The Region of Durham 2022 Greenhouse Gas Emissions Inventory and Progress Toward Net-Zero Climate Targets

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Executive Summary

This report provides an estimate of all greenhouse gas, GHG, emissions attributed to the residents and businesses in Durham Region (11.9 Mt CO_2e, 16.01 t per capita, in 2022). This comprehensive, community-wide GHG inventory is considered the baseline to which overall net-zero targets pertain. The inventory is more comprehensive than the Region's *corporate emissions* (about 170,000 tonnes per year) or limited scopes of inventories such as The Atmospheric Fund (5.73 Mt in 2021). The 11.9 Mt value is consistent with provincial and national inventories, but is broader, including upstream and downstream activities associated with the residents and economy of Durham. Of those 11.9 Mt CO_2e, 3.15 Mt CO_2e were associated with items exported from the Region. How these emissions relate to Canada and the world's overall emissions is discussed, with a focus on 'fair' attribution.

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.

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^{o} C above pre-industrial values, nor even the minimum 'safe' target of limiting temperature increases to below 2^{o} C (prerequisites for a net-zero economy). The UN finds that climate policies currently in place point to a 2.8^{o} C temperature rise by the end of this century[1].

The inventory in this assessment requires estimates in several areas; however, it is sufficiently robust to facilitate comparisons across communities in Canada and globally (many with similar net-zero targets) and is structured to help integrate and monitor joint efforts by Durham-based partner organizations with their own net-zero targets, *e.g.*, Ontario Power Generation (2040) and Ontario Tech University (2040).

Clear GHG mitigation priorities exist for the region. These include:

- Shift to low-carbon integrated mobility (far fewer single occupant vehicle trips, especially in internal combustion engine, ICE, vehicles);
- Redesign neighbourhoods to be far less reliant exclusively on car access; Phase out natural gas for space heating (consider adopting, or urging provincial adoption of, bans on natural gas in new neighbourhoods, similar to Nanaimo and Montreal);
- Shift personal purchasing practices, *e.g*., fewer flights and cruises, eat less meat (especially beef), emphasise waste minimization (especially food waste).

[1] https://www.unep.org/resources/emissions-gap-report-2022

Background

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 – 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; 0.0275 per cent). This level was relatively constant for 11,700 years giving rise to the Goldilocks-like Holocene Epoch, a period of stable climate that enabled agriculture and civilization to flourish.

Today the concentration of carbon dioxide has increased to 418 ppm and is rising by 2-to-3 ppm every year. 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. More than half the world's total GHG emissions occurred in the last 30 years, despite having annual negotiations[4] to mitigate these emissions. The richest 10 per cent of the world's population, including every Canadian, generate more than half the world's GHG emissions, yet middle-income countries, like China and increasingly India, have the fastest rising emissions.

<u>The Troubles with Transitions</u>

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 on who should pay, and who should proceed at what pace, will increase[5]. The two largest mitigation activities for Durham Region are low-carbon transportation (EVs, possibly hydrogen and mobility as a service) and discontinuing the

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[2] (1000 kg, or 2205 pounds)

[3] A 'ball park' estimate for emissions and targets is that at 450 ppm CO_2 a 1.5^{o}C temperature increase is locked in (in about 5 years with the remaining carbon budget of 250 $GtCO_2$) and 2^{o}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. COP28 is taking place in Dubai December 2023. 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 limit the temperature increase to 1.5° Annex above pre-industrial levels." The 1.5^o C objective is now highly unlikely and the 2^o C level will probably be breached this century.

[5] A good example is Nanaimo, BC recently banning natural gas connections to new buildings, and the intense lobbying by Alberta's oil and gas industry to overturn the decision Nanaimo must unban Natural Gas - Support Canadian Energy.

use of fossil gas[6] to heat buildings. Lifestyle changes, such as fewer international flights, smaller vehicles and more integrated mobility, and changes to diet are also likely.

Climate in Context

Municipalities (regional and local) are typically the most pragmatic level of government and best able to balance local concerns and aspirations with economic, social, and environmental imperatives. Governments, and households, need to juggle many, at-times conflicting priorities. Geopolitical tensions, like the war in Ukraine, as well as Ontario's housing crises, and affordability concerns, are examples of the breadth of issues impacting the Region of Durham.

Climate change is only one of several inter-related bio-physical and socio-economic challenges. Others include loss of biodiversity, over-use of fertilizers (N and P), water availability, equity (including poverty, especially in low-income countries), geopolitical shifts and strife.

This report outlines the Region of Durham's (community-wide) annual progress toward meeting the net-zero-by-2050 target. Despite this target being less than 30 years away, enshrined in Canadian legislation, and echoed by hundreds of cities, provinces, businesses and other countries, there are few credible community plans of where we are in terms of overall greenhouse gas (GHG) emissions, leave alone how we are going 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 within a community regardless of where they 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 2022 each resident of Durham on average was responsible for about 16 tonnes of GHG emissions. This is among the highest in the world (top five per cent).

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.

Depending on the area of analysis, *e.g.,* City of Oshawa, Region of Durham, Greater Toronto Area, Province of Ontario, Great Lakes Region, or Canada, per person GHG emissions will vary, however all values can remain credible and consistent.

[6] The term fossil gas is used interchangeably with natural gas, and at times biogas. All are types of methane, CH_4, which has higher global warming potential (GWP) but shorter life in the atmosphere than CO_2 (86 times the impact over 20 years). 'Fossil' denotes the common gas (methane) found in geological sedimentary basins. Biogas is methane generated within the last few years through biological processes. The term 'renewable natural gas' is also used for this methane.

The Region of Durham, like Ontario Tech University and Ontario Power Generation declared a net-zero target for GHG emissions[7]. 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) as outlined in Figure 1 and Figure 11. 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^{o}C average temperature increase and should prepare for at least 2.5^{o}C this century (an enormous impact). Impacts include rising costs of infrastructure, storm intensity, growing social strife, food security and climate refugees.

Measuring our Emissions

Measuring GHG emissions is not straightforward. The global total is relatively well known (Figure 1), 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[8]. 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[9] 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

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[7] 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.

[8] In a complex interchange that can take millions of years, GHGs cycle through the five parts of the earth: geosphere, hydrosphere, atmosphere, cryosphere, biosphere.

[9] The oceans also absorb half the additional heat of climate change.

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[10]. 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 (Figures 2-4)[11]. 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[12]. 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.

The challenge with community-wide mitigation plans

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. So too the Province of Ontario and Government of Canada. Businesses and organization also have only a small 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), have limited impact on their own.

In Canada, the challenge is exacerbated as the transition to a low carbon economy places significant 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 and historic).

