Bringing climate policy up to date – decreasing cost projections for renewable energy and batteries and their implications - Case study Canada

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Authors:
Hanna Fekete, Leonardo Nascimento, Katharina Lütkehermöller

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Authors
Hanna Fekete, Leonardo Nascimento, Katharina Lütkehermöller

Contributing authors
Niklas Höhne, Jakob Wachsmuth

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Table of Contents

List of Figures

List of Tables

Abbreviations

CO_2	Carbon dioxide
EVs	Electric vehicles
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
NDC	Nationally Determined Contributions
PCF	Pan-Canadian Framework
RE	Renewable energy
LULUCF	Land use, land use change and Forestry

1 Introduction

Under the Paris Agreement, countries defined their mitigation commitments as part of their nationally determined contributions (NDC) in the run-up to the Paris Climate Summit 2015, COP21. A few countries have revised their NDCs since the adoption of the Paris Agreement (e.g. Argentina), or communicated a different approach (e.g. USA will leave the Paris Agreement and no longer pursue its NDC). On aggregate, NDCs are not yet sufficient to limit temperature increase to the limits agreed in the Paris Agreement, and would lead to warming of about 3°C (Climate Action Tracker, 2018).

The Paris Agreement foresees regular revisions of NDCs following the Global Stocktake, with the objective to increase ambition over time. These revisions should be informed by up to date information on the country circumstances (Northrop *et al.*, 2018). Costs of zero or low-carbon technologies are one factor that countries could consider when thinking about revised ambition levels.

The costs for renewable electricity generation and electric vehicles have dropped since the NDCs were developed, and future cost projections also decreased as a result. Wachsmuth and Anatolitis (2018) suggest a simple method to estimate increased RE capacities and EV penetration resulting from these cost decreases. The method assumes that lower battery costs lead to a higher market uptake of EVs and that the savings from decreased RE capacity cost are reinvested in the same technology. If technology costs forecasts halved since the preparation of the NDC, for example, the country could now add double the capacity compared to earlier expectations. Wachsmuth et al. provide global data on future technology cost progressions since 2015.

Canada has submitted an NDC with the target of reducing emissions by 30% below 2005 levels by 2030. In 2017, it submitted an updated NDC document explaining how it intends to meet the target (Government of Canada, 2017). While the mitigation target of 30% below 2005 by 2030 remains as in the original INDC (Government of Canada, 2016), the revised document states an absolute emissions level of 523 MtCO_2e/a associated to the % reduction target.

Our analysis applies the method from Wachsmuth and Anatolitis to Canada, using country specific data sources for costs and expectations on technology development. It aims to present the potential impact of taking renewable generation and storage cost reductions into account to raise ambition of NDCs, as one element of various to consider for NDC revisions. It first describes the expectations for renewable energy and EV underlying the NDC and gathers cost estimates from that time and today. Section 3 illustrates potential adjusted target levels from the NDC, looking at increased ambition in renewable energy and EVs exclusively. The last section discusses the results in the context of other policy documents and current developments in the country and draws conclusions on the feasibility of the adjusted numbers.

2 The starting point: Renewables and electric vehicles in Canada's NDC

Canada's NDC states the target of reducing economy-wide greenhouse gas (GHG) emissions by 30% below 2005 levels by 2030, and states that this is equal to 523 MtCO_2e in 2030 (incl. emissions from land use, land-use change and forestry (LULUCF)). The NDC illustrates three main areas of mitigation to achieve the targets:

- Emissions reductions from announced measures as of November 2016.
- Emissions reductions from measures in the Pan-Canadian Framework.
- Emissions reductions from additional measures.

The NDC specifies emissions reductions for the three areas, however no official documents are available that provide scenario analysis around the NDC level. Canada's latest emissions projections from 2016 illustrate only scenarios that miss the target (Environment and Climate Change Canada, 2016). The think-tank Pembina Institute provides independent emissions projections. Their "Pan-Canadian Framework (PCF) Extended to Mid-Century" scenario meets the NDC target (Energy Innovation & Pembina Institute, 2018b). This research uses the PCF scenario to estimate the expected renewable energy additions and uptake of EVs under the NDC (see Table 1).

