On the way to net-zero
The 2030 milestone

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On the way to net-zero: the 2030 milestone

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About the Institut de l'énergie Trottier (IET)

The IET was created in 2013 thanks to a generous donation from the Trottier Family Foundation. Its mission is to train a new generation of engineers and scientists with a systemic and trans-disciplinary understanding of energy issues, to support the search for sustainable solutions to help achieve the necessary transition, to disseminate knowledge, and to contribute to discussions of energy issues. Based at Polytechnique Montréal, the IET team includes professor-researchers from HEC, Polytechnique and Université de Montréal. This diversity of expertise allows IET to assemble work teams that are trans-disciplinary, an aspect that is vital to a systemic understanding of energy issues in the context of combating climate change.

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1 Introduction

On June 30th, 2021, Canada adopted Bill C-12, which sets a 2050 net-zero target for the country's greenhouse gas (GHG) emissions and a 40-45% reduction by 2030 (compared to 2005) as its first milestone. Achieving these goals requires that Canada's economy undergo a deep and rapid transformation that will involve all Canadians.

A transformation of this magnitude must be carefully planned to ensure that actions can deliver expected results and consequent investments are made. Yet, planning is challenging given that GHG emission reduction efforts often collide with short term economic and social interests, rapidly evolving technology, and multiple actors and stakeholders.

Given the uncertainty and many unknowns surrounding this energy transition, it is therefore essential to assess, on nearly an ongoing basis, the potential impact of efforts which are underway. Measures announced to deliver such a transition also need to be under the proverbial microscope, so as to reorient or intensify them as quickly as possible.

In this brief report, we first compare three recent modelling exercises (Table 1) to assess the efforts deployed by provinces and the federal government on the way to Canada's 2030 milestone.

Table 1 – Modelling exercises compared in this report

Name	Description
CER2020	*Canada's Energy Future 2020* by the Canadian Energy Regulator (CER 2020)
CEO2021	*Canadian Energy Outlook 2021 – Horizon 2060 by the Institut de l'énergie Trottier and e3cHub (Langlois-Bertrand et al. 2021)*
ECCC2020	*Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2020 by Environment and Climate Change Canada (ECCC 2020a)*

Building on these comparisons, we then examine what transformations need to take place to achieve projected sectorial reductions. The aforementioned analysis then leads us to the observation that measures and actions, in place and announced, are far from sufficient to reach the 2030 milestone.

We then conclude by applying CEO2021's net-zero by 2050 scenario projection to identify short term actions compatible with net-zero pathways that can help close this gap.

2 Comparing projections to better understand the challenge

Prospective energy modelling is limited in Canada. In this report, the results from CEO2021 are compared to the two other national projections listed above, with a special focus on ECCC2020, given its high level of detail.[1]

These comparisons require some care as the categorization of emissions among the sectors varies in the diverse projections, making detailed sectoral comparisons difficult. However, despite these differences, it remains possible to estimate what each projection tells us about the potential transformation of Canada's energy sector.

2.1 The Canadian Energy Regulator's projections

Of the three projections discussed here, CER2020 is the least detailed since it provides only scant information on GHG reductions linked to its scenarios, making it impossible to analyze its results sector by sector. However, it is relevant to deduce emissions from its projections as they are used both in ECCC2020 and CEO2021. CEO2021 adopts the hypotheses of CER's Reference scenario for both REF and CP30 scenarios and those of CER2020's Evolving scenario for its net-zero scenarios with respect to economic growth and oil and gas prices, among others.

While CER2020's Reference scenario projects a growth in oil (+25%) and gas (+10 %) production, its Evolving scenario, which includes a carbon price that reaches \$125/tCO_2e by 2050 and lower fossil fuel prices, projects that oil production will increase by about 10% between 2019 and 2030, with natural gas output increasing by 5%. In parallel, the consumption of fossil fuels decreases by 12% in 2030 with respect to 2019, similar to the 10.5% reduction projected in CEO2021 between 2016 and 2030 in CP30. Even though GHG emissions projections are not provided in the CER's report, it is possible to deduce their evolution from projections of energy production and

[1] Because of the large number of scenarios treated on an equal footing in Dion et al. (2021) and the absence of quantified reductions in Meadowcroft (2021), a similar comparison with these two other recent independent reports on pathways to net-zero for Canada cannot be made here.

consumption: without extensive reductions in GHG emissions by unit of oil and gas produced (energy emissions intensity), the increase in fossil fuels production coupled with a limited reduction in consumption in CER2020's Evolving projection suggests that by 2030 emissions will remain constant or, at best, slightly decrease with respect to 2005. CER2020's projections do not therefore support a path compatible with Canada' GHG reductions targets for 2030.

