The Region of Durham 2023 Greenhouse Gas Emissions Inventory and Progress Toward Net-Zero Climate Targets

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Executive Summary

In 2023 greenhouse gas, GHG, emissions attributed to the residents, businesses and institutions of Durham Region are estimated at 29.8 Mt CO_2e, or about 39.5 tonnes per person. This is more than double last year's estimate of 11.9 Mt CO_2e, or 16.01 tonnes per person for 2022. Durham Region's emissions of course did not double in just one year. Rather, what is provided in this year's inventory is a more comprehensive accounting of all emissions, upstream of Durham (Scope 3), those emissions that took place in Durham in 2023 (Scopes 1 and 2), and emissions that are likely to be emitted downstream in future from activities that took place in Durham in 2023 (Scope 3).

Consistent with The Atmospheric Fund (TAF) inventory, Durham Region's emissions, across constant categories, increased by about 1.9 percent 2022 to 2023. To meet Canada's, and Durham Region's, targets, emissions need to decline by 3 percent per year, each year to 2050 (therefore Durham Region's GHG emissions are almost 5 percent above stated target).

The inventory in this report is consistent with global best practices (Global Protocol for Communities and ISO 14064) and is one of the world's most comprehensive for a community. The inventory is provided not as tool for chagrin or blame, but to better understand the scale and complexity of Durham Region's goal of being net-zero by 2050 (no unabated GHG emissions). The inventory also highlights how Durham's mitigation efforts need to be lead locally, but undertaken within a provincial, national and global framework.

Like the Government of Canada, this assessment defines 'net-zero' as the economy either emits no greenhouse gas emissions or offsets its emissions. And like Canada, Ontario, and most of the rest of the world, the Region of Durham is not on track to meet net-zero targets. A credible path to net-zero by 2050 remains elusive.

Durham Region is in good company. Several partner municipalities (e.g., Clarington, Whitby, Pickering) institutions (e.g., Ontario Tech University, separate and public-school boards) and businesses have also set net-zero targets. These are consistent with the Canadian Net-Zero Emissions Accountability Act (CNZEAA), adopted by the Parliament of Canada in June 2021.

The Region of Durham may feel it is 'swimming upstream' in its efforts to reduce GHG emissions. For example, Ontario's CO_2 emissions from electricity generation increased by 30 percent from 2015 to 2023 and are on track to double again before 2050. The Region has no reasonable means to oppose this increase (and is already a strong supporter of low-carbon electricity by serving as host for Pickering and Darlington nuclear power stations). Also in 2023, after intense lobbying by Enbridge and some area municipalities, Ontario's Minister of Energy took the unprecedented step of overruling the Ontario Energy Board's decision to shift natural (fossil) gas connection costs upfront to encourage more energy efficient choices. Enbridge will continue to amortize these costs over 40 years (well after municipal, provincial and federal governments have claimed that they will be net-zero). Emissions from natural gas continue to rise, with no credible plan for mitigation.

Perhaps the biggest challenge for Durham Region to achieve net-zero goals is the apparent apathy of Canadians, and others, to reduce GHG emissions. Canadians are the only major high-income country that has seen emissions increase since 1990. Support for a consumer price on carbon (an approach shown to be among the most cost-effective, and fair, ways to reduce emissions) has waned to the point where it is likely to be discontinued (with no practical option to replace it).

Efforts are considerable and the pace is increasing, however locally and globally, our collective progress is not on track to meet the Paris Agreement's aspirational goal of limiting global temperature increases to 1.5° C above pre-industrial values, nor even the minimum 'safe' target of limiting temperature increases to below 2° C. The UN finds that climate policies currently in place point to a minimum 2.8° C temperature rise by the end of this century.

As climate changes continue to intensify, the Region of Durham, residents, businesses and institutions, will need to redouble adaptation efforts. For example, the Durham Region Health Department's 2024 Climate Change and Health report provides a comprehensive and credible menu of suggested policies and actions.

There is however considerable good news. GHG emissions in many countries have peaked. The US in 2010, and China's are expected to peak in 2025. Canada's emissions may have peaked in 2005, although they are increasing about 2 percent per year post-COVID (mainly due to oil and gas development). Global GHG emissions are projected to peak within the next decade.

Clear GHG mitigation priorities continue to exist for Durham Region. These include:

- Shift to low-carbon integrated mobility (far fewer single occupant vehicle trips, especially in internal combustion engine vehicles);

- Redesign neighbourhoods to be far less reliant on car access; Phase out natural gas for space heating (urge provincial adoption of bans on natural gas in new neighbourhoods, similar to Vancouver and Montreal);

- Shift personal purchasing practices, *e.g*., fewer flights and cruises, eat less meat (especially beef), emphasise waste minimization (especially food waste);

- Continue to pursue, and expand, programs such as building retrofits and the Durham Community Energy Plan.

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Background[1]

The cause of our shifting climate is well known, greenhouse gases are emitted as a by-product of innumerable human activities, especially those that combust fossil fuels. Greenhouse gases are a very small part of the atmosphere (measured in parts per million, ppm, and billion, ppb) – yet they act like a powerful blanket that traps in heat.

At the start of the Industrial Revolution the atmospheric concentration of the main greenhouse gas (GHG) carbon dioxide, was around 275 parts per million (ppm; or just 0.0275 per cent). This level was relatively constant for 11,700 years giving rise to the Goldilocks-like Holocene Epoch. In this period of stable climate agriculture became widespread and civilization took root.

Today the concentration of carbon dioxide has increased to 425 ppm and is rising by more than 3 ppm every year. This level has not been seen since the Pliocene Epoch more that 3 million years ago when global temperatures were 2.5° C – 4° C warmer than pre-industrial levels. This increase in CO_2 came from releasing 1.5 trillion tonnes[2] of carbon since 1750, mainly through burning fossil fuels (coal, oil, gas)[3]. Although 1.5 Tt is an enormous number, less than half was released between 1750 and 1990, the year of the first Intergovernmental Panel on Climate Change (IPCC) report. Most of the world's total GHG emissions have occurred in the last 30 years, despite having had negotiations[4] each year to mitigate these emissions.

The main challenge of climate change is the difficulty in shifting our energy systems, and lifestyle choices, as the world's population continues to increase, and grows wealthier. Despite knowing the harms caused by increased greenhouse gasses, emissions continue to rise – 2023 was another record year for emissions, 57.1 Gt CO2e (57.1 billion tonnes).

Another challenge with climate change is that contribution to the problem, and likely impacts, are highly unequal. The richest 10 per cent of the world's population, including every Canadian, generate more than half the world's GHG emissions. The poorer countries of the world, many low-lying, near the equator, and with many coastal cities, are already experiencing climate impacts much more severely than Canada. They are seeking recourse.

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[1] This report updates the previous report; where information has not changed, some material is verbatim from the 2023 edition.

[2] (1000 kg or 1 tonne (t), or 2205 pounds; 1 billion tonnes is 1 Gt, 1 trillion tonnes is 1 Tt))

[3] A 'ball park' estimate for emissions and targets is that at 450 ppm CO_2 a 1.5°C temperature increase is locked in (in about 5 years with the remaining carbon budget of 250 $GtCO_2$) and 2°C at 550 ppm (about 23 years with 994 $GtCO_2$ remaining) see, https://www.mcc-berlin.net/en/index.html

[4] The first annual 'Conference of the Parties' (COP) under the United Nations Framework Convention on Climate Change (UNFCCC) was held in Bonn, Germany 1995. The IPCC is the international scientific body convened under the UFCCC's mandate. COP29 took place in Baku, Azerbaijan in November 2024. The UNFCCC was agreed to at the Rio Earth Summit in 1992. The first Kyoto Protocol to (unsuccessfully) limit GHG emissions was signed in 1997. The 2015 UNFCCC Paris Agreement established an overarching goal to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to an aspirational limit of temperature increase to 1.5° above pre-industrial levels." The 1.5° C objective is now highly unlikely and the 2° C level will probably be breached this century.

National GHG emissions tend to mirror development pathways. For example, China surpassed the US as the world's largest emitting country in 2006. India's GHG emissions will likely surpass the US before 2050. Canada is one of the few high-income countries whose emissions increased last year.

The Trouble with Transitions

We are in the initial stages of decarbonizing our economy (and reducing methane, CH_4, and nitrogen N_2O). Progress will intensify. Uncertainty, social friction, and stops-and starts should be anticipated. Domestic and international debates about who should pay, and what the pace of the energy transition should be, will increase[5].

The election of Donald Trump to a second term is important. The US may well withdraw from the Paris Agreement in 2025 and discontinue many of the climate mitigation activities initiated through the Inflation Reduction Act (IRA). This will have an impact on Canada's GHG mitigation efforts. Canada is also likely to have a national election in 2025. The Progressive Conservative Party, who are leading in the polls, are promising to discontinue the consumer carbon tax. The current Liberal government, that brought in the tax, further weakened public support for the tax by eliminating heating oil in late 2023. Global consensus suggests a price (tax) on GHG emissions is among the most effective ways to reduce emissions (impact, fairness, progressiveness). Replacing this tax in future will be more costly and less effective.

Scientists agree, increasing GHG emissions and resulting climate change is an existential threat to communities, societies and economies. Governments also agree, and many have committed to transition away from fossil fuels (i.e., a unanimous agreement with the 195 IPCC members). The speed of this transition is now hotly debated, with those reluctant to shift, and industries that may have profits disrupted, such as some automotive, fossil fuel, and the land development and building sectors, actively slowing the process.[6]

The two largest mitigation activities for Durham Region remain low-carbon transportation (EVs, better transit, active mobility, and mobility as a service) and discontinuing the use of fossil gas to heat buildings. Lifestyle changes, such as fewer international flights, changes to diet, smaller vehicles and more integrated mobility, and are also important.

The Region of Durham, comprising eight constituent local municipalities, is a part of a larger urban agglomeration (Toronto Region, or Golden Horseshoe) that behaves as a common community, e.g., economy determined by transportation practices and real estate prices. This larger urban agglomeration is largely controlled by provincial and federal governments. The Region of Durham has limited ability to change energy supply, manufacturing practices, and

[5] Good examples are Vancouver and Nanaimo, BC who recently banned natural gas connections to new buildings, and the intense lobbying by the oil and gas industry to overturn the decision https://www.cbc.ca/news/canada/british-columbia/vancouver-councillors-vote-to-keep-natural-gas-heating-ban-1.7395652 and Nanaimo must unban Natural Gas - Support Canadian Energy.

[6] See 2023-24 Enbridge and BILD presentations to local councils in southern Ontario, delays in EV schedules in the US and Canada.

lifestyle choices of its residents in isolation of the broader Canadian, and North American, community.

A challenge associated with the energy transition is overcoming the inertia associated with the status quo. For example, fossil fuels are heavily subsidized around the world (Fig. 12). In Canada, where the national government has agreed to phase out fossil fuel subsidies, there is still an annual $38 billion subsidy to fossil fuels. Existing companies exert considerable influence on the political system by promoting a 'go slower' approach, locking in existing infrastructure and approaches. Future companies like the clean energy sector, are often smaller and evolving, and can exert less influence than existing, legacy industries. The future has few lobbyists, while the past is replete with companies lobbying to maintain reliance on fossil fuels, and material use, e.g., the plastics industry. Canada's oil and gas industry generated more than $250 billion in revenue in 2022 (about 3% of Canada's GDP; Fig 13).

Canada's oil and gas industry supports today's economy. Forgoing this financial contribution will be difficult, however, a low carbon, clean energy future, will save most households. Overall energy costs should be lower, and the costly externalities associated with fossil fuels reduced. For example, health impacts, climate change, and transportation (more than a third of all global shipping is fossil fuels). Another key aspect of the fossil fuel economy is that it is inherently inefficient. More than 60 percent of energy from burning fossil fuels is lost in conversion to usable energy.[7] About 40 percent of world shipping is moving oil, gas and coal.[8] Enormous efficiencies are possible.

Climate in Context

Politics, profits and personal preferences aside, the metrics that matter most to climate mitigation are atmospheric concentration of carbon dioxide (~425 ppm CO_2), methane (CH_4 ~1932 ppb), and current GHG emissions (57.1 Gt CO_2e in 2023).

This report outlines the Region of Durham's (community-wide) annual progress toward meeting the net-zero-by-2050 target. Despite this target being only 25 years away, enshrined in Canadian legislation, and echoed by hundreds of cities, provinces, businesses and other countries, there are few credible community and institutional plans to get there from here.

Community climate plans differ from country plans in that they need to capture GHG emissions attributed to residents and businesses in a community regardless of where the emissions took place. Emissions associated with imports, exports and included in items like international travel, food and building materials, need to be accounted, e.g., "Scopes" 1, 2 and 3 (see Annex 1).

Measuring GHG emissions is not straightforward, but credible estimates can be made that include emissions from all activities associated with lifestyle, employment, and geography. In 2023 each resident of Durham on average was responsible for about 39.5 tonnes of GHG emissions. This is among the highest in the world (top five per cent).

[7] International Energy Agency (2020), from US Energy Information Administration, Monthly Energy Review 2019
[8] Forbes, Dec. 5, 2023. How will climate action change the face of global shipping?

Canada is a signatory of the Paris Agreement. Meeting national (and international) emissions reduction targets will be enormously difficult. However, withdrawing from the Agreement would trigger significant economic and geopolitical consequences.

The Region of Durham, like Ontario Tech University and Ontario Power Generation declared a net-zero target for GHG emissions[9]. Like the Government of Canada's net-zero declaration, this assessment provides an economy-wide evaluation of the target for all GHG emissions, i.e., Scopes 1, 2 and 3 (upstream and downstream). The target suggested is for the total share of the global GHG emissions attributed to activities in Durham.

This report provides a comprehensive GHG inventory from local and global activities of those living within a defined geographic area (Region of Durham). This is not intended to facilitate blaming or shaming, but rather provides a detailed roadmap on the scale of the challenge, and possible routes for mitigation.

Climate change and mitigation of GHG emissions is complex. No single government, institution, or individual can solve this challenge. Adding to the complexity of mitigating GHG emissions is the need to adapt to a changing climate (the Region of Durham is already experiencing a 1.1ºC average temperature increase and should prepare for at least 2.5ºC this century (an enormous impact). Impacts include health effects[10], rising costs of infrastructure, storm intensity, growing social strife, food security and climate refugees.