Table 1 Overview of different indicators in the scenario meeting the NDC targets

Additional measures under scenario	"PCF extended to mid-century" scenario
PV capacity (2017 – 2030)	4,108 MW
Wind onshore capacity (2017 – 2030)	5,165 MW
Wind offshore capacity (2017 – 2030)	160 MW
Electric Vehicles (2017 – 2030)	3.04 million

Source: (Energy Innovation & Pembina Institute, 2018a)

The scenario assumes a strong increase of solar and onshore wind. Also, the uptake of electric vehicles is substantial. Offshore wind energy plays a minor role, so this analysis does not further consider this technology.

Comprehensive cost estimates for renewable energy technologies and batteries are not available in Canada. Official analyses use estimates from the US-based National Renewable Energy Laboratory (NREL) (see (National Energy Board of Canada, 2017), p. 60). As part of the methodology, we compare estimates from NREL's Annual Technology Baseline from 2016 to most recent 2018 estimates (NREL, 2018) (see Table 2).

To account for geographic differences between the US and Canada, for wind we use the category of wind speeds that reflect the Canadian average wind speed. We also convert the investment costs to Canadian dollars, using conversion rates from 2016 and 2018.

Table 2 Comparison of technology cost projections in 2016 and 2018 from NREL, compared to global data from (Wachsmuth and Anatolitis, 2018).

	Solar PV			Wind (onshore)		
	2020	2025	2030	2020	2025	2030
NREL 2016 (CAD/kW)	1,890 to 2,520	1,260 to 2,520	1,000 to 2,520	2,900 to 3,080	1,920 to 2,370	1,870 to 2,370
NREL 2018 (CAD/kW)	1,470 to 1,660	1,000 to 1,520	850 to 1,520	2,000 to 2,170	1,650 to 2,190	1,190 to 2,190
Reduction of cost estimate based on values above	-34% to -22%	-40% to -20%	-40% to -15%	-31% to -30%	-14% to -8%	-37% to -8%
Global reduction of cost estimate	-50% to -25%	-52% to -20%	-52% to -17%	-56% to -30%	-51% to -11%	-51% to -15%

Note: Global reduction of cost estimates are based on the Levelized Costs of Energy, while Canada specific estimates result from investment costs

Battery costs estimates are not available for Canada or in the NREL cost database in the year of 2016, only for 2018. For comparability, we use the global data reported by Wachsmuth and Anatolitis (2018) for this technology (change in of cost estimates of -33% to +40% the last historical year, -32% to +14% for 2025, and -52% to -19% for 2030).[1]

[1] Note that the "worst case" scenario shows an increase of cost estimates for the time periods 2017 – 2020 and 2021 to 2025. This means that under this scenario and these time intervals, less EVs are added than under the scenario meeting the NDC. The increase after 2025 however makes up for this, and in total, the adjusted additions are higher.

3 Results: Impact of revised cost estimates on emissions and fuel spending

Assuming that cost savings are reinvested completely in the same technology and within the same time period (2016 – 2020, 2021 – 2025, and 2026 – 2030) leads to increased additions in renewable capacities and lower battery costs lead to a higher market uptake of EVs, according to the method suggested by Wachsmuth and Anatolitis (2018), which in turn causes changes in GHG emissions and fuel spending.

Figure 1 and Table 3 illustrate the resulting adjusted emission levels, compared to the NDC values. Depending on the assumption of reduction of cost estimates (worst case/best case), the adjusted values are 4 to 9 $MtCO_2e$/a lower in 2030 than the NDC value. Since renewables are assumed to displace natural gas non-peaking plants – an electricity generation option with lower emissions compared to coal, their impact is smaller than if they were used as an alternative to coal-fired electricity generation. The largest potential impact, 6 $MtCO_2e$ reduction, is caused by electric vehicles. They are assumed to reach about 7 million vehicles by 2030 in the best-case scenario, which represents 20% of the total number of vehicles registered in the country in 2017 (Statistics Canada, 2018).