Table 2 – Scenarios considered in this report

Source	Scenario	Description
CEO2021	**REF**	Reference scenario with no constraining GHG reduction targets. Macroeconomic assumptions (GDP, population, oil and gas export prices) are aligned with the Reference scenario used in CER2020 imposing no additional constraints in terms of GHG emissions reductions but including policies already in place.
CEO2021	**CP30**	REF + carbon pricing increase schedule announced by the federal government in late 2020, with a price reaching \$170/tonne of CO_2e in 2030.[2] To accelerate the impact of carbon pricing, this scenario also lowers the hurdle rate with respect to standard practice.
CEO2021	**NZ50**	Net-zero emissions target on total CO_2e by 2050, and a 40% reduction target by 2030 (with respect to 2005). *This corresponds most closely to the current 2030 government's targets.*
ECCC2020	**REF***	Reference case including all policies and measures funded, legislated and implemented by federal, provincial, and territorial governments as of September 2020. Oil and natural gas production and price assumptions are close to those of the CER2020 (ECCC 2020d).
ECCC2020	**HEHE**	REF* + initiatives on climate actions currently announced by federal, provincial and territorial governments, up to and including the plan for A Healthy Environment and a Healthy Economy (specifically, the proposed changes in carbon pricing, the Clean Fuel Standard, complementary sectoral measures, and nature-based solutions) (ECCC 2020d).

2.2 The Canadian Energy Outlook

The recently released CEO2021 is a modelling effort that analyzes possible transformation pathways required to achieve net-zero GHG emissions in Canada, with a special focus on the energy system. Using NATEM from ESMIA Consultants, the modelling optimizes scenarios with regard to cost, constrained by specific GHG reduction targets. We retain here three scenarios : two references scenarios with no GHG reduction constrained — REF, which is business as usual with all measures and

[2] Two adjustments were necessary to incorporate this schedule: first, a discount rate was used to transform prices proposed by the government in the schedule into their equivalent for the year when they are applied (for instance, $170 announced this year is worth $131 in constant dollars for 2030, when adjusted for inflation; second, this maximum price reached in 2030 is then adjusted for inflation for the remainder of the period, i.e. until 2060.

policies currently in place, and CP30, which mainly adds the planned carbon price increase schedule to 2030 —, and NZ50, which imposes emission reductions aligned with the federal targets (- 40% with respect to 2005 by 2030 and net-zero by 2050) (Table 2).

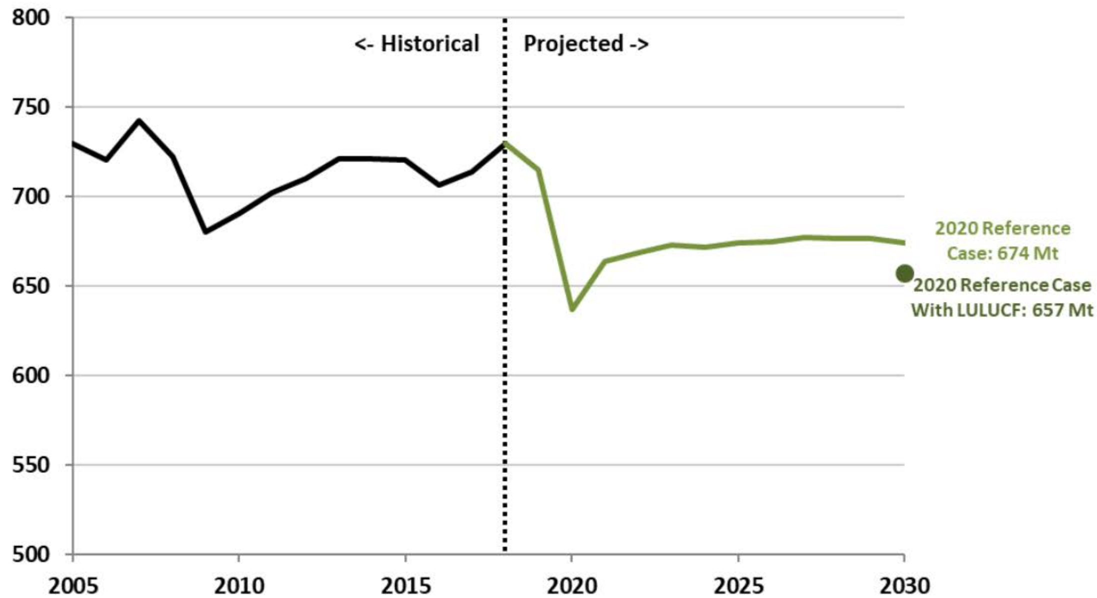
Importantly, results from the two reference scenarios used in CEO2021 suggest that measures in place at the federal and provincial levels are insufficient to prevent the growth of GHG emissions; with respect to 2005, these are projected to grow by 3% by 2030 in REF. Even including the increased carbon pricing to $170/t by 2030 and the proposed Clean Fuel Standards would lead to overall reductions of only 16% with respect to 2005 by 2030. This is far from the previous 30% reduction target for that year and even further from the recently revised objective of 40%-45% reduction.