The United Nations Environment Program's 2023 Emissions Gap Report No More Hot Air, is equally pessimistic suggesting that to get on track to limiting warming to below 2°C, annual global emissions in 2030 need to be 14 GtCO2e (range: 13–16 GtCO2e, >66 per cent chance) lower than what current government commitments imply, and 22 GtCO2e (range: 21–24 GtCO2e, >50 per cent chance) lower for a warming limit of 1.5°C. For 2035, these gaps increase by 4 GtCO2e for a 2°C warming limit, and 7 GtCO2e for a 1.5°C limit.

Specifically, if action in line with 2°C or 1.5°C pathways were to start in 2024, then global emissions would need to be reduced by an average of 4 and 7.5 per cent every year until 2035, respectively. If enhanced action that goes beyond current unconditional NDCs is delayed until 2030, then the required annual emission reductions rise to an average of 8 per cent and 15 per cent to limit warming to 2°C or 1.5°C, respectively. The Region of Durham's emissions increased by about 2 per cent 2022 to 2023.

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[9] The **Corporate Climate Change Action Plan** was adopted by Durham Regional Council on March 24, 2021. The Climate Change Action Plan (CCAP) is the Region's overarching framework that sets greenhouse gas (GHG) emissions reduction targets to become Net Zero by 2045.
Short, medium, and long-term targets to reduce corporate GHG emissions are:
- 20 per cent GHG emissions reduction by 2025, below 2019 levels,
- 40 per cent GHG emissions reduction by 2030, below 2019 levels,
- 100 per cent GHG emissions reduction by 2045, below 2019 levels.

The Region's targets (corporate and community-wide) are irrespective of total population. Values are provided in this report as total and per person.

[10] See Fig. 16, from: A. Swirski and T. Zupancic, *Climate Change and Health in Durham Region: Understanding the local health impacts of climate change.* Durham Region Health Department, May 2024.

Little Little, Big Big: The challenge of reducing community GHG emissions

Community-wide emissions are the most important to focus on as they are, by definition, the most comprehensive (they include all emissions, everywhere, that can be attributed to people living and working in Durham Region). This comprehensiveness, however, introduces a challenge for attribution. For example, the Regional Municipality of Durham has direct influence on less than five per cent the community's total GHG emissions. Similarly, local municipalities like Pickering and Oshawa, have limited influence.

The Province of Ontario and Government of Canada also have limited ability to mitigate overall atmospheric GHG concentrations. Businesses and organization also have limited influence, and GHG emissions are usually not part of their key mandates. Even individual households which can directly change their purchasing habits (*e.g.,* less meat) and travel patterns (fewer flights and cruises), but also have limited impact on their own. A system-wide change is needed where network effects promote large scale shifts. For example, most people will not voluntarily shift to EVs if they do not believe charging facilities are readily available. However, tipping points are already emerging as new business structures and government support arise.

In Canada, the challenge is exacerbated as the transition to a low carbon economy places significant and disproportionate strains on large parts of the country's economy. Oil and gas production, some agricultural practices, and the way most buildings are heated, needs to change. So too much of the current transportation system needs major overhaul. Arguments are already underway on how fast and how deep GHG mitigation needs to be. The debate however is not just within provinces, or even within Canada, but is international, bringing in the added complexity of equity between countries (current, historic and future).

This report provides a comprehensive community GHG emissions inventory. The inventory highlights the intractable problem of reducing GHG emissions. Challenges arise as emissions are 'lumpy' as unique aspects of the community contribute disproportionately to the inventory. For example, auto assembly in the Durham Region contributes almost half of the community's GHG (Scope 3) emissions. Almost none of these emissions will occur in the Region, and in alternate accounting practices, the emissions would be counted in the jurisdiction where the vehicles are operated.

Meanwhile two equally large contributors to overall GHG emissions are not included in community inventories, namely the downstream emissions from fossil fuels exported from Canada (939 Mt, or 24 t per person), and the GHG emissions associated with forest fires in Canada in 2023 (2,371 Mt, or 53 t per person).

There is also a concern that presenting a community GHG inventory of this comprehensiveness foments complacency in some, 'my emissions are so small compared to forest fires, why should I bother?', and perhaps defensiveness in others, 'why single out an industry when the product is used elsewhere?'. Durham Region's GHG emissions inventory is unique, reflecting the types of industries that are located here. However, there is much that is common with the rest of Canada.

The Region of Durham's community emissions come in two broad categories: emissions from political, lifestyle and infrastructure decisions made within the community; and emissions from outside the community that residents of Durham have limited ability to influence. The first category, 'local control' is still very difficult to enact. Why, for example, should a resident in Durham forgo international travel or live in a smaller house, if the rest of the country, and world, is not exercising similar restraints. The second category, 'limited control' highlights how the residents of Durham have a very modest ability to impact activities like forest fires in northern Canada, or Brazil, fossil fuels combusted elsewhere, or even the carbon intensity of electricity supplied to Durham or continued heavy reliance on fossil gas for heating.

The fossil fuel industry in Canada is a good example of the complexities in reducing GHG emissions. Fossil fuels are Canada's largest export (about 25% of all exports; 4.84 million barrels per day – Canada exports about 80% of its crude oil production, and 45% of natural gas). The emissions (Scope 3 downstream) from these exported fossil fuels exceeded 1 billion tonnes in 2023 (more than the country's total emissions of 707 Mt CO_2e). About 30 precent of Canada's total GHG emissions are from oil and gas sector activities (within Canada).

There is little gain for Canada to stop exporting oil and gas if it is just replaced by fossil fuels from another country. Canada forgoes the revenue while overall emissions are unchanged. Complexities are exacerbated through efforts of fossil fuel companies and jurisdictions that profit from them, to slow the energy transition as much as possible (as the status quo supports income and finance). Canada, being one of the world's loosest federations, where provinces directly oversee their resources, has an especially difficult challenge. Regional differences, such as most oil and gas reserves in (landlocked) Alberta, and little in the rest of the country, a preponderance of home heating oil used in the Atlantic Region where household incomes are lower than the national average, refinery facilities that favor importing oil for eastern Canadian needs.

Forest fires are another example of the complexities associated with community-based GHG emissions inventories. In 2023 Canada had an exceptionally severe forest fire season, releasing an estimated 2.4 Gt of CO_2 (2.4 billion tonnes, or more than double the emissions associated with all exported fossil fuels in 2023, and three-times Canada's total 2023 GHG contribution). The convention of GHG emissions inventories does not include emissions from forest fires, however this is likely to change in future. Difficulties arise in measuring emissions from forest fires and other land use changes, as carbon is also being sequestered in Canadian forests (locked in wood and soil).

All of Durham's GHG emissions combined are much smaller (less than 0.5%) than just two sources of emissions in 2023, forest fires and exported fossil fuels, which are typically not included in Canada's GHG emissions inventories.

When reviewing emissions inventories, activities like eating less beef and better insulating the house, are almost insignificant in scale to fossil fuels and forest fires. However, similar to pebbles thrown in a pond, seemingly small actions in Durham can ripple outward. These 'little' efforts are compounding to provide the big impacts needed to mitigate GHG emissions around the world.

GHG emissions in the Region of Durham

Figures 2 and 3 detail Durham's total GHG emissions. Upstream emissions (Scope 3) associated with provision of key materials used within the region, include 2.1 $MtCO_2e$ embodied in the fossil fuels used within the region. For example, production activities in Alberta and the US and the Middle East, transmission, and possible leakage of natural gas. These upstream emissions add about 36 per cent to the emissions associated with combusting fossil fuels within the region. Upstream mining and processing of the uranium used to power the Pickering and Darlington Nuclear Generating Stations is another 0.4 $MtCO_2e$ (although these emissions would be subtracted if considering regional exports, e.g., vehicles and agricultural products).

The embodied carbon emissions of imported food to the region are 1.4 $MtCO_2e$. Building materials imported into the region include about 0.7 $MtCO_2e$ per year. This is added to the 1.5 $MtCO_2e$ per year emitted from heating buildings with natural gas.

The largest share of emissions is associated with the transportation sector 6.2 M tCO_2e, almost 20 per cent of total emissions. This includes about 700,000 tonnes CO_2e from air travel originating from Pearson International Airport, about 5 per cent of the Region's total emissions. Production of cement, steel, aluminum, and vehicles is about 1.2 $MtCO_2e$, about 4 per cent of the total.

Total emissions associated with electricity used in 2023 are 291,310 tonnes CO_2e (still one of the lowest values in the world) while natural gas burned to heat all buildings generated five-times more emissions, 1.5 $MtCO_2e$.

Corporate emissions from Region of Durham municipal activities are 178,000 tonnes CO_2e (Durham York Energy Centre 80,627 t; Brock West landfill 54,296 t; water supply and sewerage 24,929 t; Regional facilities natural gas 15,600 t; facilities electricity 4,100 t). This is less than one per cent of the total GHG emission associated with activities within Durham Region. Similar corporate emissions are likely attributable to the eight local area municipalities.

Net zero priorities for the organization, businesses, and residents of Durham

Figures 2 and 3 provide a comprehensive inventory of GHG contributions in Durham. Durham's GHG mitigation priorities are transportation systems; heating of buildings (use of natural gas); and changing agricultural practices (eating less meat and producing less food waste). Industries within the region that generate significant GHG emissions, are undergoing unique and ongoing mitigation efforts. For example, decarbonizing cement is an industry-wide effort with development and application of new technologies.

Durham's robust manufacturing sector produces materials such as cement, steel, and automobiles[11]. Most of these products are exported from the Region, and in a strictly 'fair' GHG inventory approach, these emissions should be borne by final customers. This however is not fully consistent with protocols for community based GHG inventories. The GPC standard ascribes these emissions to the community where emissions are generated, assuming that this is where most economic benefits of the activity accrue. For simplicity in applying emissions, the inventory assumes that 95 per cent of the manufactured products are exported from the region.

This year's inventory includes a notional assessment of typical individual household activities. For example, in addition to diet, size of home, heating method, personal activities such as air travel[12], cruises[13] and pets[14] can have a significant impact on overall GHG emissions.

Mitigation Priorities

Like last year's report, mitigation priorities for Durham Region are apparent.

Individual companies, such as St Marys Cement, General Motors and Ontario Power Generation will develop their own mitigation pathways.

The top activities for Durham Region remain:

(i) shift to a low-carbon integrated mobility (rideshare, EVs, e-bikes, active transportation, better transit).
(ii) redesign neighborhoods to reduce single occupant vehicle use and high heating and cooling demands for buildings.
(iii) phase out natural gas for space heating, *e.g.*, use heat pumps, smart thermostats.
(iv) modify buildings (new construction and renovations) to use material with less embodied emissions.
(v) reduce (or effectively offset) air transportation and cruises.
(vi) shift to diets with less meat and reduce food waste.
(vii) shift agriculture practices to enhance carbon sequestration in soil and reduce emissions from livestock and manure management.
(viii) Manage waste, including reduced plastics.
(ix) minimize leaking methane in wastewater treatment, landfills, and gas transmission.
(x) shift to a more circular economy with emphasis on waste management (minimization).

[11] Large emitters as defined by Environment and Climate Change Canada in Durham Region include: St Marys Cement (1,161,426 t CO_2e in 2022); Gerdau Ameristeel (124,037 t); Atlantic Packaging (75,432 t); General Motors (92,005 t); and Signature Aluminum (14,846 t).
[12] ~145 kg CO_2 per hour per person flying, https://ourworldindata.org/travel-carbon-footprint
[13] ~450 kg per day per person of cruising https://www.myclimate.org/en/
[14] ~2-3 tonnes CO_2 per year for medium sized dog, https://8billiontrees.com/carbon-offsets-credits/carbon-ecological-footprint-calculators/dog-carbon-footprint/

Consistent with the top priority, the Region should establish an integrated mobility program that includes at least Ontario Tech, Durham College, Trent, Ontario Power Generation, Metrolinx, Durham Transit, the school boards, and Lakeridge Health. This should include a rideshare app(s).

Within the Greater Golden Horseshoe (GTA plus Hamilton and Niagara), Durham Region has the highest total land area in farms: 31.2 per cent. The Region is already developing an agriculture management plan. The priority for mitigating GHG emissions in the agriculture sector is reducing the embodied carbon in imported food (*e.g.*, 1.45 Mt CO_2e compared to 0.2 MtCO_2e generated locally), however as such a large share of land is actively farmed, regionally, efforts at silvopasture (integrated forestry, livestock, and forage) and carbon sequestration in soils, are a high priority.

The Region of Durham should be commended for stating a net-zero by 2045 target. As this report outlines, achieving this target will be challenging. Regional partner governments and organizations have also issued net-zero targets, *e.g.*, Ontario Tech University and Ontario Power Generation (2040). As outlined by the Government of Canada, these net zero targets are assumed to apply to all emissions from the economy, Scopes 1, 2 and 3 (upstream and downstream). Clear methodologies on how to define and measure overall emissions are still being developed. The Region of Durham should continue to lead in this area, *i.e.*, defining and annually publishing overall emissions, ideally in partnership with other stakeholders in the Region.

Most of the actions required to mitigate GHG emissions are not under the direct oversight of the regional government or local municipalities. The Province of Ontario, Government of Canada, local businesses and organizations, and residents, all have a key role to play. In subsequent reports, high priority activities for other stakeholders should be defined, and differentiated emissions inventories by local municipalities published.

Box 4.1 Scope of the Challenge, A Consumer's Tale[15]

Doug is about to propose to his soon-to-be (hopefully) fiancé. In preparing for the big night, he did his homework. His girlfriend, Dana, is fiercely determined to reduce greenhouse gas (GHG) emissions. Of course, that's one of the things he loves about her. Doug's cooked a special meal. Chicken, quinoa, and spinach salad, with apple pie for dessert. They have not given up meat but have reduced the amount they eat and try to stick to poultry and some fish (the whole meal, he estimates, is about 5 kg CO_2 plus 1.5 kg CO_2 for the bottle of good French wine). Doug also bought a dozen roses (about 2 kg CO_2 per stem[16]).

The engagement ring is another 550 kg CO_2 (350 kg for the gold, 200 kg for the 1 carat diamond). They do not have the budget for a honeymoon cruise (which could add another 4-5 t CO_2), but plan to go to a resort in Muskoka, with minimal additional emissions).

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[15] From Hoornweg (2025) *Canada's Cities in a Changing World (1920-2120): The Halftime Report*, in press.

[16] In Durham Region most roses are imported from South America (typically Columbia and Ecuador) and driven north from the main US Airport, Miami. Emissions estimated to be slightly lower than those for roses in the UK (Dutch Roses: 2.437 Kg CO2, Kenyan roses: 2.407 Kg CO2 – see www.flowersfromtheuk.org)

The total annual GHG emissions of a Canadian are around 20 t (20,000 kg CO_2 per year) and Canada has committed to get to zero by 2050. The engagement ring and their wedding (probably another 1,000 kg CO_2) are a special occasion that the couple hope will be offset over their lifetime choices, especially when alternatives, like better transit, EVs, and low carbon energy (carbon equivalent of less than 20 g/kWh), are the norm, which will make reducing emissions easier.