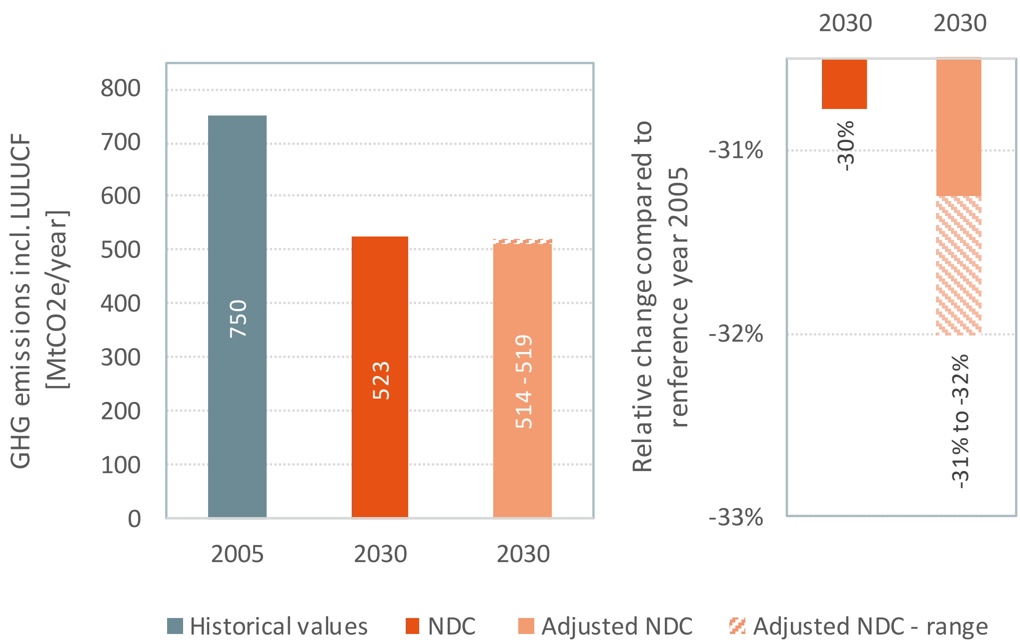

Figure 1 Comparison of adjusted emissions levels to NDC (absolute values and relative change of emissions compared to reference year 2005)

Table 3 shows the adjusted additional capacity additions and EV penetration. Total renewable electric capacity additions over 2017 – 2030 are 5.4 – 7.3 GW higher than under the scenarios that represents the NDC. Electric vehicle uptake is fast under the scenario meeting the current NDC since it expects that about 3.5 million vehicles are on the road by 2030. In the most optimistic case in this study, the adjusted value is almost double this number.

Table 3 Adjusted technology additions resulting from reinvesting cost savings of RE and EV technologies

	Adjusted NDC
Additional PV capacity (cumulative over 2017 – 2030) [MW]	1,046 to 2,589
Additional wind capacity (cumulative over 2017 – 2030) [MW]	4,371 to 4,741
Additional EV (cumulative over 2017 – 2030) [number of vehicles]	289,240 to 2,970,800

This research converts the capacity additions over years to cumulative capacity and electricity generation in 2030, and resulting from that the implied emissions reductions (Figure 1 above) and fuel savings (Table 4 below). For Canada we assume, that all additional renewable electricity generation decreases gas-fired power plants that do not have the main purpose of supplying peak load. The current plans already foresee a phase-out of coal. The additional electricity consumed by EVs is covered via the electricity grid, meaning we use the average grid factor to calculate emissions of the EVs. The main assumptions are available in detail in Annex II.

The savings from decreased fuel spending remain as a net-benefit to the economy. Theoretically, Canada could reinvest those and iterate this step until the additional savings tend towards zero. Such an approach would maximise the technology additions while balancing costs and benefits. Nonetheless, there might be a mismatch of actors within the country. For example, owners of electric vehicles will not invest their fuel savings in more EVs. For power generation, fuel savings are a result of displacing fossil technology. Actors spending less are fossil power producers that will not necessary invest the savings in renewable energy alternatives.

Table 4 Impact of reinvesting cost savings on fuel savings

	Unconditional NDC	
	2025	**2030**
Savings from decreasing gas electricity generation [Million USD/a]	659 to 470	836 to 772
Savings from decreasing oil demand in transport [Million USD/a]	2,270 to 497	2,139 to 138

Note: The increased electricity demand from EVs is deducted from the additional renewable electricity generation and thus reflected in these estimates.

4 Conclusions: NDC revision possible based on reduction of cost estimates

This research suggests that by considering technology cost developments of wind, solar PV and batteries since 2017, Canada could increase the ambition of its NDC target. Assuming that cost savings in those technologies would be reinvested in the same area, the NDC target of 30% below 2005 levels could be reduced by 1 – 2 % points, or by 4 to 9 $MtCO_2e$ in 2030 in absolute terms.

The adjusted renewable energy additions are slightly more ambitious than current trends in the country. Canada's Energy Future 2017 explores different scenarios how the energy sector might develop. In its reference scenario, it includes 10.8 GW additional wind capacity up to 2030, and 2.8 GW additional solar capacity. In comparison to this, our adjusted additions are 10.2 GW of wind by 2030, and 6.7 GW of additional solar PV.