2.3 Environment and Climate Change Canada's projections

ECCC's projections include a reference scenario (denoted here as REF* to avoid confusion with CEO2021's REF scenario) that incorporates the CER's energy production and demand projections as well as provincial and national measures up to 2019, as well as a revised projection that incorporates the announced increase to $170/tCO_2e$ by 2030 (current dollars) and includes the expected impacts from green infrastructure programs included in Canada's new climate plan, "A Healthy Environment and a Healthy Economy" (HEHE scenario), proposed by the federal government at the end of 2020 (ECCC 2020b).

Before comparing scenarios, it is useful to look at ECCC2020 projection of GHG emissions in the REF* scenario (Figure 1). This model includes a sharp drop in 2020, associated with the COVID-19 crisis, followed by a slow increase in emissions from the minimum until 2030, which never returns to 2018 emissions. REF*, therefore, postulates that the transformations that took place in 2020 introduced a new plateau in emissions that is sustainable for the next decade.

Figure 1 – ECCC2020's projected emissions (reference scenario)



Source: ECCC (2020a)

2.4 Comparison of total emissions projections

These projections are compared with those from CEO2021 in Table 3. As mentioned above, direct sectoral comparisons cannot be made between ECCC2020 and CEO2021: ECCC's model uses a breakdown of emissions into economic sectors, while CEO2021's modelling aims to reproduce as closely as possible the UN categories used for the production of national GHG inventories instead (ECCC 2021), starting from energy data published by Statistics Canada. For example, some emissions assigned to industry in the NATEM model are credited to the oil and gas sector in ECCC's modelling. Although, in this case, we cannot directly compare numbers in sectoral emissions, it is still possible to assess the relative changes in each of these categories, and evaluate their implications based on size.

Table 3 – Projections of emissions on the 2030 horizon from CEO2021 and ECCC2020 (in $MtCO_2e$).

Sector[3]	CEO2021				ECCC2020			
	2016	2030			2018	2030		
		REF	CP30	CP30 - REF		REF*	HEHE	HEHE - REF*
Buildings	72	64	60.0	-4	92	82	65	-17
Oil and gas	161	196	173	-23	193	194	138	-56
Electricity	82	75	33	-42	64	21	11	-10
Industry	116	108	91	-17	78	82	61	-21
Transport	197	230	213	-17	186	178	151	-27
Waste	17	18	8	-10	42	41	31	-10
Agriculture	60	65	65	0	73	77	74	-3
TOTAL[4]	705	754	642	-112	728	674	531	-144
LULUCF						-17	-27	

Targets : -30% = 511 ; -45% = 401

NATEM's modelling for CEO2021 reproduces a significant decline in 2020—down to 692 $MtCO_2e$ for REF and 689 $MtCO_2e$ for CP30 from 723 $MtCO_2e$ for 2018, with the difference being due to the lowering of the hurdle rate, as explained in Chapter 1 of CEO2021—but one that is less deep than ECCC. Moreover, CEO2021's reference scenario projects a rapid rebound that leads to a net increase of 49 $MtCO_2e$ in 2030 with respect to 2016 (31 $MtCO_2e$ with respect to 2018), while REF* projects a very small bounce between 2020 and 2030 (about 30 $MtCO_2e$), which leaves the total well below 2018 (-53 $MtCO_2e$).

In CEO2021, the introduction of a higher carbon price along with more aggressive investments (CP30 scenario) lead to a small reduction in emissions between 2020 and 2030 (-47 $MtCO_2e$ to 642 $MtCO_2e$). For ECCC2020, the higher price on carbon, together with other investments announced in December 2020 (HEHE scenario), would generate a much greater transformation, leading to a further 110 $MtCO_2e$ reduction with respect

[3] Even though the names of the sectors are the same, the two models do not define them in the same way (and do not have the same reference year). CEO2021 more closely follows the international definitions used, for example, in Canada's National GHG Inventory. ECCC adopts the economic sectorial classification for its modelling. This explains why there are some discrepancies in how the emissions are distributed among sectors, even though the total emissions match.

