Alberta, this policy would establish a limitation on emissions from emerging natural gas power plants. A potential risk is a supply gap from the 10% of electricity in Canada currently generated from natural gas; this can be filled by cheaper renewable energy as projected to 2030, and the CHP target discussed.[10] Furthermore, the economic and political risk of stranded natural gas extraction assets can be addressed by diversifying natural gas utilization in low-emission strategic areas such as local plastics, ammonia, and airplane fuel production.[11,12]

Highlight #4: Transportation Feebate on Light-duty Vehicles (LDVs)

The feebate system creates a revenue-neutral solution to reduce inefficient LDVs on the road, with a pivot point of 10L/100km. Canada currently operates a non-continuous feebate at the time of purchase, but this policy does not apply to the majority of the fleet.[13] If Canada increases its feebate to 76% of the global best practice rate, emissions by 2030 would be reduced by 6 MT. This means for every vehicle sold that exceeds the allowable fuel efficiency, $1026 would be charged for every 2L over the pivot point. This presents a slight increase, but is relatively in line with Canada's 2018 Fuel-Inefficient Vehicle Tax Rates, which charge $1000 for every litre above 12L/100km.[14] This lever creates sufficient incentive for new purchasers to invest in fuel efficient vehicles, as the ongoing total cost of fuel would also be lowered (effectively replacing the need for fuel economy standards). However, an interdependent policy that impacts this analysis is the rise of electric vehicles (EVs), which do not require fuel input. With the EV market share increasing from 0.55M to 1.56M vehicles between 2030 to 2050, and with gasoline vehicles declining over the same time period from 1.26M to 0.44M, the revenue-neutral nature of this policy is not indefinitely self-sustaining.

Highlight #5: Low Carbon Fuel Standard

Under the PCF, the Low Carbon Fuel standard is set at a 13% reduction of carbon emissions by 2030, which equates to a renewable requirement of 2% of the fuel blend. This package increases the standard to 26%, which aligns with the upcoming Canada Clean Fuel Standard. While specific targets have not yet been released, a

[7] Canadian Solar Industries Association, "Solar Electricity, the 'Indexed-REC' & Cost to the Carbon Levy."
[8] Lafond et al., "Barriers to Community Owned Renewable Energy."
[9] CBC News, "Indigenous Investors Required in next Alberta Renewable Power Auction."
[10] Ray, "Lazard's Levelized Cost of Energy Analysis—Version 12.0."
[11] Sherman, "Natural Gas Boom."
[12] CBC News, "How $2.1B for Alberta Petrochemicals Will Keep More Plastics Production Local."
[13] German and Meszler, "Best Practices for Feebate Program Design and Implementation."
[14] Canada Revenue Agency, "Excise Tax on Fuel-Inefficient Vehicles."

report from Navius Research indicates that fuel consumption blends will reach a requirement of 5% by 2030.[15] This benchmark exceeds our assumption, which would increase the total blend requirement to ~4%. A reduction of 26% results in a 10MT decrease in emissions by 2030, and aligns with the goal of the Clean Fuel Standard to decrease total emissions by 30MT in 2050.[16]

Highlight #6: Research and Development in Carbon Capture and Sequestration

This package enables 20% of Canada's carbon capture and sequestration (CCS) potential to be achieved by 2030. While CCS is unable to become economically viable to be scaled up at low carbon tax or cap-and-trade scenarios such as in our $50/tonne 2030 case, enabling 20% of CCS potential through pilot projects will de-risk the economics of new technology breakthroughs and lower the operating costs of CCS technology to the extent that it can be financially viable even under lower carbon pricing scenarios by the industrial sector. In the long-term, this policy will make Canada a global leader on CCS research and development, allowing for its energy and industrial sector to globally scale locally developed solutions.

Cost Considerations

This package presents an overall net benefit to Canadians. Although cost savings from the change in revenue-neutral total outlays is slightly higher leading up to 2030, peaking at $24.4B in 2029 while the PCF costs $21.2B, this package delivers better value for money in the magnitude of emission reductions. Looking out to 2050, this package creates $34.9B greater cost savings than the PCF. When evaluating the cash flow changes to each actor, it initially appears that the government gains $25.3B by 2030, while consumers are charged $15.6B. However, these increased government revenues could be used to offset consumer costs through rebates and incentivization of the green premium. The social cost savings are over 8000 lives by 2030, and climate benefits of $30 billion compared with the change in total outlays of $24 billion. The additional recommended policies carry relatively low abatement costs in the NPV to 2030 revenue-neutral scenario, as evidenced in Table 1. In fact, on a per-tonne abated emissions basis, introducing new policies brings down the cost of decarbonization: the cost per tonne of emissions abated in PCF was $23.88/tonne, whereas the cost per tonne of emissions abated in the proposed policy package is $21.94/tonne. A breakdown of the cost of each policy proposed, alongside pre-existing PCF policies, is shown in Figure 3. The net total abatement cost scaled with MT reductions is -$2.191B, indicating a gain to the economy from the implementation of this package, which is politically salient.