Doug can calculate the GHG emissions associated with the big night because of efforts made by a few businesses and the World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI). Work started in 1997 and in 2001 a global GHG emissions protocol was launched.

For businesses to track their emissions, they need a more comprehensive method than the territorial approach countries use to determine national emissions (estimate all emissions generated within the country's borders). The same is true for Doug wondering about his ring and roses. The gold may have come from Canada, the diamond from Botswana, and roses from Ecuador, but he wants to know the total emissions, especially the upstream (Scope 3) emissions.

The WBCSD-WRI emissions inventory uses Scopes 1, 2 and 3 to account for where emissions are generated, while reducing the risk of double-counting. Scope 1 and 2 are direct emissions, such as electricity and fuel used in company vehicles. Scope 3 are embodied emissions. For example, the upstream emissions in the parts a vehicle manufacturer assembles, or the downstream emissions from the eventual use of that manufactured vehicle after it is sold[17].

The larger challenge that Doug and Dana face is that GHG emissions are only one issue. The rate of biodiversity loss needs to slow dramatically, so too air and water pollution. A healthy economy in Canada and globally will also be important, with safe working conditions for everyone.

The engagement ring generated 60 tonnes of mining waste, and what if it is a 'blood diamond' (despite the jeweler's assurances it was not). The complexity of the challenge – accounting for the impacts at all stages of our activities – is significant.

The couple have talked about having one, maybe two, children. What kind of planet will they inherit, and what's the impact of bringing two more Canadians into the world? They are looking to buy a small house in Clarington, but only if they have easy access to the GO train for getting to work. But the future is uncertain, even before taking on a larger mortgage.

The halting progress in GHG accounting is a good example of the challenge. And measuring is much easier than genuinely reducing emissions. In recent years more businesses started to provide comprehensive Scopes 1, 2 and 3 (upstream and downstream) emissions, but many stopped and delayed, claiming customers were not interested, or the process was too complicated, especially for Scope 3 emissions.

[17] See ISO 14064-I: Greenhouse Gas Protocol

Municipalities and institutions, wanting to track their GHG emissions and progress toward net-zero targets, also started to track GHG emissions. However, only a few include Scope 3 emissions. However, as Doug's roses and ring highlight, without accounting for upstream and downstream impacts, the inventory is likely woefully inadequate.

Many businesses and governments expanded GHG emissions accounting efforts to include broader environmental, social and governance (ESG) issues. Alberta's claims that their oil and gas is preferrable to say, Saudi Arabia's, with a poorer human rights record is illustrative. In response, Saudi Arabia may question Alberta's history with First Nations communities or ask what the equivalency is between higher GHG emissions versus human rights (or abandoned wells). These complexities are behind many of the recent delays in corporate reporting of ESG metrics and postponing of Scope 3 accounting. They may also be a way to put off meaningful mitigation.

Dana and Doug's household, and the community they live in, is the optimum scale for GHG inventories and ESG accounting. A business, for example, is most concerned with selling their product. ESG metrics might be a way to differentiate themselves from a competitor, but they will be reluctant to provide information if it suggests reducing sales. Most national and provincial governments are the same. Economies, and GDP are largely derived from the sale of resources and manufactured products.

Households and communities on the other hand are concerned with both maintaining the economy (for jobs and GDP for example), as well as reducing local and global consumption (for reduced planetary impacts). The balance between the two and the pace of environmental remediation and social equity are key.

The Scope 1, 2 and 3 approach, with an appreciation for upstream and downstream impacts, can be used for activities beyond GHG emissions. A good faith account of value chain impacts will help people like Dana and Doug make the right choices for their families and the health of the planet.

Powerful Partners

In addition to Durham Region and local municipalities declaration of a climate emergency and net zero targets, as well as the Lakeridge Health and School Boards, Ontario Tech University, General Motors Canada, and Ontario Power Generation have aggressive net zero targets.

Ontario Tech University has a net zero target (all scopes) by 2040. Ontario Power Generation has a corporate net zero target of 2040, and integrated province-wide (all scopes) net zero target of 2050[18]. General Motors has one of the Region's most aspirational net zero targets and is already exhibiting leadership in the OEM (original equipment manufacturer) auto sector. General Motors has set a target to achieve carbon neutrality in global products and operations by 2040.[19]

[18] file:///C:/Users/100328238/Downloads/OPG_ClimateChange2020_Final-FINAL-ua.pdf
[19] https://www.gm.com/content/dam/company/docs/us/en/gmcom/company/GM_2023_SR.pdf

Through the Region of Durham's annual GHG inventory and net zero progress mapping (this report), at least the Region of Durham, Ontario Tech University, OPG, and GM can use a common GHG inventory (accounting for Scope 3 emissions). Aspirational activity-wide net zero targets require an overall community approach to GHG mitigation. No single municipality, institution or business can shift to net zero GHG emissions on their own. The Region of Durham is well placed to establish a critical mass of like-minded organizations, and residents in the community-wide transition to net zero.

Table 1: GHG Emissions Durham Region, 2023

OVERVIEW (GPC Table 4 with Scope 3 + 7)

NAME OF CITY:	Region of Durham, Ontario, Canada	**POPULATION:**	753,500.0 METRO AREA
		LAND AREA (km2):	2,524
INVENTORY YEAR:	2023	**GDP (US$ B):**	
		tCO2/Capita Scope 1	8.3
		tCO2/Capita Scope 1,2,3	39.5

GHG Emissions Source (By Sector)		Total GHGs (metric tonnes CO2e)						
		Scope 1	Scope 2	Scope 3 included in Basic/Basic+	Other Scope3	BASIC	BASIC+	BASIC+ S3 +7
STATIONARY ENERGY	Energy use (all emissions except I.4.4)	1,501,179	291,310	534,328	429,590	1,792,489	2,326,817	2,756,407
	Energy generation supplied to the grid (I.4.4)	80,627						
TRANSPORTATION	(all II emissions)	3,100,737	929	3,135,830		3,101,666	6,237,497	6,237,497
WASTE	Waste generated in the city (III.X.1 and III.X.2)	72,316				72,316	72,316	72,316
	Waste generated outside city (III.X.3)	48,712						
IPPU	(all IV emissions)	1,265,288			15,336,193		1,265,288	16,601,481
AFOLU	(all V emissions)	188,288			1,455,064		188,288	1,643,352
OTHER SCOPE 3	(all VI emissions)				2,454,946			2,454,946
TOTAL		6,257,147	292,239	3,670,159	19,675,793	4,966,471	10,090,205	29,765,998

GPC ref No.	GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO2e)			
		Scope 1	Scope 2	Scope 3	Total
I	STATIONARY ENERGY				
I.1	Residential buildings	864,579	92,048	280,090	1,236,717
I.2	Commercial and institutional buildings and facilities	328,153	111,848	134,389	574,390
I.3	Manufacturing industries and construction	308,447	87,414	119,850	515,711
I.4.1/2/3	Energy industries				
I.4.4	*Energy generation supplied to the grid*	80,627			80,627
I.5	Agriculture, forestry and fishing activities				
I.6	Non-specified sources				
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal				
I.8	Fugitive emissions from oil and natural gas systems				
SUB-TOTAL		1,581,806	291,310	534,328	2,407,444
II	TRANSPORTATION				
II.1	On-road transportation	3,024,578	929	1,337,074	4,362,581
II.2	Railways	75,359		36,172	111,531
II.3	Waterborne navigation			71,602	71,602
II.4	Aviation	800		1,690,983	1,691,783
II.5	Off-road transportation				
SUB-TOTAL		3,100,737	929	3,135,830	6,237,497
III	WASTE				
III.1.1/2	Solid waste generated in the region	43,521			43,521
III.1.3	*Solid waste generated outside the region*				
III.2.1/2	Biological waste generated in the region				
III.2.3	*Biological waste generated outside the region*				
III.3.1/2	Incinerated and burned waste generated in the region	3,866			3,866
III.3.3	*Incinerated and burned waste generated outside region*	11,500			11,500
III.4.1/2	Wastewater generated in the region	24,929			24,929
III.4.3	*Wastewater generated outside the region*	37,212			37,212
SUB-TOTAL		121,028			121,028
IV	INDUSTRIAL PROCESSES and PRODUCT USES				
IV.1	Emissions from industrial processes occurring in the region boundary	1,265,288			1,265,288
IV.2	Emissions from product use occurring within the region boundary			15,336,193	15,336,193
SUB-TOTAL	30	1,265,288		15,336,193	16,601,481
V	AGRICULTURE, FORESTRY and OTHER LAND USE				
V.1	Emissions from livestock	125,525		970,042.5	1,095,568
V.2	Emissions from land	62,763		485,021.3	547,784
V.3	Emissions from aggregate sources and non-CO2 emission sources on land				
SUB-TOTAL		188,288		1,455,064	1,643,352
VI	OTHER SCOPE 3				
VI.1	Energy not included In I.7 & I.8			429,590	429,590
VI.2	Building Material			701,099	701,099
VI.3	Food not included in V				
VI.4	Transportation not included in II.5				
VI.5	Water				
VI.6	Waste/Sewage Management not included in III				
VI.7	Key Infrastructure				
VI.8	Other Scope 3			1,753,847	1,753,847
SUB-TOTAL				2,884,536	2,884,536
TOTAL	Territorial	6,257,147	292,239	23,345,951	29,895,338
Total	Scope 1 and 2 Basic+ Reporting	6,127,808	292,239		6,420,047

Sources required for BASIC reporting
\+ Sources required for BASIC + reporting
Sources included in Other Scope 3
Sources required for territorial total but not for BASIC/BASIC+ reporting(italics)
Non-Applicable emissions

Figure 1: Origin of GHG Emissions, Durham Region, 2023

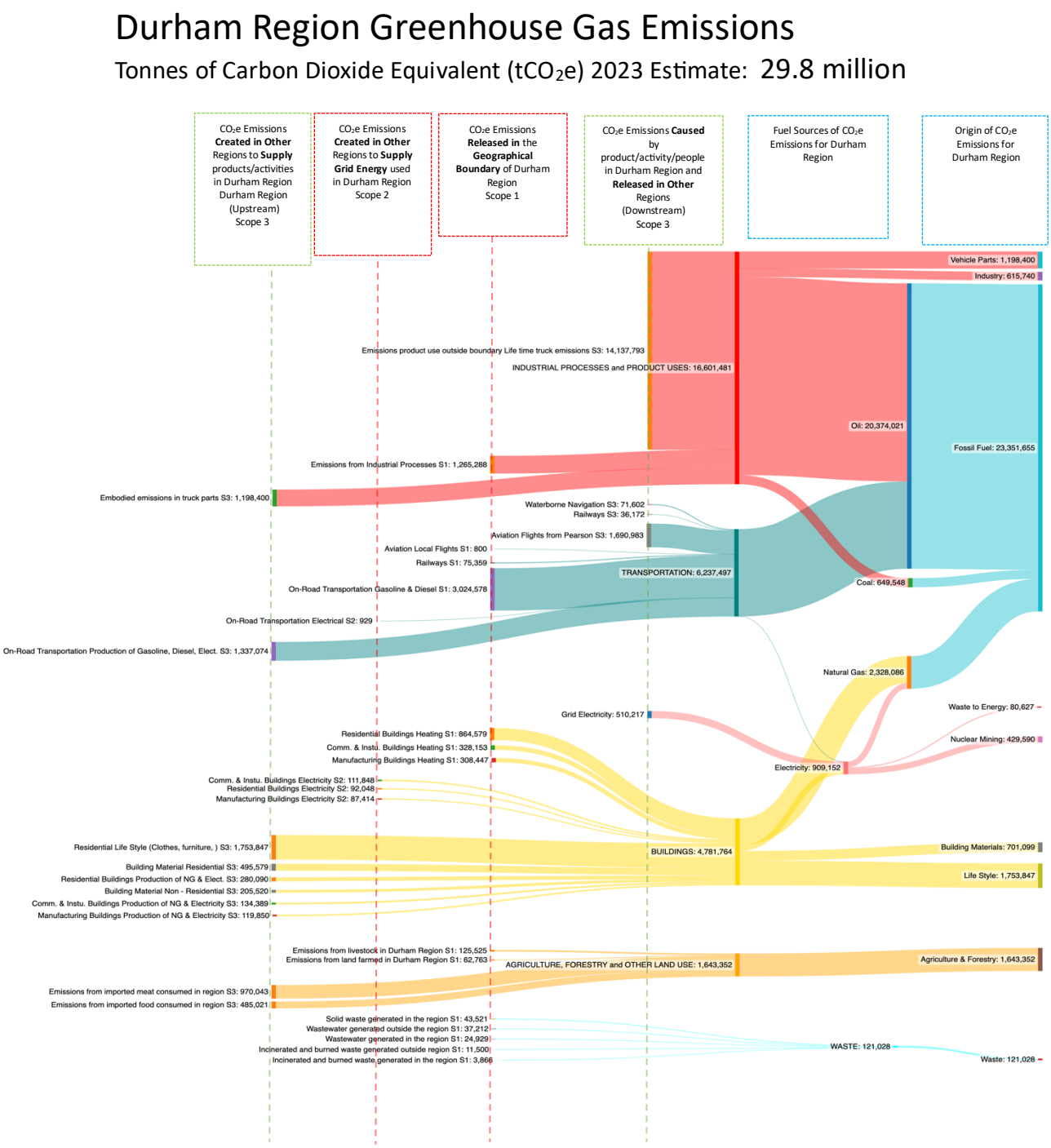


Figure 2: Durham Region, Community – Total Emissions 2023 (29.8 Mt CO_2e)