[4] Due to round-up of numbers, totals might not match the sum of separate items

to the low level of emissions achieved in 2020 and 144 MtCO_2e with respect to an already low ECCC REF* projection for 2030.

Overall, therefore, ECCC2020's modelling is significantly more optimistic than CER2020's and CEO2021's modelling both in terms of the structural effects of the pandemic in reducing GHG emissions and of a higher forecast price on carbon coupled with massive investments announced in December 2020, but provides few specific indications as to how these GHG reductions will take place.

To understand what these differences mean in terms of the transformation of Canada's energy system, it is necessary to look at the overall projected sectoral impact of the measures in place and announced, and analyze what the results suggest and how these can be contrasted with CEO2021's results.

ECCC2020 projects that Canada is on track to reduce its emissions by more than 30 % in 2030, measured with respect to 2005. The modelling presented in CEO2021 rather projects that current federal and provincial (adopted and announced) measures lead to, at most, a 16% reduction in GHG emissions by 2030, in line with what can be deduced from the Canadian Energy Regulator's Evolving scenario estimates.

2.5 Sectoral comparison between CEO2021's and ECCC2020's projections

To further analyze the possible explanations for the gap between ECCC2020's projections and those of CEO2021's modelling, this section discusses how sectoral emissions are projected to evolve and what this evolution implies in term of transformations. To avoid delving into fine differences in hypotheses and models, attention is given here to what the projections mean for the evolution of given sectors, focusing on the internal logic and consequences implied by the various projections.

2.5.1 Buildings

For commercial and residential buildings, both REF and REF* scenarios project a GHG reduction of about 10 MtCO_2e by 2030,[5] despite the growth in population and economy. This reduction is associated with energy efficiency gains and a transfer of energy

[5] As discussed previously, NATEM's and ECCC's classification of sectors are different. This means that although total national emissions are the same, they are not assigned exactly to the same sectors. That is why this report focuses here on changes with respect to emissions for the starting year (2016 or 2018) rather than on absolute values.

source from fossil to electricity for heating. Although these reductions appear small in proportion to the total energy consumption of this sector, they imply a significant change in trend, as emissions in the building sector grew by 11%, or 7.5 $MtCO_2e$ (ECCC 2021), between 2016 and 2019.

CP30 projects a 3.5 $MtCO_2e$ reduction for buildings with respect to REF and a 17% overall reduction with respect to 2016. In comparison, the HEHE scenario projects a much deeper transformation, with an additional 17 $MtCO_2e$ reduction with respect to REF*. This corresponds to a 30% reduction in emissions for this sector with respect to 2018. In CEO2021, such a level of reduction by 2030 is seen only for NZ50, largely because of the slow projected rate of decarbonization of the commercial sector.

While the technology exists today to achieve HEHE's projected level of reduction, such a transformation would require a significant increase in energy efficiency, coupled with the electrification of heating for around 25% of all fossil-fuel heated buildings in Canada, as low-carbon fuels are not available at this scale. The electrification of heating at this level would require important investments in clean electricity production as well as transport and distribution. Short of this massive grid upgrade, fossil fuels will be needed for the coldest winter months; to compensate for these emissions, HEHE's projections would require additional energy efficiency and electric heating for a larger fraction of buildings. In view of these challenges, a number of elements are not in place to support this transformation:

1. Programs announced by the federal government as part of *A Healthy Environment and a Healthy Economy* do not tie the funding to specific decarbonization targets in either the residential or the commercial sector, which makes it difficult to assume that they could deliver this level of transformation.
2. As was seen in Quebec at the beginning of the 1980s, electrifying such a large part of heating, even with heat pumps and effective energy efficiency measures, will require additional low-carbon electricity production and significant investments to upgrade the electrical grid in most provinces so that it can deliver the additional load to respond to the winter demand. The timeline for upgrading electricity production, power transmission lines, and local grids means that, unless there is a significant acceleration in planning and investments, it is unlikely for such a deep transformation to occur within a 10-year horizon.

Based on CEO2021's modelling and on general analysis, the current publicly available federal and provincial plans do not provide sufficient detail to support the level of transformation needed to reach HEHE's projected reductions in the building sector by 2030.

2.5.2 Oil and gas

The REF scenario projects a significant increase in emissions linked to oil and gas production by 2030 (+34 $MtCO_2e$), following CER2020's reference scenario. Even with CP30, emissions grow by 11 $MtCO_2e$ from 2016, corresponding to a plateau with respect to 2018 (ECCC 2021).