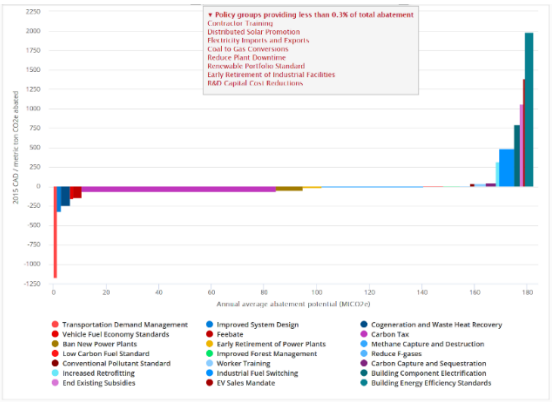

Figure 3: CO2e abatement cost curve of the proposed policy. Note that, as shown in Table 1, all the highlighted policies added on top of the preexisting PCF policies are considerably cost-effective.

Model Limitations

While this package explores key levers of climate policy, a number of improvements could be considered. For example, policy package selection could be expressed as a constrained black-box optimization problem that minimizes the cost of a policy package (or other objective function based on feasibility) while ensuring that emission targets are met. SAKS-TRO[17] is a promising algorithm designed for use with models like the EPS, and

[15] Wolinetz et al., "Analysis of the Proposed Canadian Clean Fuel Standard."
[16] Environment and Climate Change Canada, "Clean Fuel Standard: Discussion Paper."
[17] Cheng, Gjernes, and Gary Wang, "An Adaptive Aggregation-Based Approach for Expensively Constrained Black-Box Optimization Problems."

could be used to perform the optimization. Additionally, a number of policy levers not reflected in the model could change the 2030 and 2050 emission outputs. Such ideas include the impact of increased urbanization and smart cities changing electricity usage, consumer spending habits influencing industry product demand, allocated government spending of climate change revenues, and international partnerships enabling lower cost solutions.

Potential Barriers to Implementation

Jurisdictional conflicts between provincial and federal governments: medium likelihood, high impact

Under s. 92 of the Constitution, environmental concerns are a shared jurisdiction between both levels of government.[18] Recent challenges such as Saskatchewan's court case on the constitutionality of carbon pricing[19] could impact other policies in this package, such as the RPS upgrade and post-2050 new natural gas power plant ban. Ambiguity of government jurisdiction is best resolved through the Canadian Environment Protection Act. Additionally, the Pan-Canadian Framework stipulates five conditions which give provinces flexibility to enact policies through their own action plans, while remaining federally accountable.[20]

Adapting the electricity grid to support renewable policy changes: medium likelihood, high impact

The shift from non-renewable to renewables, coupled with consumer trends such as the rise of electric vehicles, will require different needs for electricity generation and transmission. Today's grids were designed for centralized plants, but the shift toward renewables requires a design that can integrate microgeneration and reduce long term reliance on natural gas[21], as this package proposed through the renewed Renewable Portfolio Standards. Additionally, grid level storage may be adopted on a case-by-case basis to mitigate the variability in renewables supply and price. For example, wind energy is often generated in non-peak load times, and when it is, aggregate supply increases can make the average pool price unfavorable to the market. While a long term solution could be incorporating batteries with the grid, until this technology is more cost effective[22] and monetizable in electricity markets, an alternative mitigation is allowing commercial purchasing power agreements to create certainty through contracts with fixed production volume and prices. Furthermore, the proposed cogeneration and waste heat recovery policy, if properly implemented, can help reduce the strain of grid flexibility requirements by sufficing large industrial loads using behind-the-meter generation. If geothermal co-production is achieved as per this policy, this would provide a firm baseload of renewable energy in provinces such as Alberta and Saskatchewan which would otherwise be susceptible to volatile wind regimes.

Conclusion

This report has explored key highlights that improve the PCF base case to fulfill Canada's 2030 Paris Climate Accord targets. The analysis produces 515 MT of emissions by 2030, which improves both the PCF and target. By simulating an increased carbon price through alternative policies, this package has identified key policy levers that can lead to a substantial magnitude of emissions reduction. The proposed policies have also been explained in terms of social, economic, and political feasibility. The adoption of this package, or a combination of policies within it, would set Canada on track to meet its 2030 Paris Climate Accord goals, and be a strategic global leader in climate change policy looking out to 2050.

[18] Legislative Services Branch, "Consolidated Federal Laws of Canada, Access to Information Act."
[19] Taylor, "Canada Watches as Ottawa's Carbon Tax Goes on Trial. See It Live Here | Financial Post."
[20] Good, "Carbon Pricing Policy in Canada."
[21] Union of Concerned Scientists, "It's Time to Upgrade the Electricity Grid."
[22] Crabtree et al., "Integrating Renewable Electricity on the Grid."

Bibliography

Bentein, Jim. “Hinton Exploring the Viability of Capturing Geothermal Heat from Re-Purposed Oil and Gas Wells.” JWN Energy, February 6, 2018. http://www.jwnenergy.com/article/2018/2/hinton-exploring-viability-capturing-geothermal-heat-re-purposed-oil-and-gas-wells/.