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[10] https://www.cbc.ca/news/canada/windsor/wheatley-explosion-gas-wells Sept 2021.
[11] https://publications.gc.ca/collections/collection_2023/eccc/En81-4-2021-1-eng.pdf
[12] 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

GHG emissions in the Region of Durham

Table 4.1 and Figures 8 and 10 detail Durham's total GHG emissions. Upstream emissions (Scope 3) associated with provision of key materials used within the region, include 1.8 $MtCO_2e$ 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 35 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 0.5 $MtCO_2e$ (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 1.3 $MtCO_2e$. Building materials imported into the region include about 1 $MtCO_2e$ per year. This is added to the 1.6$MtCO_2e$ per year emitted from heating buildings with natural gas.

The largest share of emissions is associated with the transportation sector 4.6M tCO_2e, almost 40 per cent of total emissions. This includes about 700,000 tonnes CO_2e from air travel originating from Pearson International Airport, about 6 per cent of total emissions. Production of cement, steel, aluminum, and vehicles is about 2.3 $MtCO_2e$, about 19 per cent of the total.

Total emissions associated with electricity used in 2022 are 83,895 tonnes CO_2e (one of the lowest values in the world) while natural gas burned to heat all buildings generated 20-times more emissions, 1.6$MtCO_2e$.

Corporate emissions from Region of Durham municipal activities are 169,500 tonnes CO_2e (Durham York Energy Centre 83,895 t; Brock West landfill 28,234 t; water supply and sewerage 19,488 t; Regional facilities natural gas 16,545 t; facilities electricity 3,756 t). This is less than 2 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

Figure 8 and 11 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 (See Mitigation priorities section).

Durham's robust manufacturing sector produces materials such as cement, steel, automobiles, and vehicle parts[13]. 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 the majority of 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 does not include typical individual household breakdowns. This will be added to next years assessment. For example, in addition to diet, size of home, heating method, personal activities such as air travel[14], cruises[15] and pets[16] can have a significant impact on overall GHG emissions. Knowing that a one-week international cruise might generate more emissions than a household's entire annual emissions may change personal choices over time.

A Note on GHG emissions data and Durham Region

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[17]. Deep and wide-spread cuts in emissions of this scale are critical to achieve anything close to the Paris Agreement commitment to limit warming to below 2°C from pre-industrial values [18]. The enormity of this task cannot be overstated. This is a fundamental shift in the way we live and power our economy. The shift away from fossil fuels will bring significant ancillary benefits like cleaner air (in Durham at least 350 premature deaths[19] 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.

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[13] Through the oversight of Statistics Canada's responsibility to compile GHG emissions, individual large point sources are required to report annually on their emissions. In Durham Region these include St Marys Cement (1,471,777 t CO_2e in 2021); Gerdau Ameristeel (123,544t); Atlantic Packaging (78,504t); General Motors (37,402t); and Signature Aluminum (14,066).

[14] ~100 kg CO_2 per hour per person flying, https://ourworldindata.org/travel-carbon-footprint

[15] ~1 tonne per day per person of cruising https://www.myclimate.org/en/

[16] ~2-3 tonnes CO_2 per year for medium sized dog, https://8billiontrees.com/carbon-offsets-credits/carbon-ecological-footprint-calculators/dog-carbon-footprint/

[17] '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). 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.

[18] In theory the Paris Agreement's aspirational goal of limiting global warming to 1.5°C is still possible, however current progress suggests that this target will be missed. As outlined by the UNFCCC in the lead up to COP28 in December, meeting the less ambitious 2°C target is highly questionable https://unfccc.int/documents/631600

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

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 419.2 ppm in 2023[20]). A secondary measurement would be the atmospheric concentration of methane (CH_4, now about 1995 ppb and increasing by about 15 ppb per year[21]). 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 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[22].

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.

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[20] For daily values see, https://gml.noaa.gov/ccgg/trends/monthly.html.

[21] 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.*

[22] 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.

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[23]. Second, companies and countries invest to be a key part of the 'new energy economy'. For example, pursuing electric vehicle manufacturing and mining 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.

[23] 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.

The Particular Potential of, and Risks to, the Great Lakes

Lakes Superior, Huron, Michigan, Erie, and Ontario are remnants, just very big puddles, left over from the last ice-age. Despite their large size the lakes are particularly fragile as water turn-over is extremely low (*e.g.*, Lake Superior requires 400-500 years for water to fully circulate)[24] and the area of total Great Lakes watershed is surprisingly small (all the Great Lakes combined drain an area smaller than Lake Winnipeg watershed alone; 240,000 km^2 versus 982,900 km^2).

Despite the fragility of the Great Lakes, they anchor the world's largest megaregion. An economic powerhouse encompassing two provinces and eight states, with some 100 million people and a combined wealth generating GDP of $6 trillion. If the Great Lakes Region were a country on its own, only the US and China would have larger economies.

The geographic bonanza of the Great Lakes, with its temperate climate, abundant hydropower, and water and over-land connectivity, gave rise to abundant agriculture, development of North America's interior, and world-class manufacturing capacity, *e.g.,* the auto industry launches in Oshawa and Detroit. The region is undergoing a renaissance as cities like Detroit, Cleveland, and Pittsburgh revive their downtown corridors.

Climate journalists, such as Gaia Vince (*Nomad Century*) and Parag Khanna (*Move: The Forces Uprooting Us*), are paying attention to the Great Lakes Region, suggesting the communities hugging the shores of the Great Lakes will be tasked with welcoming millions of additional climate migrants and refugees. As the world's climate shifts and areas become inhospitable, migration to more temperate, and water-rich regions will intensify. Domestic and international migration will be particularly focussed on the Great Lakes Region, including Durham Region.

Durham and the Greater Toronto Area is an important part of the Great Lakes region. Progress on climate mitigation activities and efforts to enhance resilience in Durham Region need to be placed in the context of the overall Great Lakes region. Regional bi-national efforts that brought water-sharing agreements, joint acid-rain mitigation, and a shared electricity grid, will be called on again to address climate change challenges.

[24] https://lakeheadca.com/great-lakes/lake-superior-watershed. Lakehead Region Conservation Authority

Global Trends to Monitor

Several key large-scale trends and possible activities should be monitored as they relate to climate change and its impacts on Durham Region. These include geoengineering; role of Russia; Africa's progress; date and intensity of peak fossil fuel; forest fires; continued, and possibly strengthened, inter-governmental cooperation across the Great Lakes Region. These trends may seem a world-away, however actions in Durham Region are contributing to them, and the trends will directly impact the region.