In contrast, the REF* scenario projects a plateau in emissions with respect to 2018 while HEHE sees a 55 $MtCO_2e$ reduction (-28%). REF* includes a 22% GHG reduction (-11 $MtCO_2e$) from natural gas production and processing, due in part to stricter regulations on emissions, but an increase of 13% (+11 $MtCO_2e$) in oil sands. This plateau in emissions is observed despite a 24% increase in conventional oil production, a 26% increase in oil sands production and a 6% increase in gas production, due to reduced energy emission intensity (emissions per unit of oil and gas produced).

All scenarios leading to a 30% or more reduction by 2030 include large and rapid reductions (-28% to -60 %) in emissions from the oil and gas sector. These reductions can be achieved through a decline in production and/or massive CCS deployment for this sector.

The importance of this gap cannot be understated, given the key role that the oil and gas sector is projected to play in GHG reductions over the next decade, as is suggested in both CEO2021 and ECCC2020 modelling. On the one hand, the gains in emission intensity projected in REF* are already significant. Yet ECCC does not provide any information as to how HEHE can deliver a 28% additional reduction in emissions for the oil and gas sector, given the absence of measures affecting this sector in the federal government's plan. Reductions of this magnitude would require a significant drop in production or massive investments in CCS, a reduction about half as large as the one projected in NZ50 for 2030.

On the other hand, CEO2021's REF scenario may be too pessimistic with regard to the evolution of emissions for this sector. Nevertheless, it is worth noting that to match growth in energy production, HEHE includes gains in efficiency about 40%-50% superior than levels in REF*. Based on historical trends and the modelling used in CEO2021, REF* appears already very optimistic about the capacity of the oil and gas sector to improve in emission intensity. Moreover, it remains unclear how HEHE modelling can project an additional 55 $MtCO_2e$ reduction with respect to REF* with the measures publicly announced by provinces and the federal government.

2.5.3 Electricity

Electricity production is further decarbonized in all CEO2021's and ECCC2020's scenarios. The REF scenario projects a reduction of 8 MtCO_2e by 2030, with respect to 2016 (82 MtCO_2e), with a significant further drop to 33 MtCO_2e for CP30. For its part, starting from an estimated 64 MtCO_2e for 2018, REF* projects a drop to 21 MtCO_2e by 2030, with HEHE reaching 11 MtCO_2e.

These projections can be put in the following context:

1. In its latest GHG emission inventory (ECCC 2021), ECCC estimates the emissions from this sector at 81 MtCO_2e in 2016 (1 MtCO_2e **below** CEO2021's numbers) and 70 MtCO_2e in 2018 (6 MtCO_2e **above** ECCC's numbers for modelling); decarbonization of the sector is therefore already slower than projected by ECCC.
2. With nuclear plants closing or becoming offline for refurbishing in Ontario, REF projects new gas-fired electricity production, which largely explains why emissions do not fall further. Instead, CP30 sees additional nuclear coupled with decentralized renewable production.
3. The REF* projection would mean a 70% reduction in electricity-related emissions within 10 years, reaching 83% for HEHE. While these levels are at par with NZ50, reaching them requires deep transformations in the electricity sector of a number of provinces, including Alberta, Saskatchewan, Ontario, and Nova Scotia. At present, none of these provinces has a public blueprint to support this level of decarbonization, either through support for low-emission production or carbon capture and sequestration. Furthermore, Ontario Power Generation's recent acquisition of three natural gas-fired power plants from TC Energy does not suggest a clear will to fully decarbonize the province's electricity sector, at least on a short-term horizon (OPG 2020).

These issues underline the need for more information to understand ECCC's REF* scenario on electricity emissions, as current planning from provinces with major thermal electricity production does not provide evidence supporting this transformation. Moreover, while the December 2020 federal plan announced funding for the electricity grid, neither the provinces' nor the federal government's plans provide specific measures and indicators that can support HEHE's projection.

2.5.4 Industry

The REF scenario projects an 8 MtCO_2e reduction by 2030, with a further 17 MtCO_2e (25 MtCO_2e or 22% net reduction) for CP30. With different allocations for this category, which move some emissions to the oil and gas sector, REF* projects a growth in emissions from 78 to 82 $MtCO_2e$, with a significant reduction to 61 $MtCO_2e$ (17 $MtCO_2e$ but 21 $MtCO_2e$ with respect to REF*) in HEHE.

These reductions derive from changes in processes and fossil fuel combustion. As the industry is more reactive to price signals through carbon pricing or subsidies, both models are relatively aligned with respect to emissions.