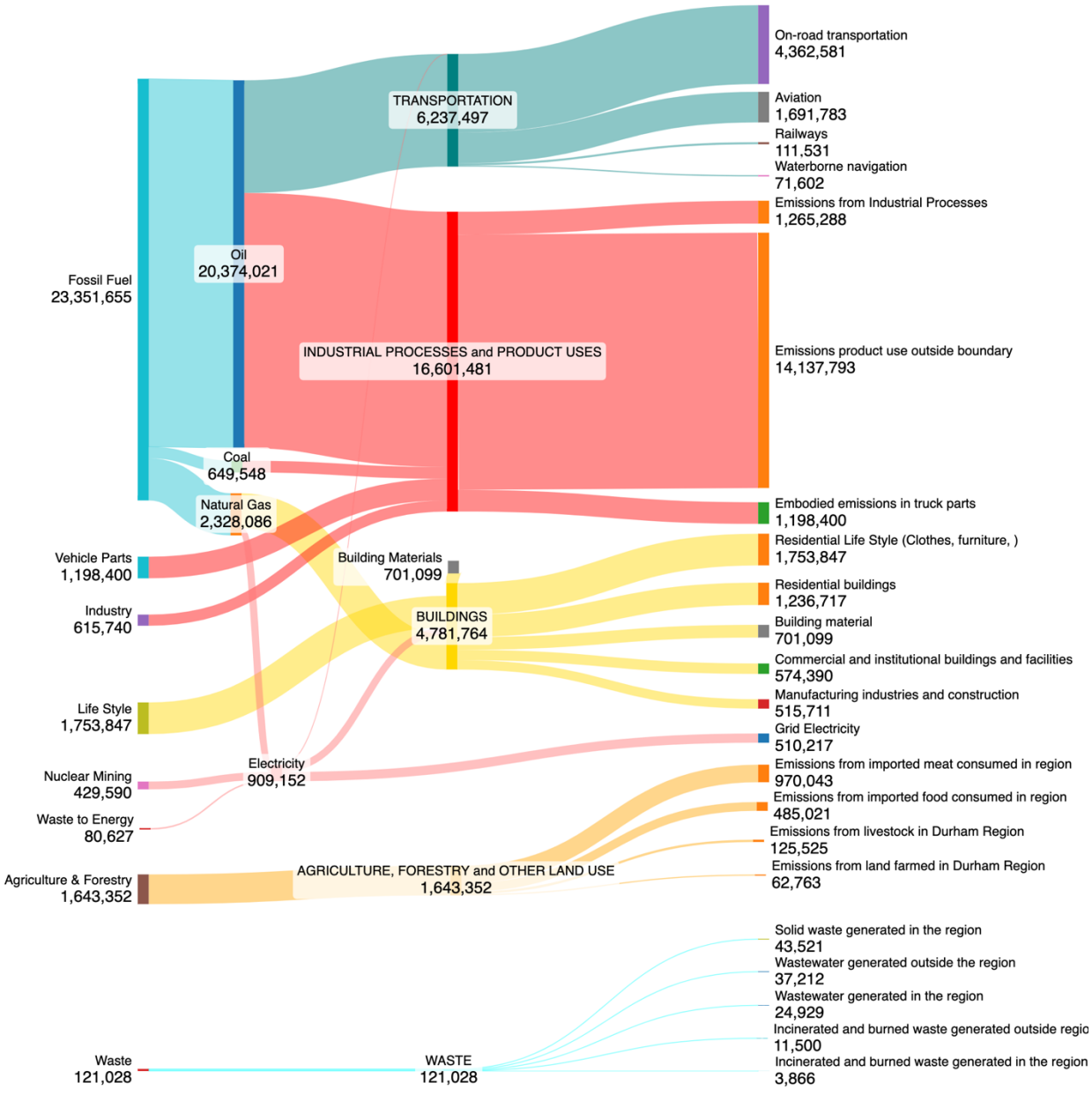


Figure 4: Global GHG emissions 2023 (from UNEP)

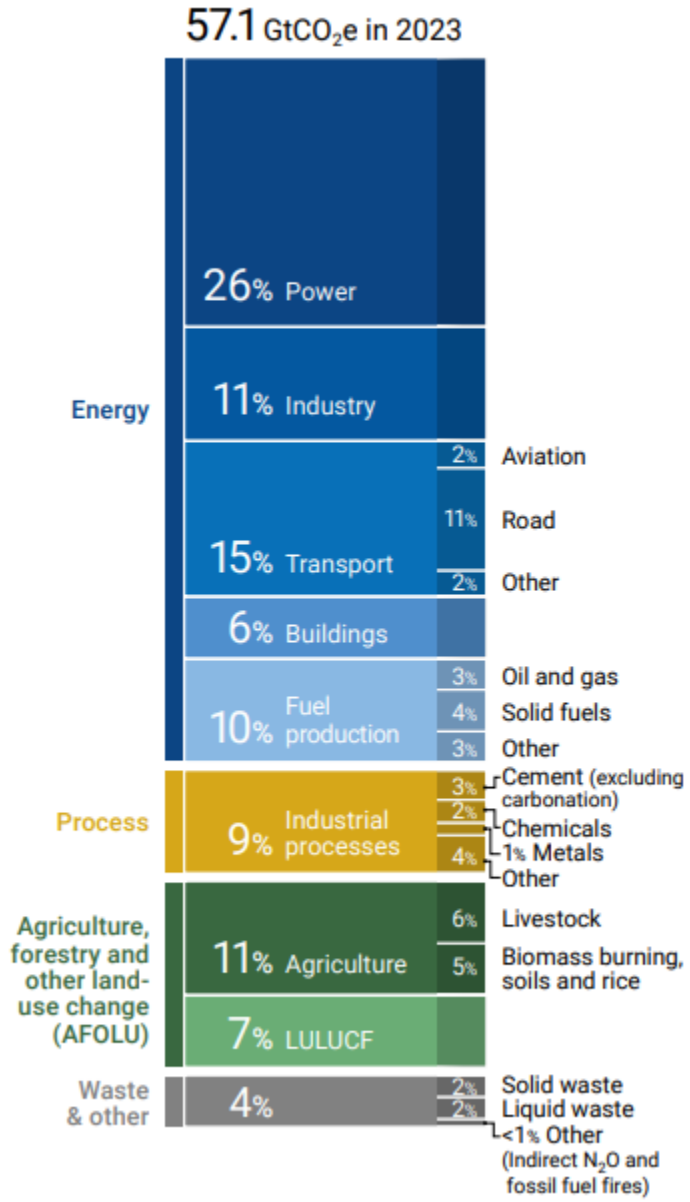


Figure 5: Concentration of atmospheric CO_2 (the Keeling Curve)

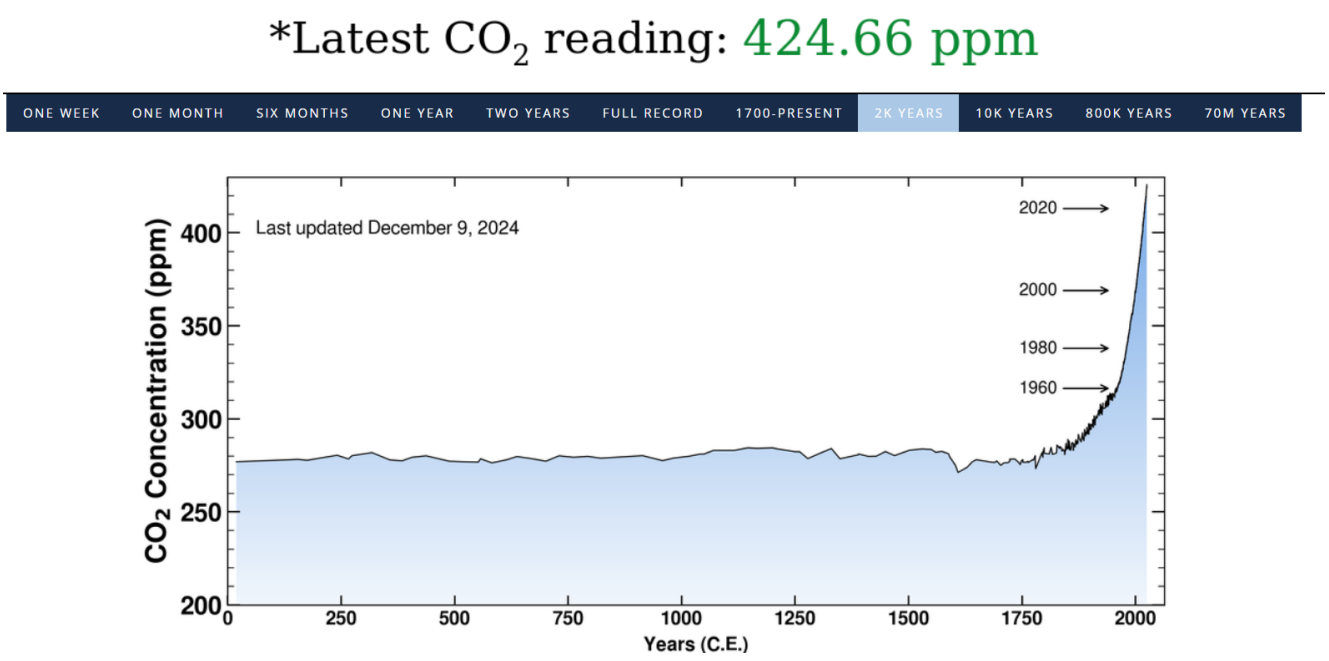


Figure 6: Concentration of methane (from 1010)

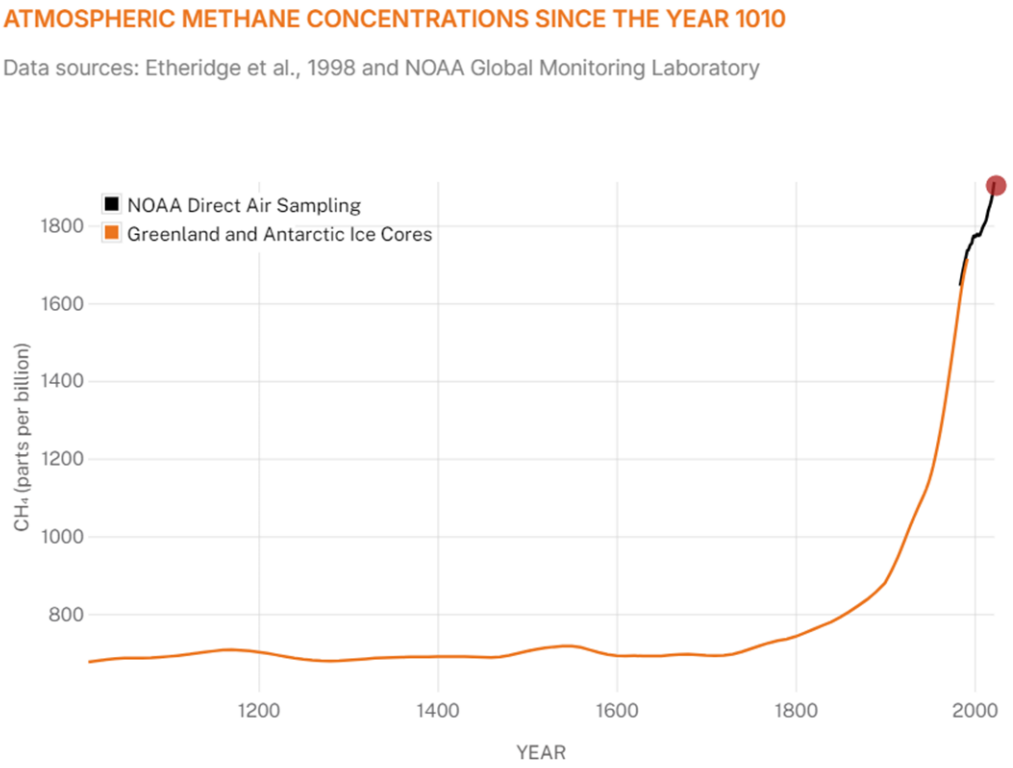


Figure 7: Concentration of methane (from 1984)

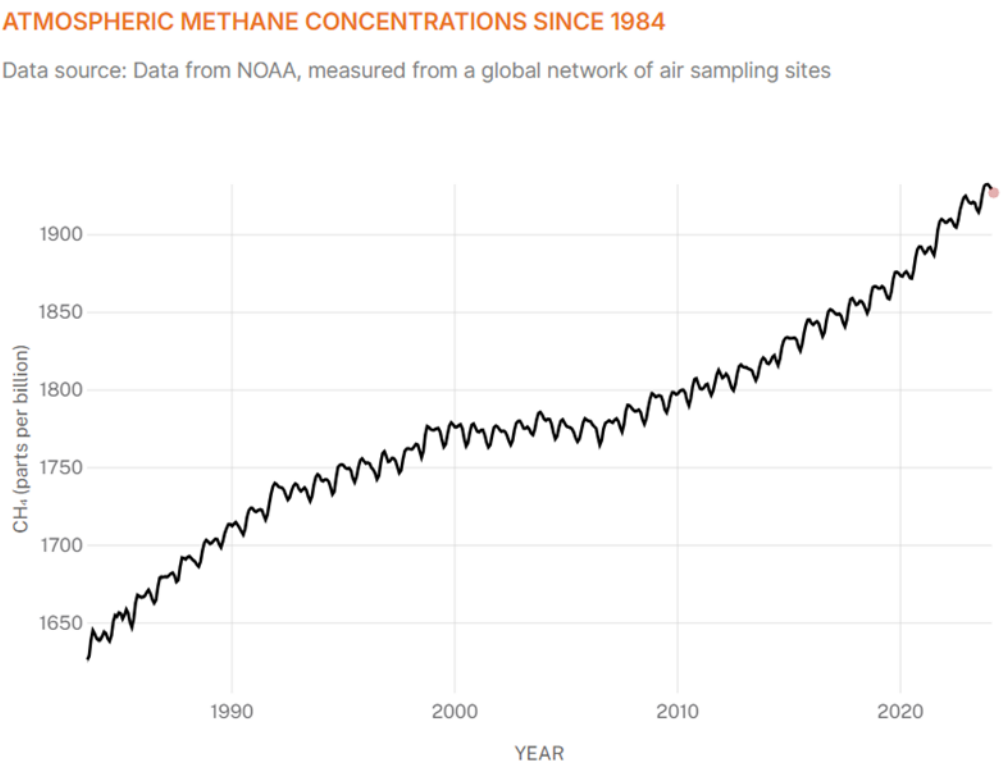


Figure 8: Historic Temperature Variations (last 2023 years)