Canada Revenue Agency. “Excise Tax on Fuel-Inefficient Vehicles,” October 26, 2017. https://www.canada.ca/en/revenue-agency/services/forms-publications/publications/etsl64/2018-list-vehicles-associated-tax-rates.html.

Canadian Solar Industries Association. “Assessing Alberta’s Renewable Electricity Program (REP): Solar Electricity, the ‘Indexed-REC’ & Cost to the Carbon Levy,” November 16, 2017. https://www.cansia.ca/uploads/7/2/5/1/72513707/20171116_cansia_represearch_submitted__002_.pdf.

CBC News. “How $2.1B for Alberta Petrochemicals Will Keep More Plastics Production Local.” *CBC*, November 23, 2018. https://www.cbc.ca/news/canada/calgary/plastics-producers-alberta-investment-1.4916916.

———. “Indigenous Investors Required in next Alberta Renewable Power Auction.” *CBC*, February 5, 2018. https://www.cbc.ca/news/canada/calgary/indigenous-investors-alternative-energy-alberta-1.4520823.

Cheng, George H., Timothy Gjernes, and G. Gary Wang. “An Adaptive Aggregation-Based Approach for Expensively Constrained Black-Box Optimization Problems.” *Journal of Mechanical Design* 140, no. 9 (June 26, 2018): 091402. https://doi.org/10.1115/1.4040485.

Crabtree, George, Jim Misewich, Ron Ambrosio, Kathryn Clay, Paul DeMartini, Revis James, Mark Lauby, et al. “Integrating Renewable Electricity on the Grid,” 387–405. Berkeley, California (USA), 2011. https://doi.org/10.1063/1.3653865.

Energy and Mines Ministers’ Conference. *Canada - a Global Leader in Renewable Energy: Enhancing Collaboration on Renewable Energy Technologies.*, 2013. https://central.bac-lac.gc.ca/.item?id=M34-15-2013-eng&op=pdf&app=Library.

Environment and Climate Change Canada. “Clean Fuel Standard: Discussion Paper,” November 17, 2016. http://ec.gc.ca/lcpe-cepa/default.asp?lang=En&xml=D7C913BB-13D0-42AF-9BC7-FBC1580C2F4B.

Flanagan, Erin, Plumptre, Bora, Kenyon, Duncan, and Wu, Karen Tam. “State of the Framework Tracking Implementation of the Pan-Canadian Framework on Clean Growth and Climate Change.” The Pembina Institute, 2017. https://doi.org/10.1163/9789004322714_cclc_2017-0028-024.

German, John, and Dan Meszler. “Best Practices for Feebate Program Design and Implementation,” April 10, 2010. https://www.theicct.org/sites/default/files/publications/ICCT_feebates_may2010.pdf.

Good, Jesse. “Carbon Pricing Policy in Canada.” 3, February 6, 2018. https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/201807E#a17.

Joskow, Paul L., and Donald R. Jones. “The Simple Economics of Industrial Cogeneration.” *The Energy Journal* 4, no. 1 (1983): 1–22.

Lafond, Laurence, Dan Mazier, Carl Cunningham, and Ed Hale. “Barriers to Community Owned Renewable Energy,” April 25, 2013, 39.

Legislative Services Branch. “Consolidated Federal Laws of Canada, Access to Information Act,” July 30, 2015. https://laws-lois.justice.gc.ca/eng/const/page-4.html.

Ray, Douglas. “Lazard’s Levelized Cost of Energy Analysis—Version 12.0,” November 2018, 20.

Sherman, Lilli Manolis. “Natural Gas Boom: What Will It Mean for Plastics Processors?,” October 24, 2013. https://www.ptonline.com/articles/the-boom-in-natural-gas-what-will-it-mean-for-plastics-processors.

Simchak, Thomas, and Stacey Davis. “Combined Heat and Power for Industrial Revitalization,” July 2013, 38.

Taylor, Stephanie. “Canada Watches as Ottawa’s Carbon Tax Goes on Trial. See It Live Here | Financial Post.” *The Financial Post*, February 13, 2019. https://business.financialpost.com/commodities/energy/lawyers-to-argue-merits-of-carbon-tax-as-saskatchewan-challenge-heads-to-court.

The World Bank. “Carbon Pricing Dashboard | Up-to-Date Overview of Carbon Pricing Initiatives.” The World Bank Map Data, November 1, 2018. https://carbonpricingdashboard.worldbank.org/map_data.

Union of Concerned Scientists. “It’s Time to Upgrade the Electricity Grid.” Union of Concerned Scientists, February 16, 2017. https://www.ucsusa.org/clean-energy/increase-renewable-energy/upgrade-the-electricity-grid.

Wolinetz, Michael, Dave Sawyer, Jotham Peters, and Seton Stiebert. “Analysis of the Proposed Canadian Clean Fuel Standard,” November 7, 2017, 106.