Geoengineering. Climate engineering (aka geoengineering) refers to a set of emerging technologies that could manipulate the environment and partially offset the impacts of climate change. Two broad areas include carbon dioxide removal and solar radiation management. A challenge with geoengineering is ironically that several options are relatively easy to implement, *e.g.,* encouraging algae growth in oceans and release of high-altitude sulphur particles. A country, or even a group of highly impacted people and businesses, might take it upon themselves to try geoengineering outside an international framework. Similarly, more powerful countries may enact geoengineering that disproportionately impacts others, who believe they have insufficient recourse for compensation. Global treaties are not sufficiently robust to deal with these possibilities. Understanding and development of the technologies is also nascent.

Role of Russia. Russia represents the world's largest potential area of 'climate refuge' (temperate and water-rich). However, Russia's current population is declining, and facing growing geopolitical isolation. What happens when Vladimir Putin is not leading Russia? Will the country be more integrated into the global family of nations, and be able to attract immigrants?

Africa's Progress. Africa is the world's youngest, and fastest growing (and urbanizing) region. In 1900, only 2 of the world's largest 100 cities were in Africa, while combined, Europe and North America had 69. By 2100, Africa will have 36 of the world's 100 largest cities, while Europe and North America will have just 10 cities, an almost seven-fold decline over two centuries. Cities, especially large well-connected cities, drive the world's economy. The way Africa urbanizes (increasing resource consumption, wealth generation, and geopolitical influence) is likely the biggest potential influence in the 21st Century.

Date and intensity of peak fossil fuel. On 12 September 2023 the head of the International Energy Agency published an OpEd predicting peak fossil fuel would occur before 2030 (demand for coal, oil and gas would all peak before 2030). This is earlier than previously forecast. OPEC quickly disputed the prediction. Moving away from fossil fuels is key to climate mitigation, however the energy transition will impact Canada's economy, and Region of Durham. Oil, coal, and gas make up 7.5 per cent of Canada's economy, and 27 per cent of the value of national exports. Impacts will be experienced unevenly, with Alberta experiencing a disproportionate effect.

Forest Fires. The Region of Durham's 2023 GHG inventory could include significant additional emissions attributed to this year's forest fires. The unprecedented fires across Canada released some 600 Mt of CO_2, about 15 t per Canadian. Emissions (and potential carbon sequestration) from forests on managed lands, like emissions associated with the Canadian military, are often included in GHG inventories, and distributed across all residents and businesses. Statistics Canada currently does not include forest fire emissions in Canada's GHG inventory, submitted to the UNFCCC. This may change.

Continued, and possibly strengthened, inter-governmental cooperation across the Great Lakes Region. The Great Lakes region is supported through one of the world's closest international partnership agreements, for example, water sharing and border crossings. The region will likely continue to anchor much of Canada's and the US' economic (and population) growth. The region will also be under greater stress due to ecosystem challenges adapting to a changing climate and population and development demands.

Shifting Global Economy and Demographics. Canadians and the institutions they support are used to an annual economic growth rate of around 3 per cent (Canada's GDP grew more than 18-times from 1960 to 2000). Canada's aging population and global economic primacy is shifting from OECD-member countries to Asia in the first half of this century and Africa in the latter half. Canadians need to anticipate economic growth closer to 1 per cent, a third of what the country is used to. The challenges of Canada's slowing economy are exacerbated the country's low, and declining, productivity (among the lowest of all OECD member countries).

Demographics and shifting global economic primacy are driving much of today's geopolitics. Overtop this strife is the necessity to mitigate and adapt to climate change. Both climate mitigation and adaptation are unevenly distributed around the world. Typically, low-income countries will bear the greatest impacts of a warming climate, while having contributed the least in GHG emissions. Middle-income countries now however are emerging as the largest GHG contributors (*e.g.*, China and soon-to-be India).

Countries are mobilizing to reduce GHG emissions. Despite the debate in Canada, the world is shifting to a global price on carbon[25]. There is also a growing recognition that delaying emission cuts makes climate change worse, even if countries reach net-zero in 2050. Again, these impacts (and mitigation efforts) are disproportionality borne by low-income countries. As low-income countries emerge economically, they may exert greater influence on Canada's economy, possibly influenced by Canada's reputation on climate mitigation, and support to the UN-supported Loss and Damages Fund.

[25] The Economist (Oct 1, 2023). "How carbon prices are taking over the world: A quarter of global emissions are now covered, and the share is rising fast."

Mitigation Priorities

Table 1 presents 40 mitigation activities estimated by Project Drawdown, prioritized by *global* mitigation potential in a 2^{o} C climate scenario. Priorities would change for potential activities in Southern Ontario, however, for residents, businesses, organizations and governments in Durham, the list provides a convenient starting point. High priority activities for the region are highlighted in green, and medium priority activities highlighted in yellow. Two key priorities for Durham are not on this list, *i.e.*, integrated mobility and redesigned neighborhoods.

Individual businesses, such as St Marys Cement, would develop their own mitigation pathways. The top five activities are notionally highlighted, *i.e.*, reduced food waste, plant-rich diet, public transit, heat pumps, and bicycle infrastructure. With the region's relatively low-carbon electricity, significant transportation emissions, and high reliance on natural gas for heating of buildings, a hierarchy of mitigation emerges, namely:

(i) shift to a low-carbon integrated mobility.
(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).

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.*, 1Mt CO_2e compared to 0.3 $MtCO_2e$ 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.

Future Work Plan: 2024

This report provides the first comprehensive community inventory for all activities within the Region of Durham. As outlined in the agreement between The Region of Durham and Ontario Tech University's Brilliant Energy Institute, progress toward the net zero target would be monitored and reported annually.

The 2024 edition of this report will (i) provide updated emissions, (ii) breakdown emissions by local municipalities (at least two), (iii) seek international peer review of the methodology presented, (iv) confirm with at least Ontario Tech University and Ontario Power Generation consistent application of 'net-zero' terminology and approach, (v) outline a process for the credible application of carbon offsets for activities within the Region, (vi) provide a case-study of overall emission reduction potential within a specific neighborhood.