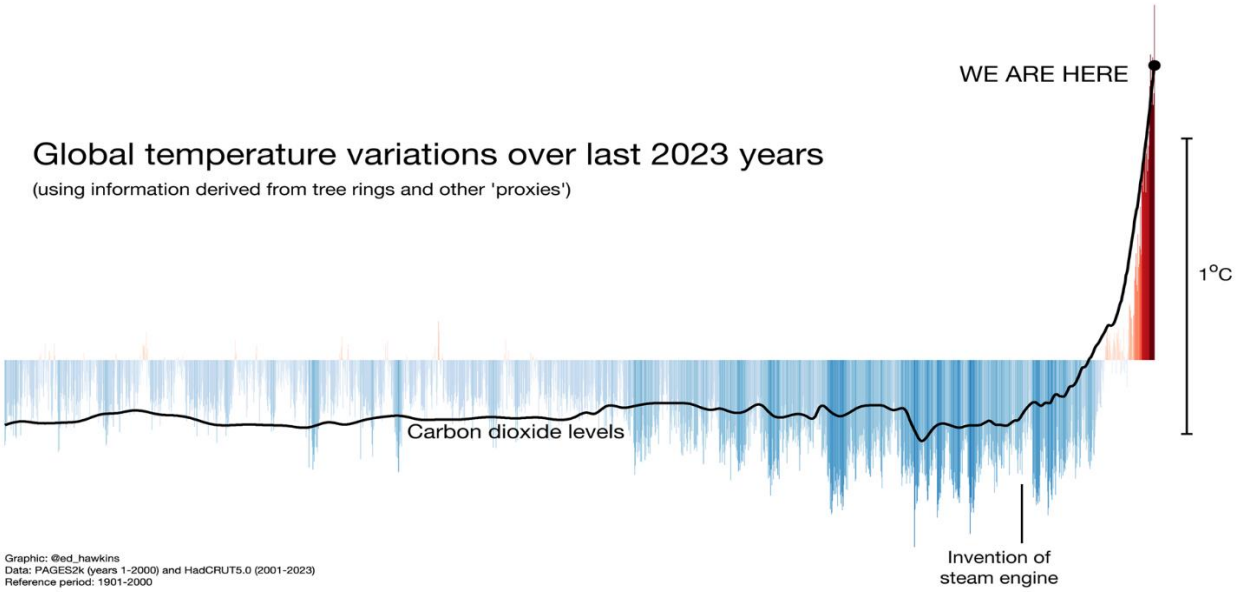


Figure 9: Global temperature variations Quaternary Period (last 22,000 years)

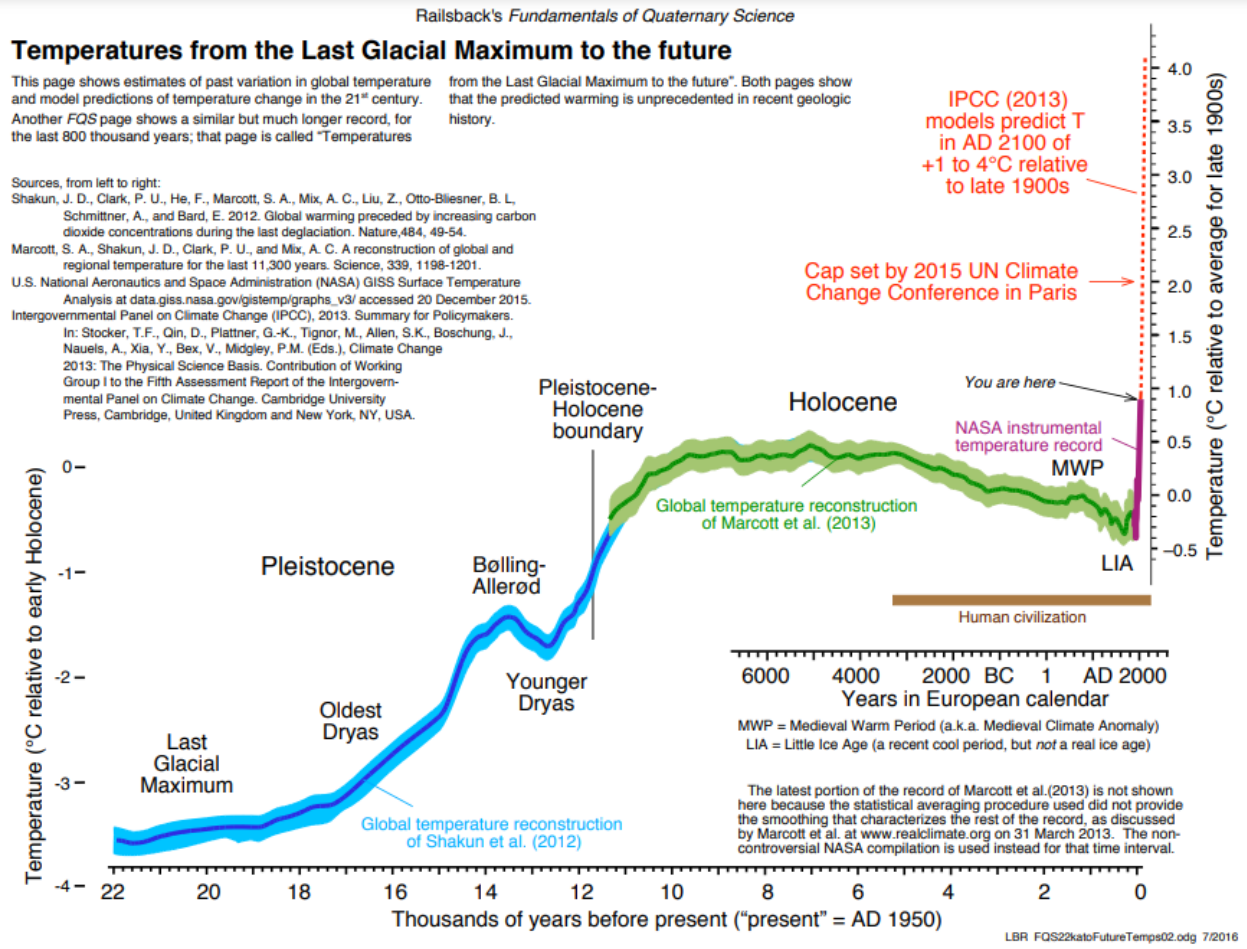


Figure 10: A comparison of Durham Region GHG inventories; Comprehensive vs TAF

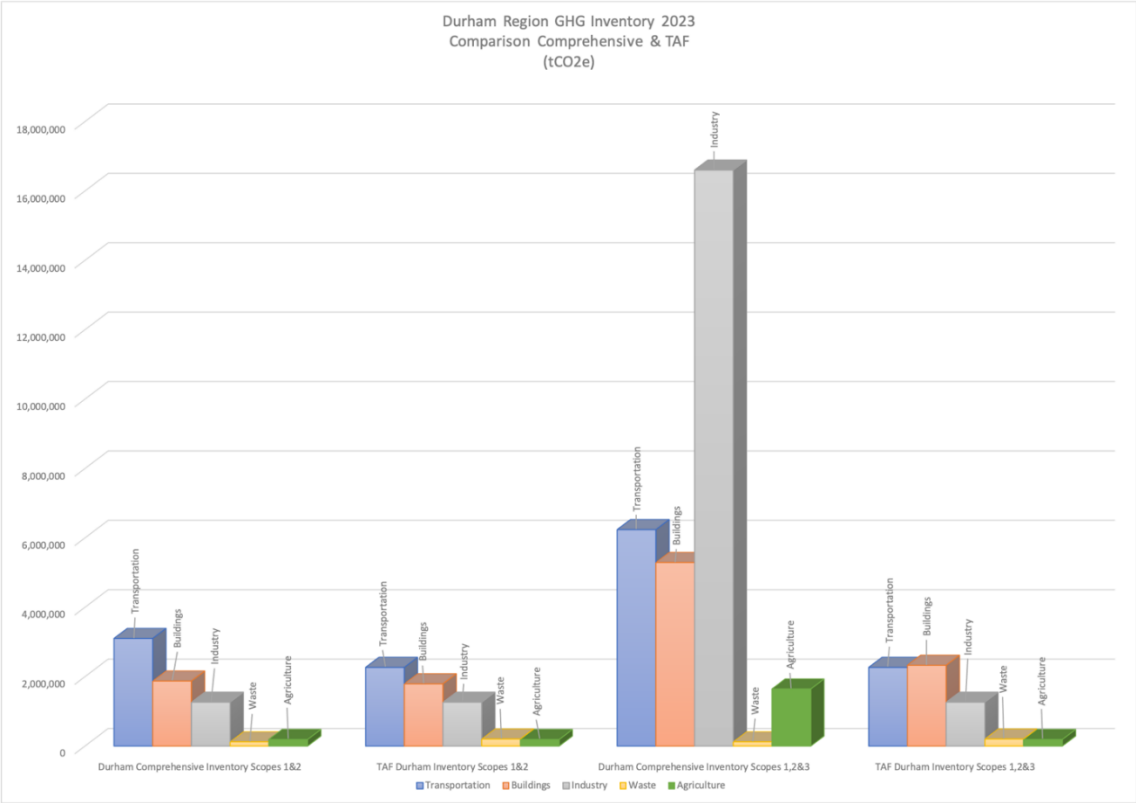


Figure 11: Durham Region GHG emissions 2023, Overview

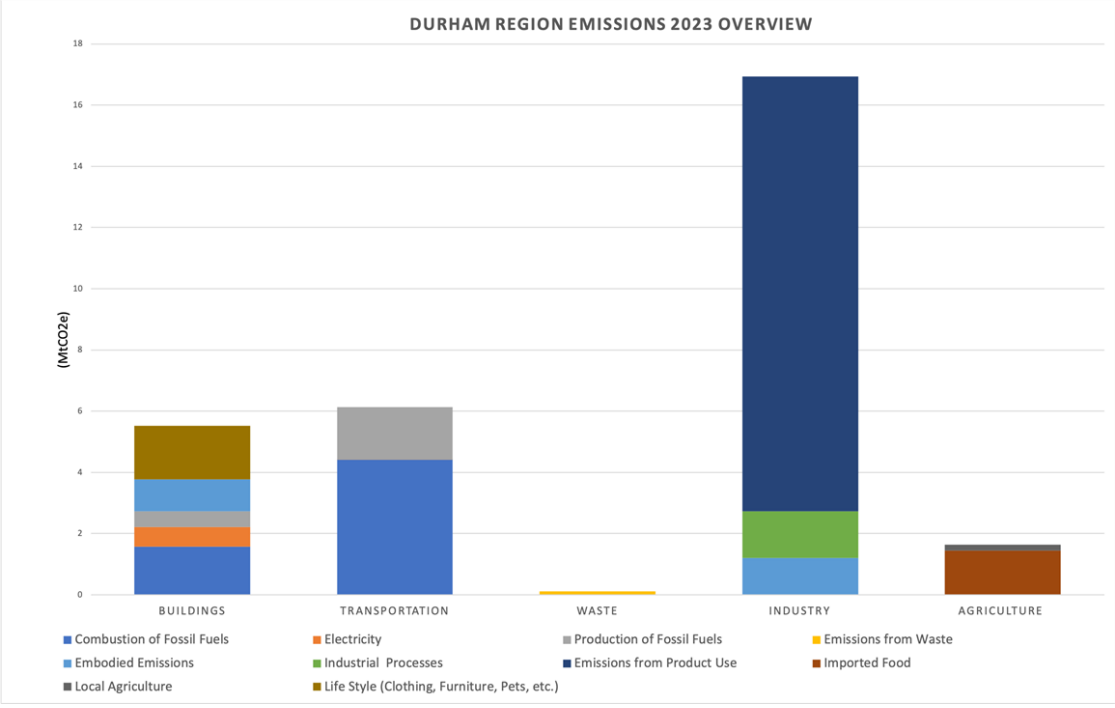
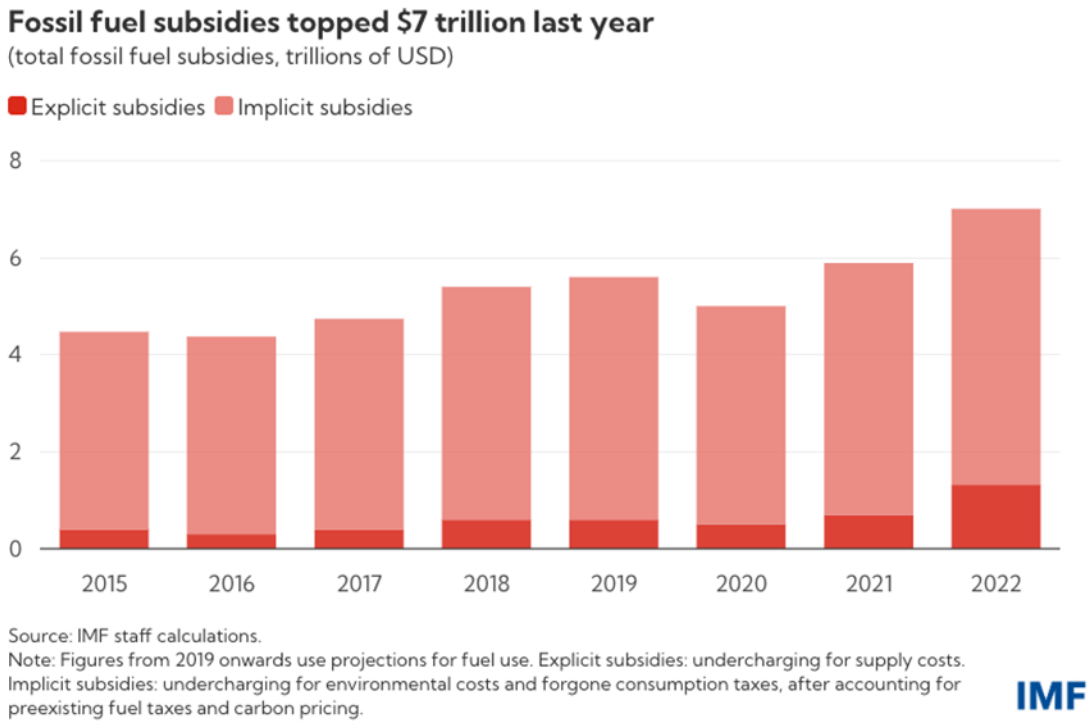