Revising the electric vehicle uptake, the method suggests up to almost 7 million EV in 2030 in the most optimistic case. These values are compatible with the Technology case scenario from the National

Energy Board published in 2017, where the number of EVs in Canada could reach around 6.6 million[2] in 2030 in the most ambitious scenario (National Energy Board of Canada, 2017).

This document provides a first rough estimate of the potential impact of this development. It cannot replace in-depth technical analysis on technical and economic potentials. One specific point of attention should be the following: The renewable additions and electric vehicle update to meet the current NDC mean a deviation from current trends. While the method of this research assumes reinvestments in exactly the same technologies where savings happen, Canada could also consider using the savings in increasing ambition in other mitigation areas, and this way might achieve a more cost-efficient solution.

This research recommends considering the stronger-than-expected decrease in technology costs when adjusting the Canadian NDC. This document provides a first rough estimate of the potential impact of this development. The examples shown here for a few technology areas using a simplified method illustrate that the fast developments can have a significant impact on future ambition. Still, revising the NDC would need to consider several other developments in other sectors, as well as their interlinkages, while evaluating the broader political and economic landscape.

[2] In Canada's Energy Future 2017, EVs are assumed to reach 8 million vehicles in 2040 under the Technology Case scenario. This value is interpolated to be comparable with the results in 2030.

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Annex I: Emissions levels tables

Table 5 Adjusted emission levels resulting from considering decreased costs as presented in Figure 2

	Reference	**NDC**	
	Original Value	**Original value**	**With updated cost estimates**
	2005	**2030**	**2030**
Emission levels (incl. LULUCF, in $MtCO_2e/a$)	750	523	514 - 519
Emission relative to 2005		-30%	-31% to - 32%

Annex II: Methodological assumptions

Table 6 Main methodological assumptions

Technology	**Type**	**Assumption**	**Source**
All	Data sources	Scenario PCF extended to mid-century meets NDC target and is used as departure point	Canada NDC and Pembina Institute Simulator
Solar	Assumption	Assumed all solar electricity generation is Utility PV (neglecting solar thermal installations and rooftop PV)	Expert judgement
Wind	Assumption	Assumed only wind onshore since wind offshore is negligible in the current power mix	Expert judgement
Evs	Assumption	Only included battery EVs, not hybrids	Expert judgement
EVs	Assumption	Assumed battery cost reduction will follow global trends	Expert judgement
Solar and Wind	Assumption	Cost projections from the US apply to Canada provided currency fluctuations and different weather conditions are considered.	Canada's Energy Future 2017 and NREL
Wind and Solar	Calculation	Power capacity and generation for renewables used to calculate capacity factor. Capacity factor used to translate capacity into power generation.	IRENA
Wind and Solar	Calculation	Emissions intensity of fossil fuels in 2015 used to calculate emissions reduction.	IEA Energy Balances
Wind and Solar	Assumption	Coal phase out planned to be finished before 2030, so assumed that additional RE will support replace natural gas non-peaking plants	Pembina scenarios
EVs	Assumption	Assumption that EVs will decrease gasoline emissions, but increase electricity emissions (average grid intensity factor, no overlap with RE additions considered)	Expert judgement
EVs	Calculation	Average fuel consumption: 0.06l/km	Expert judgement

EVs	Calculation	Average distance: 15,400 km/year	NRCAN
Wind and Solar	Assumptions	Natural gas capacity reduction will impact coal demand proportionally. Assumption that all non-peaking gas-fired power plants have the same capacity factor,	Expert judgement
Wind and Solar	Calculation	Lowest cost projections result in less savings so that is considered the worst-case scenario. Highest cost projections were used for the best-case scenario.	NREL and expert judgement
EVs	Assumption	For each extra EV, one gasoline car was removed from the fleet. This results in fuel savings proportional to the number of cars, their overall fuel consumption and fuel prices.	Expert judgement

NewClimate – Institute for Climate Policy and Global Sustainability gGmbH

Cologne Office
Clever Straße 13-15
50668 Cologne
Germany

T +49 (0) 221 999833-00
F +49 (0) 221 999833-19

Berlin Office
Brunnenstraße 195
10119 Berlin
Germany

E info@newclimate.org
www.newclimate.org