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List of Tables, Figures and Annexes

Table 1: Indicative GHG Mitigation Activities

Total Global estimates in a 2°C climate scenario from Project Drawdown[26]

For Durham Region community activities: High Priority, Medium Priority, Top 5 activities in Bold

** Activities that local governments could support for community implementation

Reduced Food Waste **	88.50 Gt[27]
Plant-Rich Diets	78.33
Silvopasture (integrated forestry, livestock, and forage) **	26.58
Methane Leak Management	25.83
Peatland Protection and Rewetting	25.40
Tree Plantations (on degraded land)	22.04
Insulation **	15.38
Regenerative Annual Cropping	15.12
LED Lighting	14.45
Conservation Agriculture **	12.81
Abandoned Farmland Restoration **	12.48
Recycling **	10.36
Building Automation Systems **	9.55
Public Transit	9.42
Efficient Trucks	9.15
Carpooling **	9.06
High-Performance Glass	8.82
Alternative Cement	7.70
Electric Cars	7.66
Smart Thermostats **	6.91
Efficient Ocean Shipping	6.72
Waste to Energy	6.27
District Heating **	6.18
Methane Digesters	6.02
Efficient Aviation	5.29
Improved Cattle Feed	4.42
High-Efficiency Heat Pumps **	4.04
Landfill Methane Capture	3.89
Reduced Plastics	3.76
Solar Hot Water **	3.41
Improved Manure Management	3.34
Nuclear Power	3.17
Walkable Cities	2.83
Bicycle Infrastructure **	2.73
Telepresence	2.64
Electric Trains	1.91
Electric Bicycles **	1.39
High-Speed Rail	1.26
Composting **	1.13
Green and Cool Roofs **	0.53

[26] https://drawdown.org/solutions/table-of-solutions

[27] Gigatons (billions) CO_2 Equivalent Reduced / Sequestered (2020–2050)

Table 2

OVERVIEW (GPC Table 4 with Scope 3 + 7)

NAME OF CITY:	Region of Durham, Ontario, Canada	**POPULATION:**	745,580.0	**METRO AREA**	
		LAND AREA (km2):	2,524		
INVENTORY YEAR:	2022	**GDP (US$ B):**	0.00		
		tCO2/Capita Scope 1			8.6
		tCO2/Capita Scope 1,2,3			15.9

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)	1,473,801	179,467	491,930	479,516	1,653,269	2,145,198	2,624,715
	Energy generation supplied to the grid (I.4.4)	83,895						
TRANSPORTATION	(all II emissions)	2,656,043	329	587,320	1,400,763	2,656,372	3,243,692	4,644,455
WASTE	Waste generated in the city (III.X.1 and III.X.2)	96,817		0	0	96,817	96,817	96,817
	Waste generated outside city (III.X.3)	0						
IPPU	(all IV emissions)	1,926,311			0		1,926,311	1,926,311
AFOLU	(all V emissions)	203,293			1,292,752		203,293	1,496,045
OTHER SCOPE 3	(all VI emissions)				1,043,750			1,043,750
TOTAL		6,440,160	179,797	1,079,249	4,216,781	4,406,458	7,615,311	11,832,092

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	866,853	56,885	270,272	1,194,010
I.2	Commercial and institutional buildings and facilities	286,860	68,677	108,970	464,507
I.3	Manufacturing industries and construction	244,853	53,905	91,165	389,923
I.4.1/2/3	Energy industries				
I.4.4	*Energy generation supplied to the grid*	83,895			83,895
I.5	Agriculture, forestry and fishing activities				
I.6	Non-specified sources	75,236		21,523	96,759
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal				
I.8	Fugitive emissions from oil and natural gas systems				
SUB-TOTAL		1,557,696	179,467	491,930	2,229,093
II	TRANSPORTATION				
II.1	On-road transportation	2,579,057	329.5	129	
II.2	Railways	76,174			
II.3	Waterborne navigation			8,119	
II.4	Aviation	812		579,071	
II.5	Off-road transportation				
SUB-TOTAL		2,656,043	329	587,320	3,243,692
III	WASTE				
III.1.1/2	Solid waste generated in the city	77,329			
III.1.3	*Solid waste generated outside the city*				
III.2.1/2	Biological waste generated in the city				
III.2.3	*Biological waste generated outside the city*				
III.3.1/2	Incinerated and burned waste generated in the city	3,857			
III.3.3	*Incinerated and burned waste generated outside city*				
III.4.1/2	Wastewater generated in the city	15,631			
III.4.3	*Wastewater generated outside the city*				
SUB-TOTAL		96,817		0	96,817
IV	INDUSTRIAL PROCESSES and PRODUCT USES				
IV.1	Emissions from industrial processes occurring in the city boundary	1,926,311			
IV.2	Emissions from product use occurring within the city boundary				
SUB-TOTAL		1,926,311		0	1,926,311
V	AGRICULTURE, FORESTRY and OTHER LAND USE				
V.1	Emissions from livestock	132,692		861,834.4	
V.2	Emissions from land	70,601		430,917.2	
V.3	Emissions from aggregate sources and non-CO2 emission sources on land				
SUB-TOTAL		203,293		1,292,752	1,496,045
VI	OTHER SCOPE 3				
VI.1	Energy not included In I.7 & I.8			479,516	
VI.2	Building Material			1,043,750	
VI.3	Food not included in V				
VI.4	Transportation not included in II.5			1,400,763	
VI.5	Water				
VI.6	Waste/Sewage Management not included in III				
VI.7	Key Infrastructure				
VI.8	Other Scope 3				
SUB-TOTAL				2,924,030	2,924,030
TOTAL	Territorial	6,440,160	179,797	5,296,031	11,915,987
Total	Scope 1 and 2 Basic+ Reporting	6,356,265	179,797		6,536,062

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:

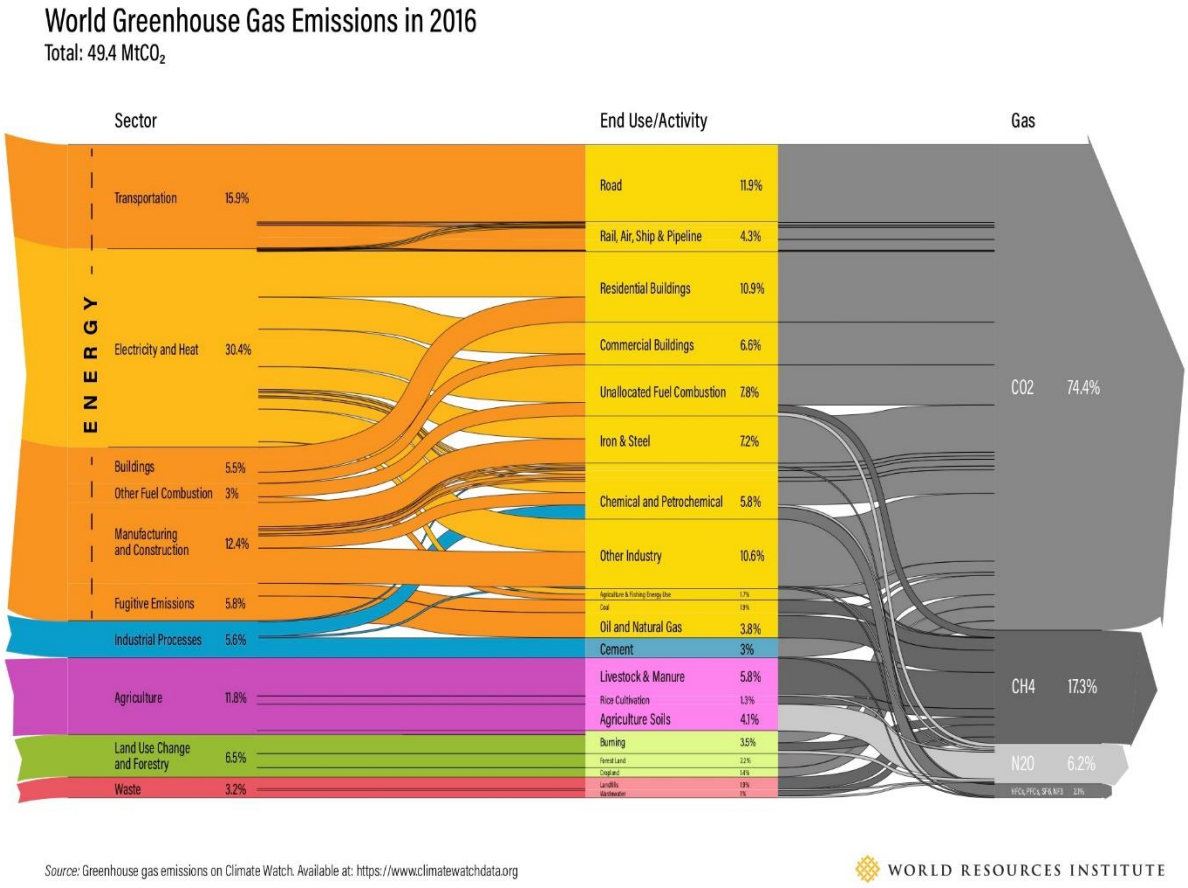


Figure 2:

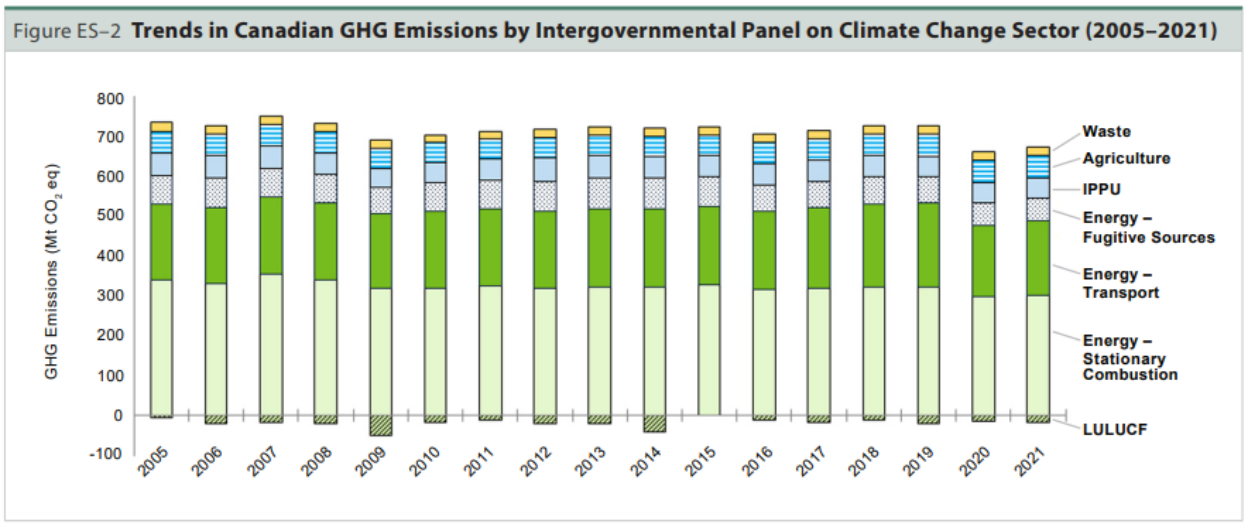


Figure 3

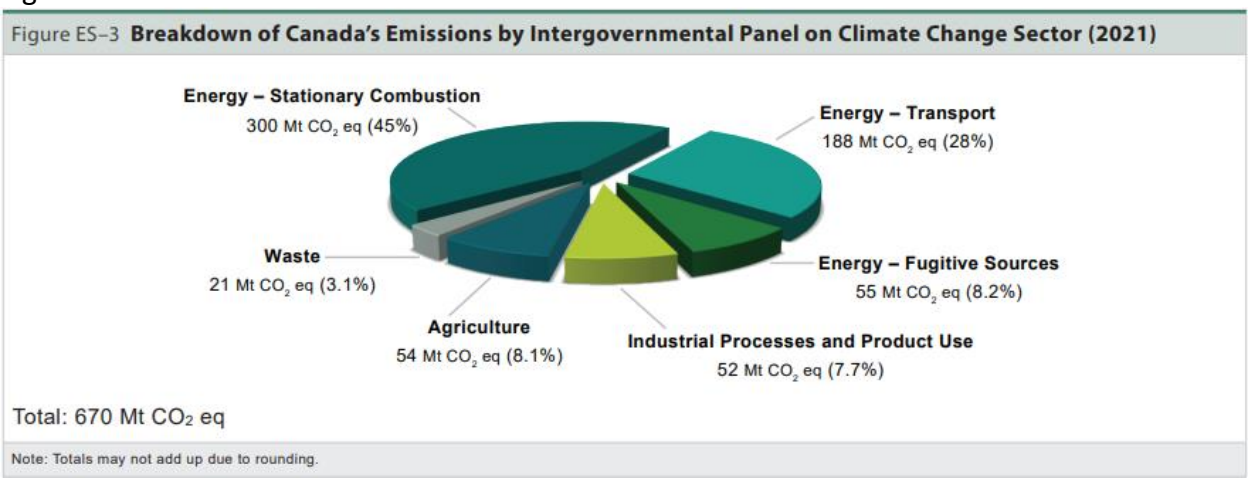


Figure 4

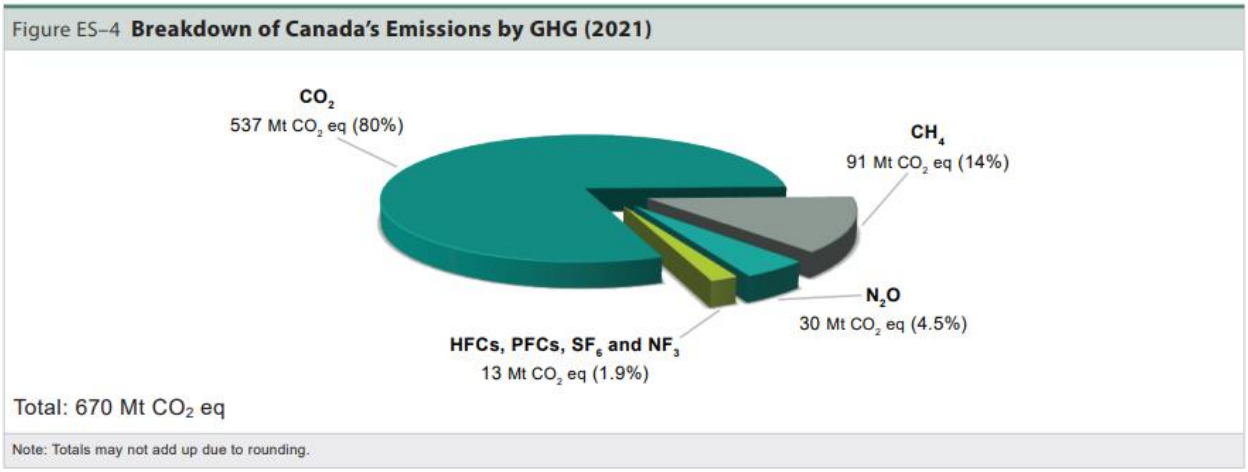