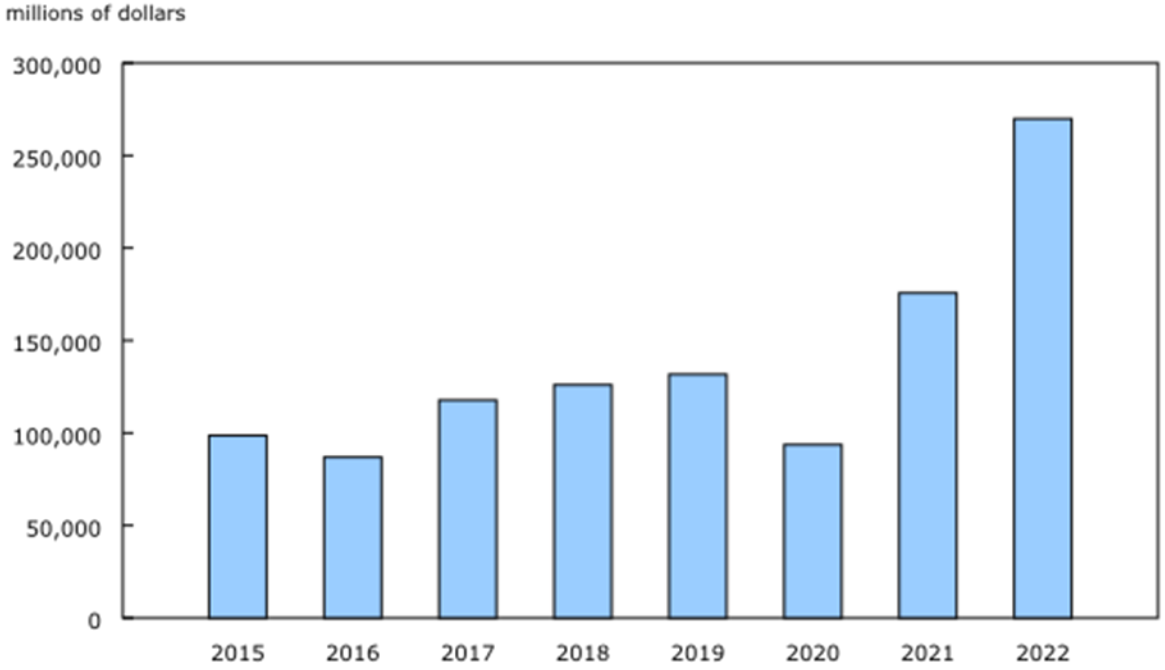
Figure 12: Fossil fuel subsidies, global and Canada (2022)



Annex III. Total (Explicit and Implicit) Subsidies, Selected Countries, 2022

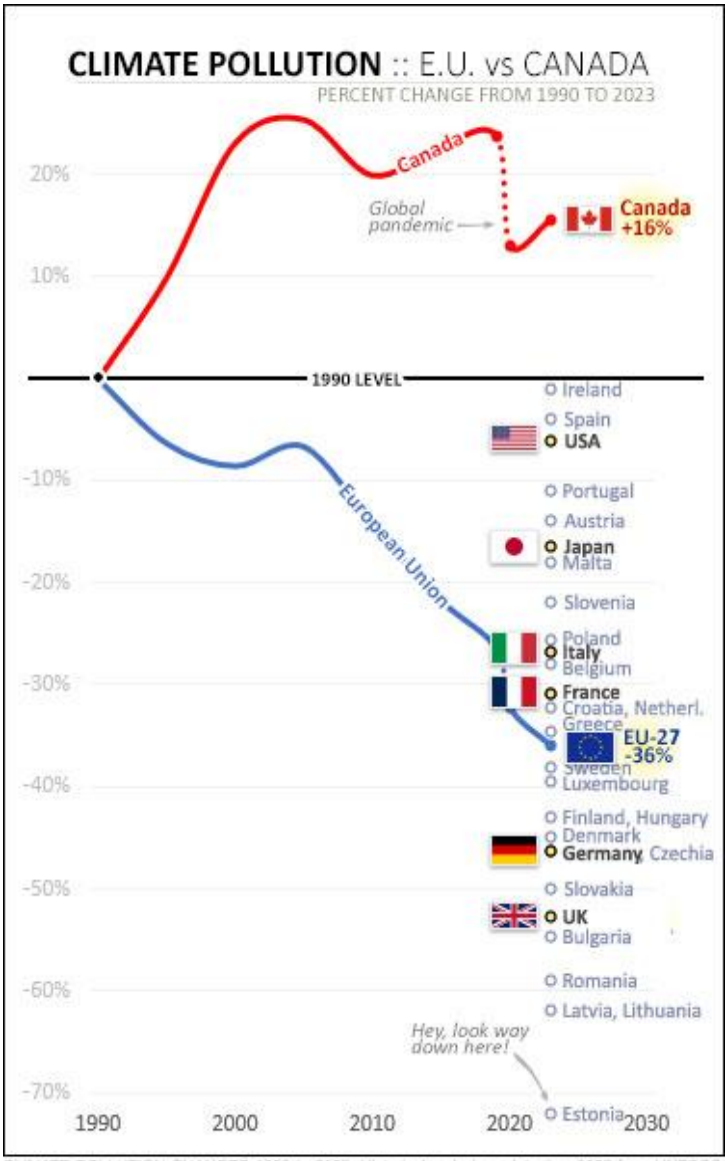
Country	Explicit subsidies			Implicit subsidies			Total subsidies		
	US$ billion	*% GDP*	*capita US$*	*US$ billion*	*% GDP*	*capita US$*	*US$ billion*	*% GDP*	*capita US$*
Canada	2	0.1	47	36	1.9	953	38	2.0	1,000

Figure 13: Revenue, oil and gas extraction industry in Canada (2015-2022)



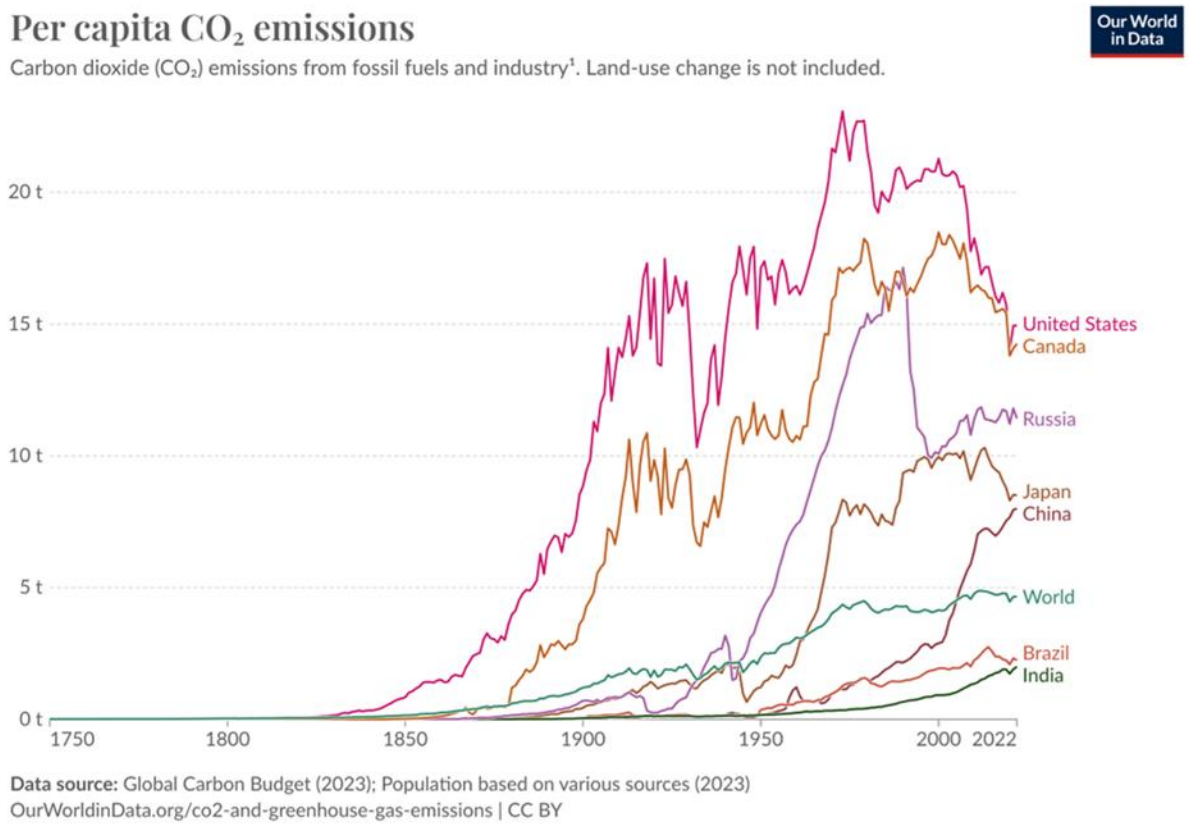
Source: https://www150.statcan.gc.ca/n1/daily-quotidien/230927/dq230927c-eng.htm

Figure 14: Canada's GHG emissions relative other high-income countries



CLIMATE POLLUTION CHANGES 1990 to 2023. Historical emissions data thru 2022 from UNFCCC National Inventory Reports in 2024. Chart shows every fifth year from 1990-2015 and then 2019 (pre-pandemic), 2020 and 2023. Dotted line shows global pandemic year. 2023 emissions estimate sources: EU-27 and its nations (European Environment Agency); Canada (440megatonnes.ca); USA (rhg.com); UK (UK govt); Japan (based on data in Statistical Review of World Energy). CHART by Barry Saxifrage at VisualCarbon.org and NationalObserver.com. Nov 2024.

Figure 15: Per capita CO2 emissions 1750 – 2022, selected countries



1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Source: unknown (the difficulties of hiding carbon neutral or net zero claims)

Figure 16: Adaptation and health impacts from climate change, Durham Region

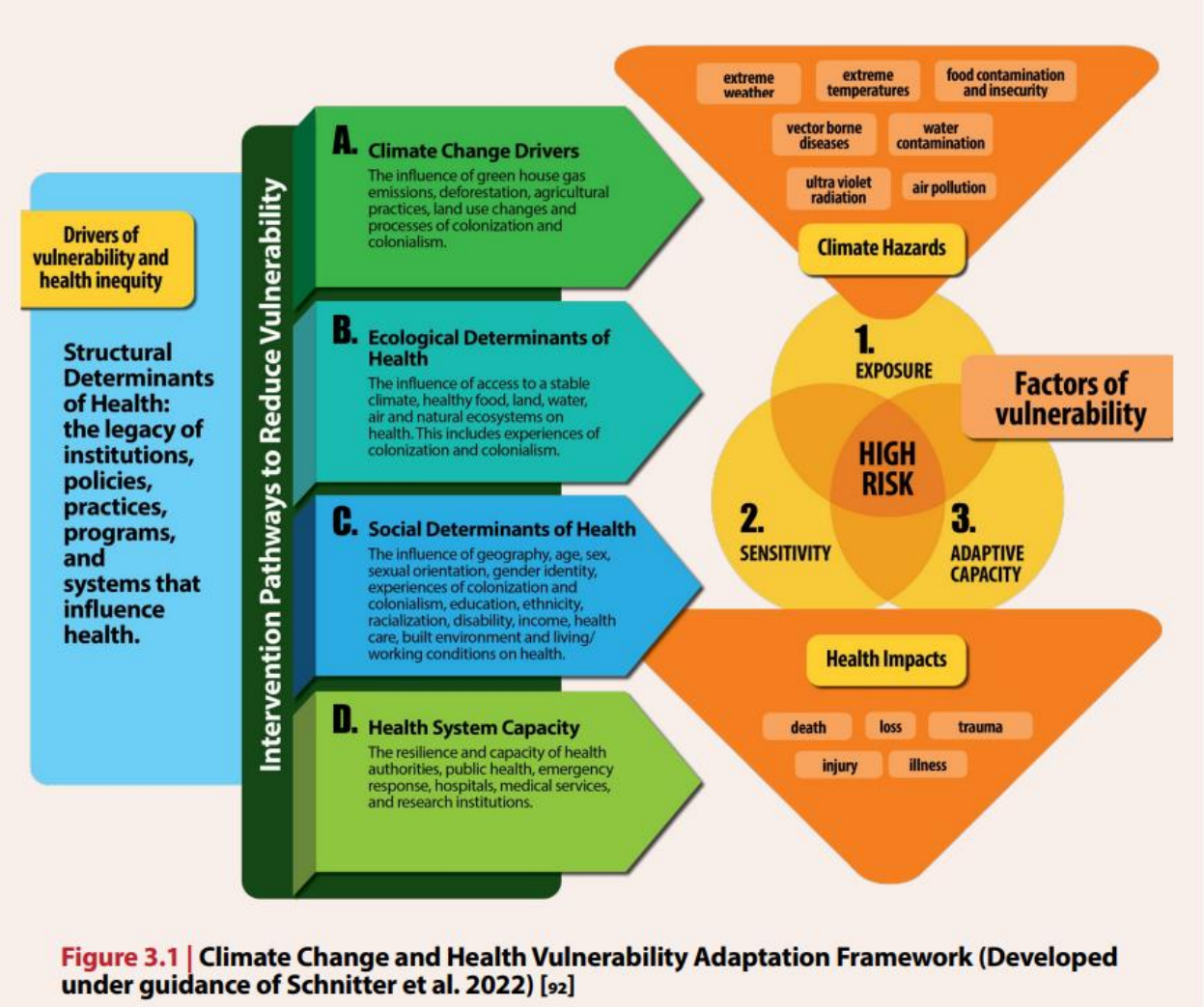


Figure 3.1 | Climate Change and Health Vulnerability Adaptation Framework (Developed under guidance of Schnitter et al. 2022) [92]

Environment and Climate Change Canada (ECCC) issues a heat warning for Durham Region when two consecutive days are forecasted to have a daytime high that is greater or equal to 31°C and a nighttime temperature greater or equal to 20°C, or a humidex greater than 40.

Annex 1: Definitions and understanding of 'Net-Zero'

The Government of Canada states, "Net-Zero emissions means that the economy[20] either emits no greenhouse gas emissions or offsets its emissions, for example, through actions such as tree planting or employing technologies that can capture carbon before it is released into the air. For the purposes of the NetZero Challenge, companies are expected to set a net-zero target and develop a plan aligned with this definition."[21]

More than 1,000 governments, organizations and businesses have declared net zero emissions targets. Even fossil fuel companies have declared net zero emissions targets. For example, Pathways Alliance, the industry association representing Alberta's oil sands development, has stated a net zero emissions target for 2050[22]. For high emitting sectors there is also discussion on use of 'Article 6' of the UNFCCC[23].

Some argue that net zero targets are as much about obfuscation and delay as genuine GHG mitigation. For example, a group of leading scientists stated:

"The time has come to voice our fears and be honest with wider society. Current net zero policies will not keep warming to within 1.5°C because they were never intended to. They were and still are driven by a need to protect business as usual, not the climate. If we want to keep people safe, then large and sustained cuts to carbon emissions need to happen now. That is the very simple acid test that must be applied to all climate policies. The time for wishful thinking is over."[24]

Transitioning away from fossil fuels, which make up such an enormous part of our economies, while also providing space for the world's low-income countries to enhance their own quality of life, requires time and considerable effort, and cooperation.

In this report, the net-zero emissions target by the Region of Durham[25] pertains to all GHG emissions that can reasonably be estimated and attributed to the activities of people, businesses, and organizations of Durham region. A community-wide assessment is required, while appreciating that for GHG emissions the generation and impacts concern the global community.