2.5.5 Transport

Transport is another sector with a long historical trend of growing emissions. In only three years, from 2016 to 2019, these grew by 8%, from 201 to 217 $MtCO_2e$ (ECCC 2021). Following on this trend, CEO2021's REF scenario projects a growing trend to 230 $MtCO_2e$ by 2030, well below historical evolution, however, as it takes into account some electrification of the sector. CP30, which projects the stabilization of emissions at 213 $MtCO_2e$, underlines the relatively weak impact of the carbon tax on a large part of transport emissions due to limited alternatives to fossil fuels.

Even taking into account the 19 $MtCO_2e$ reduction in emissions that could result from the Clean Fuel Standard, if the latter is implemented and delivers at the expect level, ECCC2020's projections show a much more rapid turn than CP30, with a reduction of 35 $MtCO_2e$ for HEHE with respect to REF*. Yet the federal HEHE plan, apart from supporting the goal aiming for 30% of new personal vehicles sold in 2030 to be zero-emission, offers few additional details in terms of clear transformations for this highly emitting sector.

To put these projections in perspective, given that personal vehicles account for 38% of all transport emissions, even if 30% of all registered personal vehicles were electrified (well above the federal target), emissions for this sector would be lowered by only 11%, far from the 19% projected by the HEHE scenario with respect to REF*, particularly as we consider that this sector has seen its emissions grow for decades. As cost-competitive low-carbon alternatives are still lacking for the commercial sector, both on and off road, and including rail, aviation and marine, it is difficult to reconcile publicly available governmental measures and targets with ECCC2020's HEHE projections.

2.5.6 Land Use, Land-Use Change and Forestry

Land Use, Land-Use Change and Forestry (LULUCF), which contribute a 27 $MtCO_2e$ reduction in ECCC2020, are not included in CEO2021's modelling. However, according to the UN, accounting for this contribution is challenging because of "potential reversibility and non-permanence” (UNFCCC 2021). For example, over the past 40 years in Canada, these emissions have varied yearly, from a net removal of 100 $MtCO_2e$ to net emissions of 250 $MtCO_2e$ (ECCC 2020c). Further detailed analysis and research will be needed to assess what level of contribution from LULUCF is reasonable.

2.5.7 Others

Although they do not cover exactly the same contributions, waste, agriculture and others evolve very similarly in both CEO2021 and ECCC2020 projections. Both REF and REF* project relatively stable emissions for waste and other sectors, and a 4-5 $MtCO_2e$ increase for agriculture. HEHE projects a 10 $MtCO_2e$ reduction overall, while CP30 projects a 5 $MtCO_2e$ reduction. The difference lies in large part with the smaller increase for the agriculture sector (+1 $MtCO_2e$) for HEHE than for CP30 (+5 $MtCO_2e$).

Given the challenges in modelling this sector, it is difficult to determine which of the two approaches is more accurate, thus more detailed work remains to be done.

3 What can be learned from this comparison of models?

As the above sectoral comparison suggests, there are some fundamental differences in the modelling results between CEO2021 and ECCC2020. While both sets of results imply that Canada’s energy system will transform itself over the coming decade, ECCC2020 projects faster and deeper reductions that would require a swift change in historical trends and aggressive and efficient action in four crucial sectors: electricity production, oil and gas production, transport, and buildings.

However, as discussed in the previous section, planning for these aggressive transformations, many of which must be undertaken by actors other than the federal government, does not seem to have begun yet. For example, reaching the projected decarbonization level in the electricity sector, including production and distribution, requires provincial-level planning that generally takes years. At present, however, provinces with large fossil-based electricity production, such as Alberta, Saskatchewan and Ontario, do not seem to be developing these plans.

It is also possible that CEO2021's hypotheses are too conservative with respect to the effect of carbon pricing, the rate at which investments to decarbonize will be made, and the effects of the massive investments in green infrastructure. However, historical trends over the last two decades have shown time and time again that the real effects of specific measures to reduce emissions are lower than expected.

Without further details on how HEHE's plan will transform specific sectors, the analysis presented throughout CEO2021, which is based on publicly available information, is unable to reproduce ECCC2020's projections. Should more information regarding measures, plans and investments be available to the government, it is essential that it be released, to allow for better independent evaluation of their impact on Canada's energy systems and projected emissions.

This is why the rest of this report, building on CEO2021's recent modelling exercise, suggests additional measures integrated into a specific decarbonization strategy built on data and strict accountability that would help Canada achieve its GHG targets for 2030 while setting it on a course to net-zero by 2050.