Figure 5:

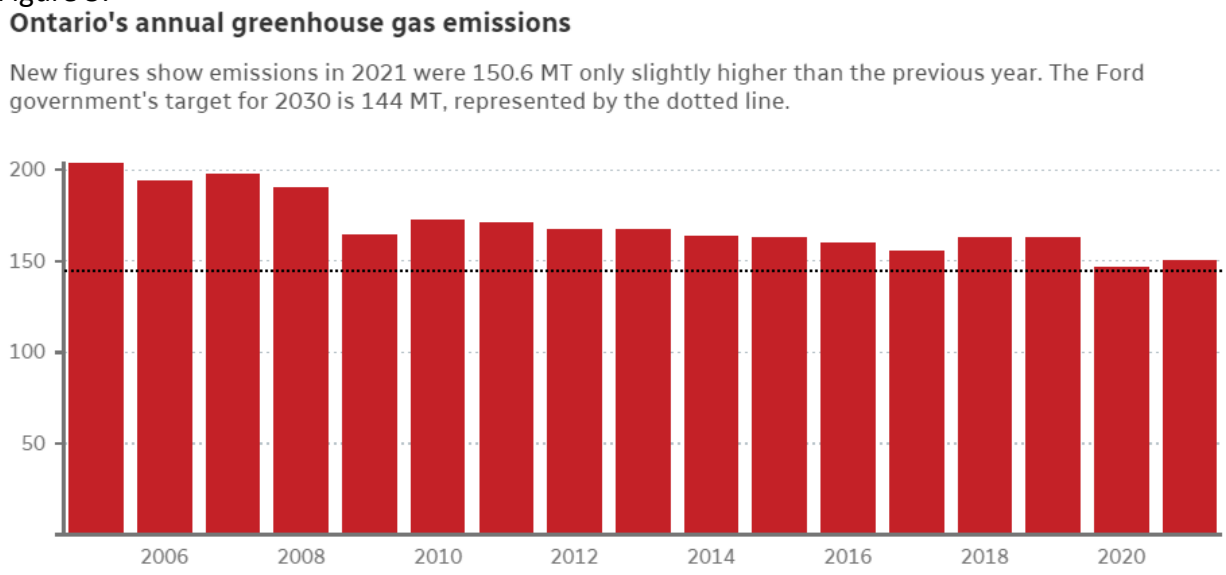
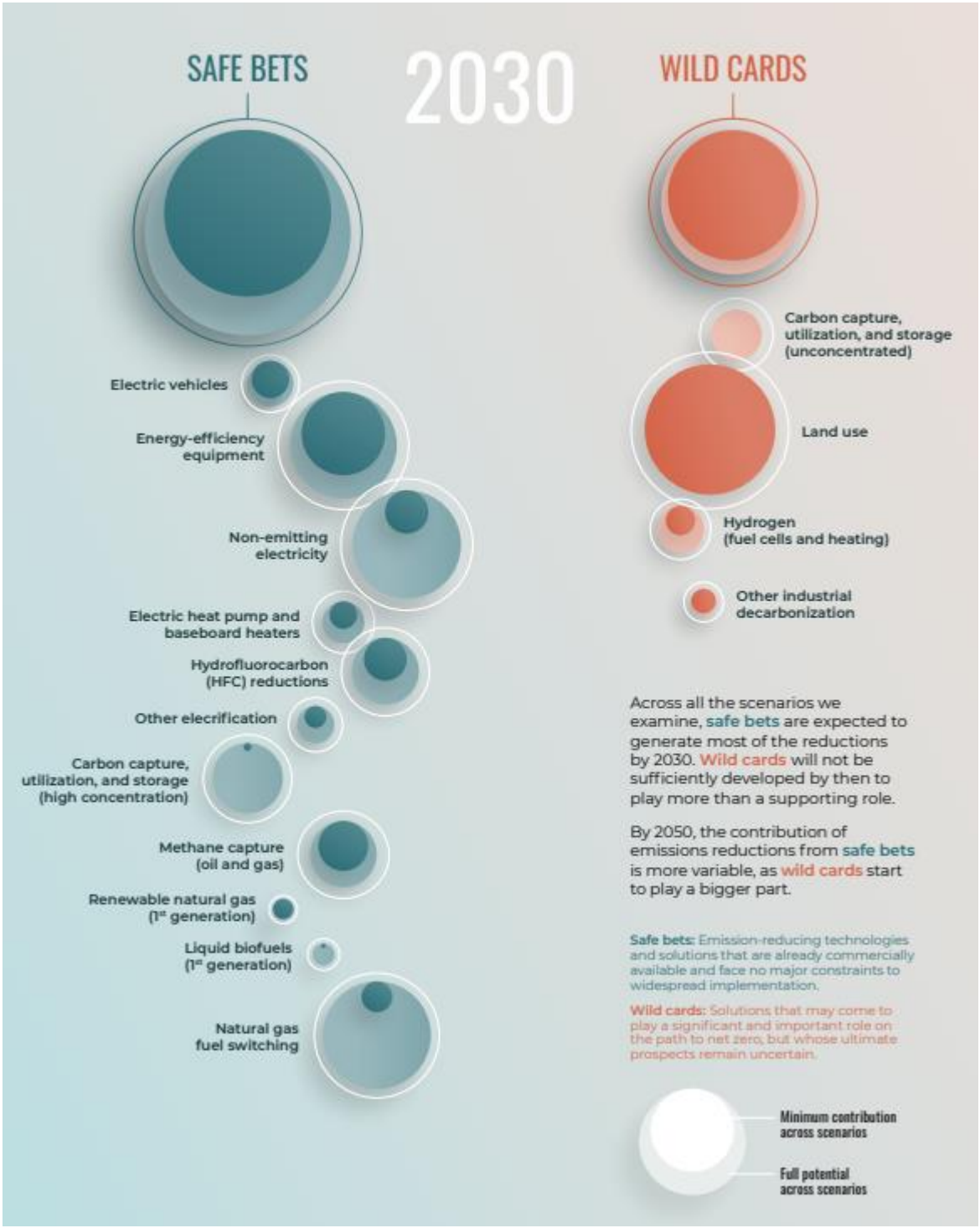
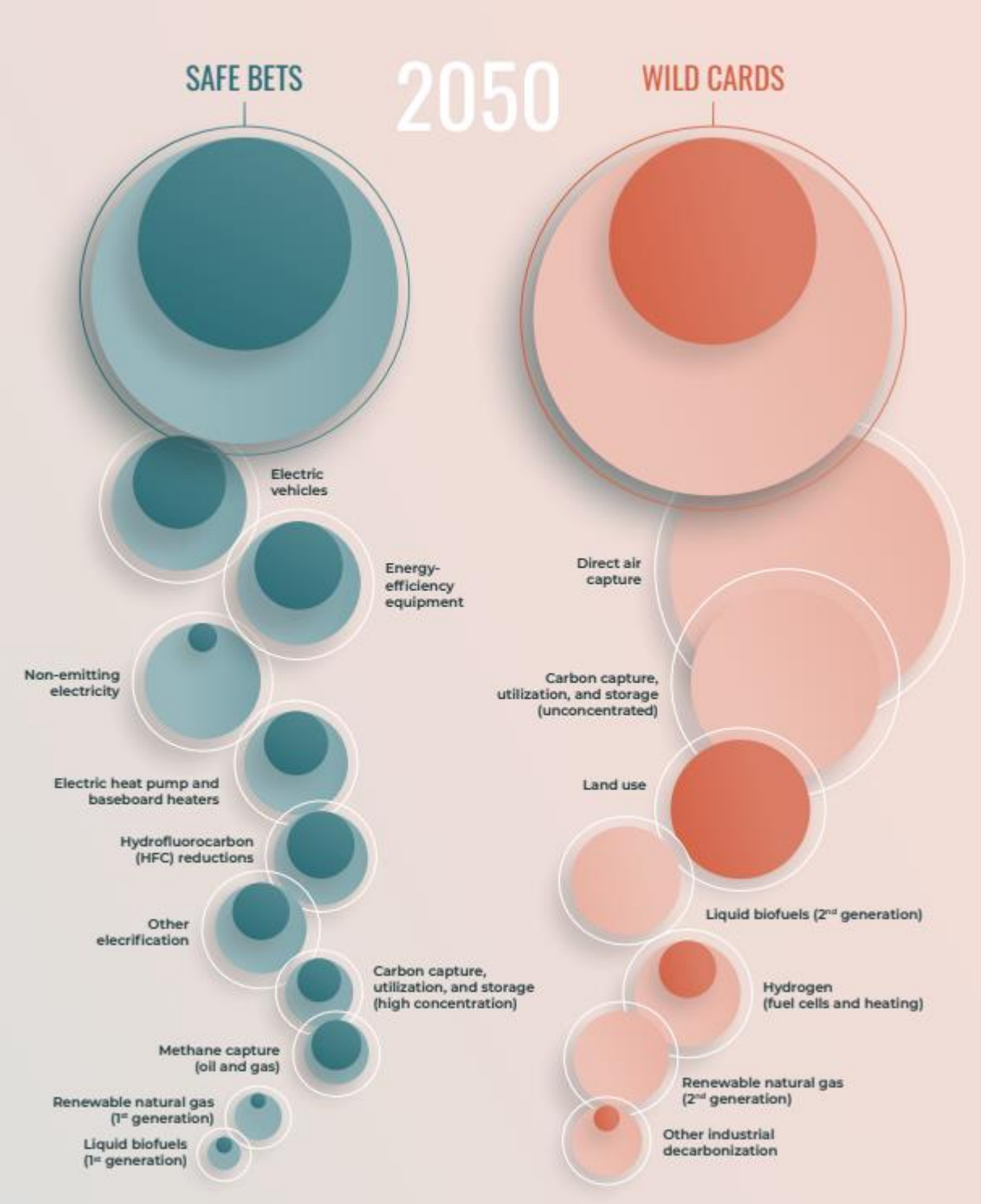