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[20] Also stated as participating community, business, or enterprise.

[21] From Government of Canada, Net Zero Technical Note, 2022 file:///C:/Users/100328238/Downloads/net-zero-challenge-technical-guide.pdf

[22] "We're working with the federal and Alberta governments to achieve our goal of net-zero emissions from oil sands operations by 2050". Pathways Alliance website.

[23] Article 6 is the provision for trading emission reductions. For example, the hope that if Canada exported natural gas that offset (and reduced) coal emissions, Canada would be eligible for (some of) those emission reductions. This is often, however, not straightforward, as the importing country is also endeavoring to reduce their own GHG emissions under the Paris Agreement. The methodology of application was largely agreed-to at COP29 in 2024.

[24] Dyke, Watson and Knorr (2021). The Conversation. https://theconversation.com/climate-scientists-concept-of-net-zero-is-a-dangerous-trap-157368

[25] And hosted organizations such as Ontario Tech University and Ontario Power Generation

Annex 2: Measuring our Emissions

Measuring GHG emissions is not straightforward. The global total is relatively well known (Figure 2), and national, or territorial, values are also reasonably clear. Challenges may arise on the comprehensiveness of the inventory, *e.g.,* many only include CO_2 which is about 80 per cent of all GHG emissions.

GHGs only contribute to the greenhouse effect when they are in the atmosphere and the time they remain in the atmosphere varies[26]. The global warming potential (GWP) varies by type of pollutant, e,g, the impact for black carbon, or soot, is just a few days, methane peaks around 20 years after release, while carbon dioxide lasts 100s of years. GHGs can be sequestered through natural processes, where they no longer contribute to the greenhouse effect. For example, 25 per cent of the CO_2 released every year is absorbed into the oceans[27] and much can be sequestered in soils and vegetation.

Another challenge with determining our emissions is that some GHGs are difficult to measure and may occur over long distances and across several jurisdictions. Methane is a good example as like carbon dioxide it is 'invisible' to human senses, yet methane leaks (aka fugitive emissions) are a significant source of overall emissions. Methane leaks from old landfills, natural gas distribution systems, at connections (stoves and furnaces), and during production and transmission. In Ontario alone, for example, there are about 24,000 abandoned gas wells, many leaking[28]. These leaking gas wells typically are only noticed when the collected methane explodes yet they contribute significantly to overall GHG emissions although the emissions are not typically accounted for in GHG inventories.

In Canada, a signatory of the Paris Agreement and member of UNFCCC, a national inventory is prepared by Statistics Canada[29]. The Paris Agreement requires Canada to submit a Nationally Determined Contribution, NDC, every 5 years. The NDC outlines how Canada, as a country, intends to meet GHG mitigation targets.

As efforts intensify for greater accuracy in inventory preparation, complexities arise, helping to foment uncertainty and leading to mitigation delays[30]. The inventory provided here is intended to monitor how the Region of Durham, and organizations within the region, are progressing toward net zero carbon targets, as well as providing policy leaders and the residents with as comprehensive an inventory as possible.

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[26] In a complex interchange that can take millions of years, GHGs cycle through the five parts of the earth: geosphere, hydrosphere, atmosphere, cryosphere, biosphere.
[27] The oceans also absorb half the additional heat of climate change.
[28] https://www.cbc.ca/news/canada/windsor/wheatley-explosion-gas-wells Sept 2021.
[29] https://publications.gc.ca/collections/collection_2023/eccc/En81-4-2021-1-eng.pdf
[30] For example, recent findings on how Exxon scientists knew very well the accuracy of climate models and warming influence of fossil fuels as early as the 1950s, yet the company and its trade association financed a disinformation campaign with the goal to delay action https://www.science.org/doi/epdf/10.1126/science.abk0063

Annex 3: A proposed (generic) Council Climate Resolution

A professional engineer tasked with advising municipal council today on how to respond to Canada's climate changes expected over the next 50-to-100 years might provide a report along the following lines:

To: Municipal Council, Our Town, Canada

From: Don Ho, P. Eng. City Engineer, Our Town, Canada

WHEREAS combustion of fossil fuels such as oil and gas release large quantities of CO_2, these and other greenhouse gas (GHG) emissions (about 57 billion tons in 2023) are leading to a rapidly changing climate (one of the fastest rates of change ever experienced in geological history, akin to a meteorite impacting the earth);

AND WHEREAS the atmospheric concentration of CO_2 (and other greenhouse gases such as methane) was stable at 280 ppm since the Holocene age and our 'Goldilocks-like' climate began some 11,500 years ago, but concentrations rose with the Industrial Revolution starting around 1760, and passed the 'safe' 350 ppm level in 1989 and today is around 425 ppm and increasing about 2.4 ppm every year (the rate is still increasing - more than half the total CO_2 ever emitted through human activities occurred in the last 30 years). CO_2 emissions are expected to pass the 450 ppm level in 2040 at which point global temperature increase is on track to surpass 2.0^{o}C triggering climate 'tipping points' this century (such as loss of permafrost, Greenland ice sheet collapse, ocean circulation changes, boreal forest shifts);

AND WHEREAS Canadians, per person, are among the world's highest GHG emitters (and only partly because the country is big and cold), and the world is engaged in challenging negotiations to reduce GHG emissions and provide compensation through a Loss and Damage Fund (animosity and blame within and between countries is expected to increase);

AND WHEREAS Our Town has a 'net zero' carbon by 2050 target, along with many other Canadian communities, and as legislated by the Government of Canada, however we are not on track to reach this target (no one is in Canada);

AND WHEREAS the GHG emissions that are under Our Town's direct control are less than 3 percent of the community's total emissions[31i] – however community emissions, that are under everyone's influence, should account for 'Scope 3' emissions associated with consumption that occurs anywhere (e.g. air travel, cruises and imported food that add at least an additional 35%).

[31] Canadian 'territorial' emissions are about 30% oil and gas sector, 22% transportation, 13% buildings, 11% industry, 10% agriculture, and 8% electricity (about 18 tons per person; not counting forest fires which were as much as an additional 18.8 tons per person in 2023).

Each Our Town resident contributes over 20 tons CO_2 per year, not including their share of Canadian forest fires;

AND WHEREAS more than 2.5 billion people live in areas expected to be outside of a safe climate niche by 2060, and today more than 750 million people do not have access to electricity (more than 1 billion people living in low-income communities today are the most threatened by climate change, but have contributed virtually nothing to the problem);

AND WHEREAS most municipal infrastructure is designed with a factor of safety applied across a reasonably well-known climate horizon, such as rates of precipitation, temperature, and wind speeds, and that this stable planning horizon can no longer be relied upon beyond, say 2040;

AND WHEREAS Our Town, and related provincial and federal services, has an infrastructure backlog in excess of $3 billion (more than 30% of current value; about 25% of our infrastructure is operating beyond its projected lifespan);

AND WHEREAS climate change is only one of several inter-related planetary system threats, others include biodiversity loss, land use changes, we require a systems or sustainability approach with dynamic solutions;

AND WHEREAS Our town, like other Canadian communities, is vulnerable to supply disruptions, such as medical supplies, food and energy, and the electricity grid is in particular need of strengthening;

AND WHEREAS we are dedicated to reconciling with the First Nation communities that we share the land and increasingly the culture with, we recognize that work is still needed and maybe this task of saving mother earth may bring us closer together;

AND WHEREAS the following is broader than a standard municipal engineering recommendation, the integrated nature of the challenge, and the 'all hands-on deck' requirement for effective solutions, necessitates an approach beyond single professional disciplines and community mandates;

THEREFORE, BE IT RESOLVED that Council adopt the following ten-point sustainability plan.

1. Inform the community that we are in the danger zone. The climate is already changing, rates of global degradation are increasing, massive change is underway but there is much we can do as a community to prepare, and to reduce the scale of the problem. At least once-per-year, residents should receive information outlining how their homes and our community can be made more resilient.
2. Recognize the built-in inertia (businesses striving for status quo, human reluctance to change, regional and international inequities) and be kind with each other in the challenges associated with the changes coming, while also being resolute that we are all in this together, so everyone needs to be part of the transition efforts.

3. Canada, because of its temperate climate and substantial water resources, including Our Town, will likely face significantly higher pressures to receive immigrants and international migrants. Housing flexibility, greater transience of citizens, and the need to build more durable partnerships with communities outside Canada should be anticipated.

4. The risk is high that related to this massive global change, there will be military hostilities in the next 50 years, including Canada. Our Town will of course be called on to support this war(s), however as a community we should assert our beliefs that a peaceful, supportive transition is possible, and preferrable. We need to also show this within our own community.

5. Our Town's 'old world' infrastructure is rapidly moving outside state of good repair, with serious maintenance backlogs and rapidly declining resiliency. This is common with other, non-municipally managed, but equally critical infrastructure, such as electricity generation and distribution. A five-year rolling infrastructure management plan should be prepared for Council, with publicly discussed recommendations, links to other levels of government, and updated annually.

6. Our Town municipality, businesses and residents, should anticipate the crossing of local climate and ecosystem tipping points. Lakes may become anoxic, greater fire intensity and frequency, flooding and severe weather will be more common.

7. Our Town, being contiguous to That Town and Their Town, should forward this resolution to them and ask how we may establish a more durable sustainability partnership (e.g., common metrics, shared disaster response planning, coordinated economic development offices, mobility apps, and data management systems).

8. Integrated mobility (transit, ride sharing, bicycles, walking, and low-carbon vehicles) is one of the most important initiatives needed to reduce GHG emissions, enhance resilience, and increase economic development (while enhancing well-being). Our Town can work with neighboring communities, municipal associations, and provincial and federal governments to develop and implement and 'mobility as a service' programs along with supporting infrastructure.

9. Data collection, security, and communications systems are increasingly critical to the safe and sustainable operation of Our Town. Our Town needs to partner with residents, businesses and visitors, on data platforms, and the active monitoring and communication of sustainability metrics. A data management plan will be prepared and presented to Council for consideration. The principle of subsidiarity suggests that this plan be developed and implemented by local communities and scaled upward (across Canada and internationally).

10. Recognizing that we need to develop a more sacred relationship with the land as a key aspect in the transition to sustainability, we should seek a more durable partnership with our neighbouring First Nations communities and residents of Our Town.

Possible Question and Answer session following the report.

Q. What about geoengineering?

A. Geoengineering, the intentional effort to limit solar radiation from reaching earth, will probably be pursued within the next 50 years. Things are that bad. However, we will never be able to fine tune impacts, and we do not yet know how effective interventions may be. There will be winners and losers. Whole countries may feel disenfranchised, and when we can not come together as countries to establish preventative (and much cheaper) approaches to climate change, most people are very doubtful that we will be able to come together to manage a much more complex activity like geoengineering. Also, most engineers cringe that the term 'engineering' is applied to this approach as it is almost impossible to apply a factor of safety against the intervention.

Q. Why did your engineering predecessors not warn Council more loudly about climate change before?

A. Civil engineering curriculum has included climate change considerations for more than 40 years, and the Government of Canada, and other UN members are on record calling for substantive reductions to GHG emissions in 1987 when Our Common Future (the Brundtland Report) was released. Talking about planetary systems at a municipal council meeting is uncommon. Arguably our provincial and federal governments should be leading this discussion and implementing meaningful programs. However, the scale of the challenge, and the changes required, are so large, that some procrastination is inevitable, and partisan disagreements on possible approaches likely. Industry, especially the fossil fuel industry, is also still actively promoting a 'go slow approach' to safeguard profits as long as possible. Alternatives are not easily available. Canada is largely at the 'who will pay, and how much' stage. Local governments in Canada tend to be more pragmatic (and perhaps less partisan), and even though their mandated political remit is relatively small, their management of infrastructure is significant (municipalities in Canada own and mange about half the country's infrastructure). Municipalities in Canada will be tasked largely with safeguarding our infrastructure through the sustainability transition – that is why we are coming forward today with this resolution.

Q. Is not a tax on carbon a tax on everything? People are already facing affordability challenges, what you propose seems to imply future costs, much higher costs.

A. True CO_2 emissions are a significant by-product of our lifestyles, and in many areas easily available alternatives for businesses and residents do not yet exist. However, economists and policy experts tend to value pricing signals for their ability to nudge behaviour. Canada will also be subject to border adjustment tariffs as other countries reduce their emissions faster than us. More than a quarter of the world's carbon emissions are already subject to a price on carbon. Canada is in a precarious position in that our emissions, per person, are among the highest in the world, and even though climate impacts will be severe in Canada, especially in the Arctic, our northern latitude is an enormous geographical advantage. We should expect global resentment toward us, as a country to rise. We are also starting to see the price of inaction on climate

change, and from the perspective of Our Town, the costs to safeguard our infrastructure are higher than what the cost of prevention might have been.

Q. What should we tell our constituents, especially younger ones?

A. Things are changing, and the pace of change is likely to increase over the lifetime of anyone alive today. Climate change is just one symptom of our economic and social system being out of balance. The human species will get through this. Within 50 years our global society can transition to energy and materials levels that are sustainable. Getting there will not be easy, but it is much better than the alternatives. Also, the planet is very resilient and there is still much to safeguard. We can be optimistic.

Q. If we want a second opinion, who should we invite to Council?

A. Possibilities include Katherine Hayhoe, a Canadian climate scientist living in Texas, Christine Figueres, who headed the negotiations for the Paris Agreement, and Corinne Le Quere, an outstanding Canadian-British climate scientist at University of East Anglia.