An analysis of the evolution to Canada's energy system required to reach ECCC2020's GHG projections for 2030 suggests that a large part of the differences with CEO2021 projections involves a level of transformation not supported by publicly available plans and measures. This implies that the gap stems from a more optimistic view of the capacity of Canada's economy to transform in the absence of a clear path or well-defined constraints, especially as concerns the oil and gas, building, and transport sectors.

3.1 What do the various scenarios teach us for 2030?

Extending the modelling period until 2060, CEO2021 presents cost-optimal transformation trajectories given a certain number of constraints. While REF and CP30 do not impose specific emission reductions, NZ50 is the trajectory aligned with Canadian GHG targets, imposing the newly announced goal of a 40% reduction for 2030.

Comparing CP30's evolution with that of NZ50 (Table 4) over the next years enables us to make some specific observations as to foreseeable difficulties and ways to achieve the required transformations, while underlining the challenge that reaching these targets represents and remaining on a path to net-zero by 2050.

3.1.1 The low-hanging fruits

Like recent reports (Dion et al. 2021; Meadowcroft 2021), CEO2021's modelling results indicate that only a few sectors have the technology available at the appropriate cost to allow for a rapid reduction in emissions, namely in electricity and heat production, as well as in industry.

As discussed above, significant reductions in industrial processes and combustion already occur within CP30 (-22%) but are accelerated in NZ50 (-42%). Although substantial, these reductions are barely at the expected level for the sector to reach its part of the target; as a result, they do not compensate for missed targets in other sectors.

Electricity, for its part, decarbonizes much more deeply (-60% in CP30 to -89% in NZ50). However, since the electricity sector is already decarbonized at 80%, these reductions are relatively small in absolute numbers, around 73 MtCO_2e for NZ50. While exceeding average targets, waste, which sees emissions reduced by 52% in CP30 and 63% in NZ50, is also a small contributor to overall reductions at between -8 and -10 MtCO_2e.

3.1.2 The holdout sectors

While technology is available to transform building heating, costs and barriers to investments limit the transformation of this sector over the 2030 horizon and total reductions are below overall targets at -32% for NZ50, when combining residential and commercial buildings. The building sector is therefore both a low-hanging fruit, because of existing solutions, and a resisting sector due to barriers to entry associated with the technologies needed and the scale of the transformation, which involves hundreds of thousands of buildings.

Transport and agriculture are also difficult to decarbonize over a short horizon. While emissions rise in CP30, transport decreases its emissions by only 13 MtCOe2 (-6%) in NZ50, with a similar percentage reached for agriculture.

Table 4 – Emission reductions by sector for CP30 and NZ50 with respect to the model reference year (2016)

	2016 ($MtCO_2e$)	2030		2050	
		CP30	NZ50	CP30	NZ50
Total emissions ($MtCO_2e$)	705	642	438	598	0
Reductions wrt 2005 (730 $MtCO_2e$)		-12%	-40%	-18%	-100%
Main contributing sectors					
Electricity	82	-60%	-89%	-94%	-167%
Waste	17	-52%	-63%	-58%	-68%
Oil and gas (inc. fugitive emissions)	161	+7%	-60.0%	+14%	-94%
Residential buildings	41	-27%	-41%	-74%	-95%
Sectors difficult to decarbonize					
Industry	116	-22%	-42%	-18%	-133%
Commercial buildings	31	-3%	-21%	-9%	-98%
Agriculture	60	+8%	-5%	+20%	-31%
Transport	197	+8%	-6%	+0%	-74%

3.1.3 Energy efficiency and productivity

Many analyses place energy efficiency at the center of decarbonization (Dion et al. 2021). While energy efficiency must be sought, historical trends do not support its use as a deep change actor. There are a few reasons for this. First, low-cost energy efficiency is already being implemented in cost-optimized projections, irrespective of GHG targets. Second, energy efficiency often requires careful management that is not sustained over time (Gunasingh, Zhou and Hackel 2018). Lastly, in the quest for net-zero emissions, it is sometimes necessary to reduce energy efficiency, for example by replacing natural gas with biomass in a furnace.

Energy productivity is a much more reliable approach, especially in the context of electrification. Moving from fossil fuel to electric propulsion, for instance, can increase energy productivity by a factor of three to four. Similarly, replacing electric baseboards with heat pumps can multiply energy productivity by two to four. However, this gain is already included in the cost-optimized trajectories presented here and, as such, cannot be counted in addition to the discussed transformations.

3.1.4 Acting on the only possible lever: oil and gas production

In NZ50, with the exception of waste, electricity production and industry, no sector discussed in this section comes near to reaching its respective fraction of emissions reduction. Both CEO2021's modelling for NZ50 and HEHE underline that to reach 2030's targets, oil and gas production, including fugitive emissions, must compensate for the lack of GHG reductions of other sectors, where decarbonization is hardest.