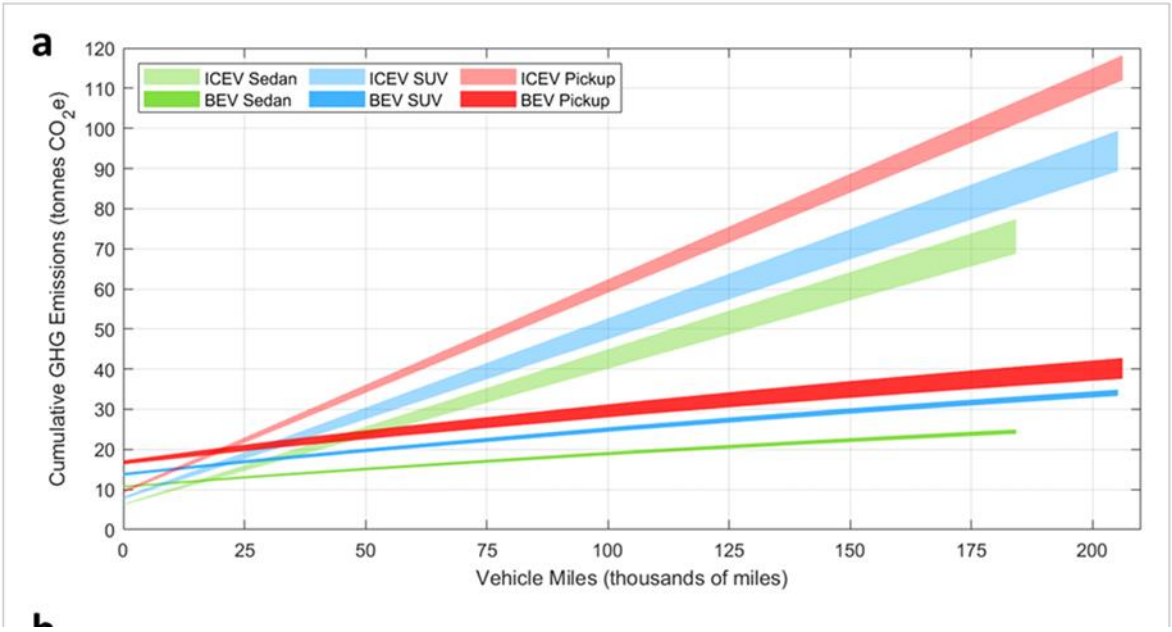
Helpful books include Hannah Ritchie *Not the End of the World: How we can be the first generation to build a sustainable planet;* Gwynne Dyer *Intervention Earth: Life-Saving Ideas from the World's Climate Engineers;* Michael Mann *Our Fragile Moment: How Lessons from Earth's Past Can Help Us Survive the Climate Crisis*; Bill Gates *How to Avoid a Climate Disaster*; Minouche Shafik *What we owe each other: A new social contract for a better society*; Deb Chachra *How Infrastructure Works: Inside the Systems That Shape Our World*; and Parag Khanna *Move: How Mass Migration Will Reshape the World – and What It Means for You*.

Annex 4: Estimating GHG emissions from auto assembly activities in Durham Region

Traditionally, companies focus on direct emissions from their own facilities (scopes 1 and 2). Recently, they are also considering scope 3 emissions, which include purchasing decisions, partnerships, employees, distribution, investments, and product use. In some manufactured goods, scope 3 emissions can far exceed scope 1 and 2 emissions. Auto assembly and manufacturing is a case in point. The fuel combusted after point of sale and resulting carbon emissions typically are much greater than the emissions embodied within the components needed to make-up the vehicle (scope 3 upstream), or emissions associated with the manufacturing process, and vehicle delivery.

To make informed decisions and reduce CO_2e emissions, the entire lifecycle of each product needs to be measured. For example, making an Oshawa manufacturing facility zero emissions would reduce total product emissions by less than one percent. This underscores the need for a holistic, 'cradle to grave', approach when identifying the best places to intervene to reduce emissions.

Figure A4.1: Lifetime GHG emissions, Sedan, SUV and Pickup vehicles (ICE and EV)



As illustrated in Fig A4.1, above, internal combustion engine vehicles (ICEV) generate more lifetime emissions beyond about 25,000 miles (40,000 km). Lifetime use of a typical pickup vehicle is 200,000 miles (325,000 km). This results in lifetime emissions of approximately 110 tCO_2e. In 2023 at estimated 150,000 vehicles were assembled in Durham Region. The lifetime

(scope 3 downstream) emission from these vehicles is about 16.5 $MtCO_2e$. The GPC emission methodology applies those lifetime emissions to the year in which the vehicles are sold (shipped from manufacturing facility).

Figure A4.3: Total GHG emissions associated with vehicle assembly in Durham Region, 2023

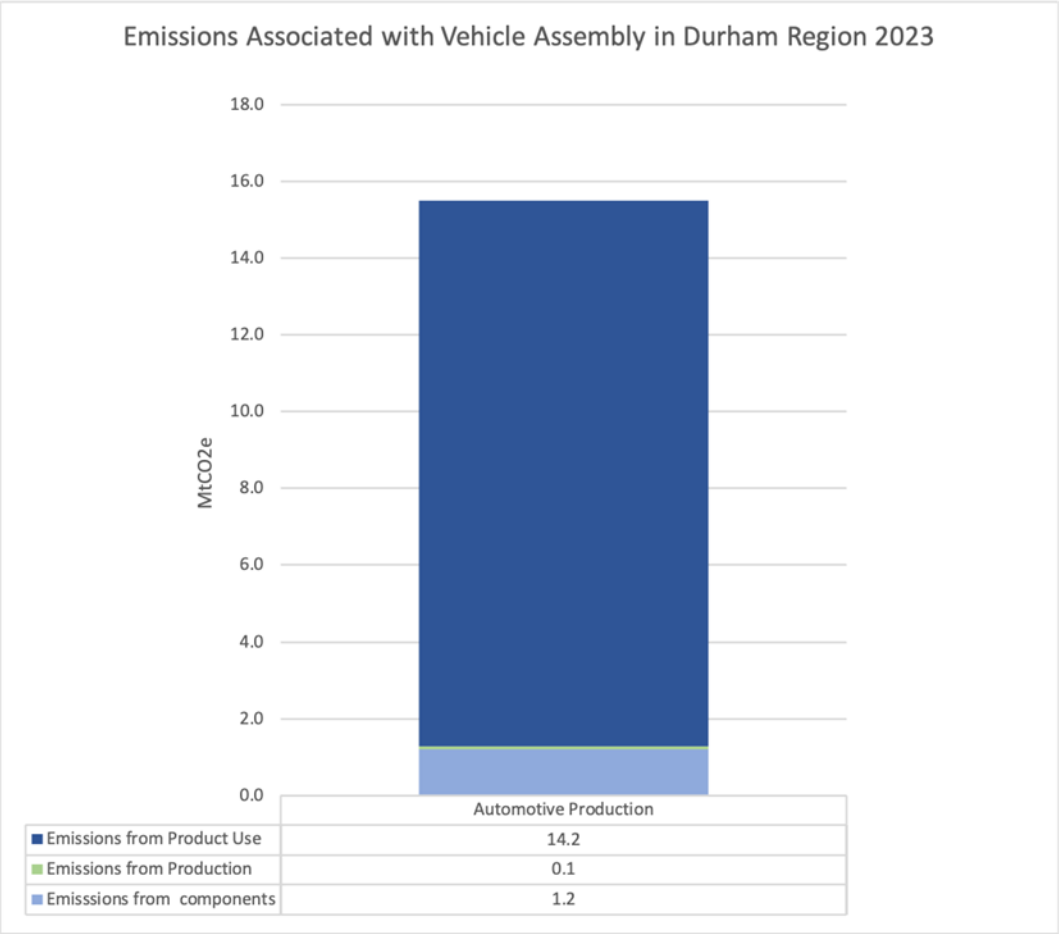


Fig. A4.3 provides total overall GHG emissions associated with the vehicles assembled in Durham Region in 2023. About 150,000 pickup vehicles were assembled and shipped. Scope 1 and 2 emissions, associated with operation of the assembly plants, was 0.1 Mt CO2e (less than 1% of the total). Scope 3 (upstream, before assembly) emissions included in the parts for manufacture were 1.2 Mt CO2e. Scope 3 (downstream, after point of sale), lifetime use of vehicles was about 14.2 Mt CO2e. This larger amount is the emissions associated with the lifetime gasoline and diesel used in the vehicles manufactured in 2023.

Annex 5: The Canadian Net-Zero Emissions Accountability Act, which became law on June 29, 2021, enshrines Canada's commitment to achieve net-zero emissions by 2050[32]. A fundamental shift in the way we live and power our economy is required to achieve this commitment[33]. The shift away from fossil fuels will bring ancillary benefits like cleaner air (in Durham at least 350 premature deaths[34] per year would be avoided if fossil fuels were abated), however the path to get there is fraught with friction from associated societal and economic shifts. Heated debate and disputes over 'fair' mitigation commitments (and compensation) should be anticipated.

The best number to monitor progress as a (planetary) community responding to climate change is probably the atmospheric concentration of carbon dioxide (CO_2) monitored atop Manua Loa in Hawaii. Beginning in 1958, this is the world's longest continuous measurement of planetary CO_2 (also called the Keeling Curve after Ralph Keeling who initiated the measurement). CO_2 is the most important contributor to climate change, and a direct by-product of fossil fuel combustion. In 1958 the concentration was 317 ppm, up from about 280 ppm in the mid-1700s prior to the start of the Industrial Revolution. CO_2 concentration is increasing by as much as 3 ppm per year (about 425 ppm in 2024[35]). A secondary measurement would be the atmospheric concentration of methane (CH_4, now about 1995 ppb and increasing by about 15 ppb per year[36]). These two GHGs drive more than 90 per cent of global warming.

The news is grim but hope springs eternal. The Paris Agreement framework convention includes a requirement for all signatory countries to provide territorial GHG inventories plus collective stocktaking every five years, and if the combined nationally determined commitments, NDCs, are believed to be inadequate to meet climate targets, *i.e.,* keeping global warming below 2°C, negotiations to 'ratchet down' emissions are required.

COP28, this year, is a time for this 'stocktaking'. Collective pressure to significantly enhance mitigation efforts should be anticipated by all signatories. This is particularly important to Canada since, regardless of national political party in power, Canada's mitigation challenge is

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[32] 'Net-zero' is defined as our economy either emits no greenhouse gas emissions or offsets its emissions. Canada joined over 120 countries in committing to be net-zero emissions by 2050, including all other G7 nations (United Kingdom, United States, Germany, Italy, France, and Japan). The US may rescind its commitment with the election again of Donald Trump. Numerous provinces, businesses, institutions, and communities have also made net-zero-by-2050 commitments, including the Region of Durham, Guelph, Ontario Tech University (2040), Ontario Power Generation (2040), Vancouver, Hamilton, Toronto (2040), Halifax, Newfoundland and Labrador, Nova Scotia, British Columbia, and Quebec. Many countries are progressing faster on their net-zero transitions and are likely to impose border adjustment tariffs on Canada, and others, if our emissions do not also decline.

[33] The Paris Agreement's aspirational goal of limiting global warming to 1.5°C is no longer practicable. As outlined by the UNFCCC in the lead up to COP29 in November, meeting the less ambitious 2°C target is also highly questionable. Durham Region should brace for a climate increase above 2.5°C this century. https://unfccc.int/documents/631600

[34] Projected from Health Canada; https://www.canada.ca/en/health-canada/services/publications/healthy-living/health-impacts-air-pollution-2021.html.

[35] For daily values see: https://gml.noaa.gov/ccgg/trends/monthly.html and https://keelingcurve.ucsd.edu/

[36] Methane is measured in parts per billion (CO_2 in parts per million). The atmospheric half-life of GHGs varies; methane 10.5 years, carbon dioxide 120 years, and nitrous oxide 132 years. Therefore, as a GHG, methane has a disproportionately high impact in the near-term. *See: Iowa State University.*

especially onerous (largely from high emissions associated with oil and gas development and the transportation sector, and possibly forest management). Canada faced this challenge before; unable to meet Kyoto Protocol commitments Canada withdrew from the Protocol. Withdrawing from the Paris Agreement would likely be of greater consequence for Canada[37].

In Canada, compilation of the national territorial GHG inventory is mandated to Statistics Canada. The most recent inventory was submitted for 2021 (see Figures 3-4, and Figure 5 for Ontario's GHG emissions).

Hundreds of actors need to engage for meaningful GHG mitigation. The Government of Canada may have passed the Emissions Accountability Act; however, the federal government needs strong support from provinces, municipalities, businesses, and households to meet climate targets. The scale of the challenge will undoubtedly bring forward people, companies, political parties, other countries, who suggest the goal is too ambitious, or a better approach is possible.

Unlike Canada's withdrawal from the Kyoto Protocol, withdrawing from the Paris Agreement, would likely bring severe sanctions. The United States is a committed to the Paris Agreement as is the EU. All countries are wrestling with the same mitigation challenge facing Canada, however Canada, with its high-reliance on exports and as a 'middle-size' country, is particularly bound to be part of the global community of countries.

There are several 'no regret' actions to reduce the use of fossil fuels: (i) decarbonize electricity; (ii) integrate carbon-free mobility; (iii) remove fossil fuels in space heating of buildings (and associated cooling); (iv) use tools such as carbon sequestration in hard to abate sectors such as plastics manufacturing; (v) shift to low-carbon manufacturing of steel and cement. In the agriculture and land use sector shift to low-carbon machinery, reduce consumption of beef and lamb (higher methane emissions), precision use of nitrogen and phosphorous applications, soil sequestration of carbon, forestry practices. Efforts should also be enhanced to reduce methane emissions through (i) waste management (solid and wastewater); reduce leaks in gas transmission and use (and forgo expansion for building heating); better manure management.

Countries (and regions within these countries) are vying for economic primacy through the energy (GHG mitigation) transition. This takes two broad approaches. First, existing fossil fuel suppliers (countries, companies, and regions) lobby to slow the transition, and position their source of supply as preferential[38]. Second, companies and countries invest to be a key part of the 'new energy economy'. For example, pursuing electric vehicle manufacturing and mining

[37] Canada's historic emissions, *i.e.,* our national contributions to global atmospheric levels are among the highest in the world; our progress in reducing emissions is less than other high-income countries; our historic contributions to climate funds are less than average high-income countries, and; geopolitical tensions suggest middle-sized countries like Canada need to rely more on (and support) rules based international order.

[38] Global fossil fuel reserves are significantly higher than what can be 'safely combusted' under any credible climate scenario (coal > 150 years; oil > 50 years; gas > 55 years at current consumption levels). For the next several decades suppliers will position themselves to provide within a shrinking market through price, availability, and claimed attributes such as lower-carbon production, better human rights, less environmental impact.

and mineral development for the transition, *e.g*., subsidizing battery manufacturing for EVs and developing Ontario's 'Ring of Fire'.

The third aspect affecting the energy transition is the push and pull of social and technological change. Human nature is not typically well-suited to undergo the scale and speed of change being called for under the Paris Agreement. Local and global politics, that drive public policy, need to follow a complex path fraught with dangers of protests. Examples of this include the 'yellow vests' in France protesting rising fuel prices and the recent backsliding on mitigation targets in the UK), regional frictions (*e.g*., the differing economies of Quebec and Alberta), and finger-pointing and reticence on who should lead and pay. Overlaying this enormous social and economic shift, is the impact from a changing climate. Already, with just 1.1 ^{o}C increase of global temperature, current infrastructure is challenged, food supply is shifting, and storm intensity and frequency are increasing, leading to unprecedented human migration, and rising costs. These impacts are intensifying.

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