To do so, oil and gas reduce emissions by 60% for NZ50, representing a decline of 97 $MtCO_2e$ with respect to 2016. With projected gains in emission intensity, these targets are associated with a production reduction of nearly 60%. While Chapter 7 of CEO2021 discusses alternative pathways that preserve higher production levels, all trajectories to reach 2030 targets, as shown by the HEHE scenario, involve emission reductions for this sector that are above national targets and that compensate for the challenges of decarbonizing the other sectors.

If demand for oil and gas in the rest of the world decreases over the next year, with oil and gas prices falling, Canadian production will naturally falter along with emissions. However, with higher prices, reducing emissions will be more challenging and involve either limiting production or the rapid deployment of effective large-scale technologies to capture and sequester emissions.

Especially in the early stages of net-zero pathways, most GHG reductions must come from the industrial sector, including oil and gas production, electricity generation, commercial buildings and transport-related activities, rather than from sectors like residential buildings and personal transport, under the direct control of citizens. Accordingly, a price on carbon must be accompanied by rapid planning for decarbonizing electricity production, expanding the grid and addressing other barriers to transforming these sectors.

3.1.5 The role of industrial transformation

As revealed by CEO2021's modelling, the rapid reduction in emissions needed to reach 2030 targets cannot occur through changes at the individual or distributed level—be they in transport, buildings, or personal buying habits. Sectors that will drive the reduction include a relatively small number of units that interact closely with governments, namely electricity production, heavy industry, and oil and gas. This makes it both easier for authorities to engage in dialogue and harder to resist lobbies. More openness about this challenge, similar to what took place in the 1980s with the ozone layer issue, could help build popular pressure to make the appropriate moves.

4 Thinking in terms of pathways

Irrespective of the modelling tools, the challenge of reaching 2030 targets was profoundly changed by the adoption of a long-term net-zero goal. As long as 2050 involved an ambitious 70% or even 80% GHG reduction, it was possible to see partial decarbonization solutions, such as fuel switching or more aggressive energy efficiency measures, as viable; it was always possible to justify that another sector could compensate for the missing reductions.

With a net-zero focus on a 30-year horizon, such an approach is no longer economically realistic. It makes no sense to deploy technological solutions, such as natural gas in transportation, that will have to be replaced in 15 or 20 years. Moreover, to reach zero emissions, failure in one sector or subsector to full decarbonize cannot be compensated by reductions elsewhere, only by capture and sequestration, a technology that should remain the ultimate backstop, given the uncertainties surrounding its costs and its scaling possibilities.

A diversion to transition solutions, moreover, reduces investments needed for net-zero solutions, increasing their cost and further delaying the transformation. This emerges very clearly from the modelling results presented in CEO2021, which show almost no adoption of such technology.

More important than 2030 targets is thus the deployment of measures and the start of deep transformations that will lead to net-zero over a 30-year horizon. It is essential to avoid making moves for the short run that will hinder the longer play.

5 Where to go from here?

Just like any other modelling exercise, energy modelling is a strongly truncated representation of reality. As such, no model is complete or perfect. Therefore, the value of modelling rests on various highlights it provides based on specific hypotheses. One of the best way to exploit this values is comparative analysis, between scenarios and models, which allows to go beyond specific biases and limitations, in order to garner fundamental understanding of the issues.

Here, a comparison of various decarbonization modelling efforts and an analysis of associated sectoral transformations, shine lights on the steps required to reach the 2030 emission reduction milestone. They also demonstrate the critical gap between publicly announced actions and those required to reach the stated milestone.

Yet, scenarios such as NZ50 (from CEO2021) suggest that it is both technologically and economically possible to reduce Canada's GHG emissions by 40% within the next 10 years. However, major rapid actions, beyond what is already publicly announced and in place, are needed to succeed. These actions must be coordinated between various orders of government. These actions must start now.

Government and industry discussions to address some of the transformations discussed here are likely taking place behind closed doors. However, given previous generalized failures in the delivery of reductions, it is essential to adopt public sector and sub-sector objectives – in addition to clearly identifying pathways to deliver on the latter. It's also essential that GHG reduction target be significantly more ambitious than the 2030 one, so as to compensate for inevitable failures that will occur on the way.

The year 2030 is just around the corner. Pathways to get to 2030 emission reduction goal require bold and broad actions grounded in evidence, and supported by society's leaders. Over the past few years, many governments, private sector actors and stakeholders have made considerable progress on both fronts, which is great news. Yet as we have demonstrated here, there is more that remains to be done, and we need to start now.

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