Figure 6: Proposed Greenhouse Gas Mitigation Strategies; Canada-wide, all scenarios 2030



Canadian Institute for Climate Choices, 2021

Figure7: Proposed Greenhouse Gas Mitigation Strategies; Canada-wide, all scenarios 2050



Canadian Institute for Climate Choices, 2021

Figure 8

Durham Region Greenhouse Gas Emissions

Tonnes of Carbon Dioxide Equivalent (tCO_2e) 2022 Estimate: 11.9 million

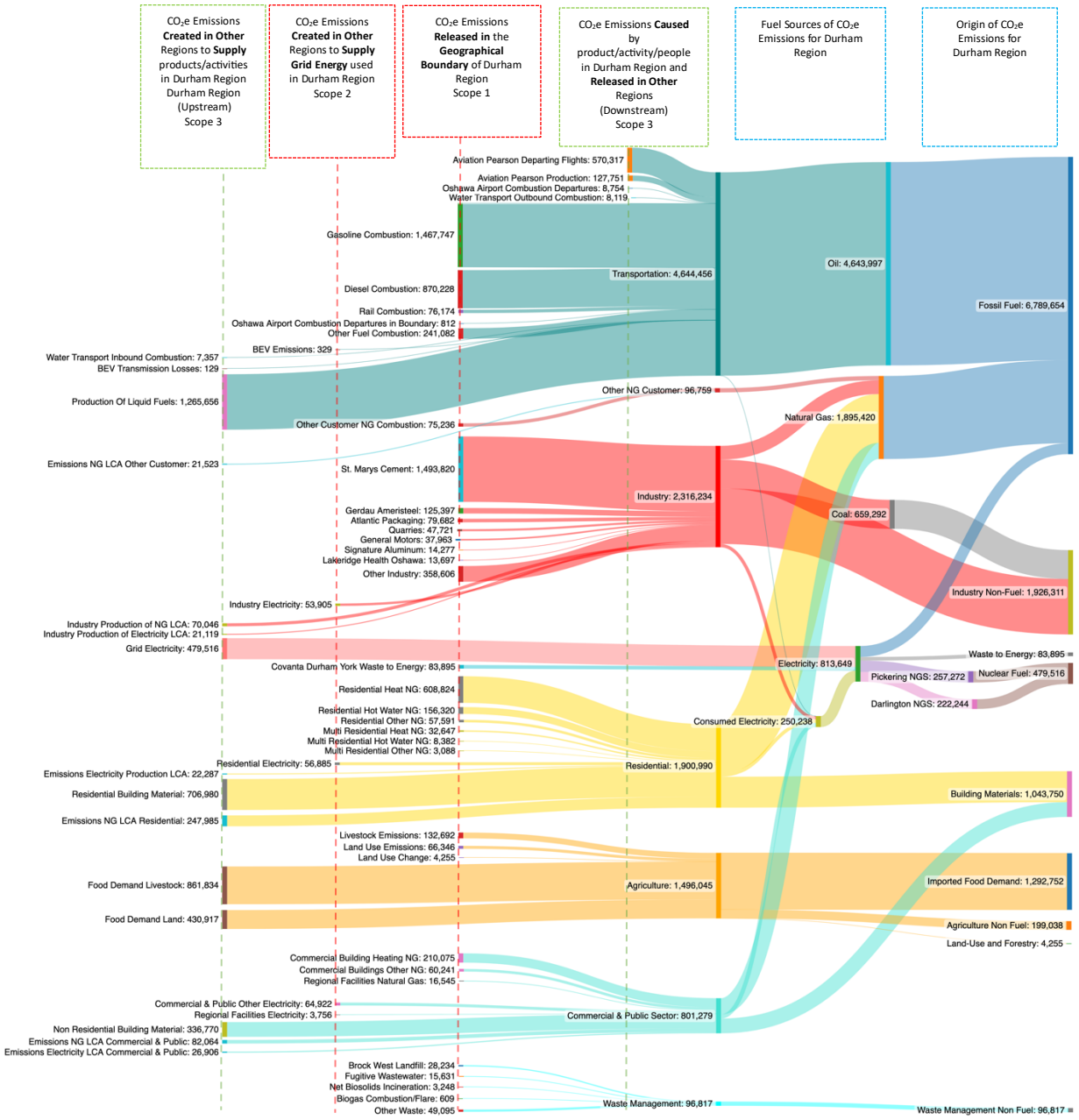


Figure 9

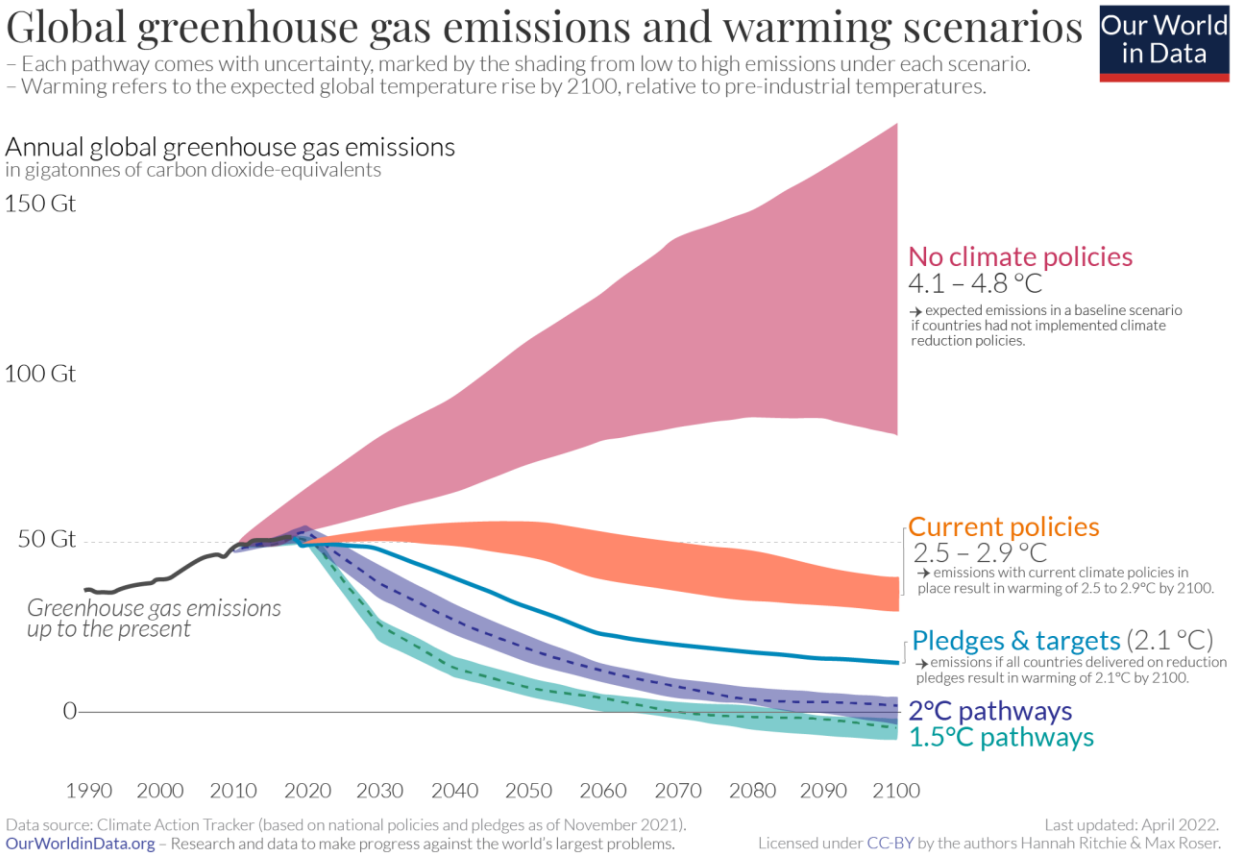

Global greenhouse gas emissions and warming scenarios
– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.
Our World in Data
Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide-equivalents
150 Gt
100 Gt
50 Gt
0
Greenhouse gas emissions up to the present
No climate policies
4.1 – 4.8 °C
→ expected emissions in a baseline scenario if countries had not implemented climate reduction policies.
Current policies
2.5 – 2.9 °C
→ emissions with current climate policies in place result in warming of 2.5 to 2.9°C by 2100.
Pledges & targets (2.1 °C)
→ emissions if all countries delivered on reduction pledges result in warming of 2.1°C by 2100.
2°C pathways
1.5°C pathways
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Last updated: April 2022.
Licensed under CC-BY by the authors Hannah Ritchie & Max Roser.

Figure 10: Durham Region, Community – Total Emissions 2022 (11.9 Mt CO_2e)

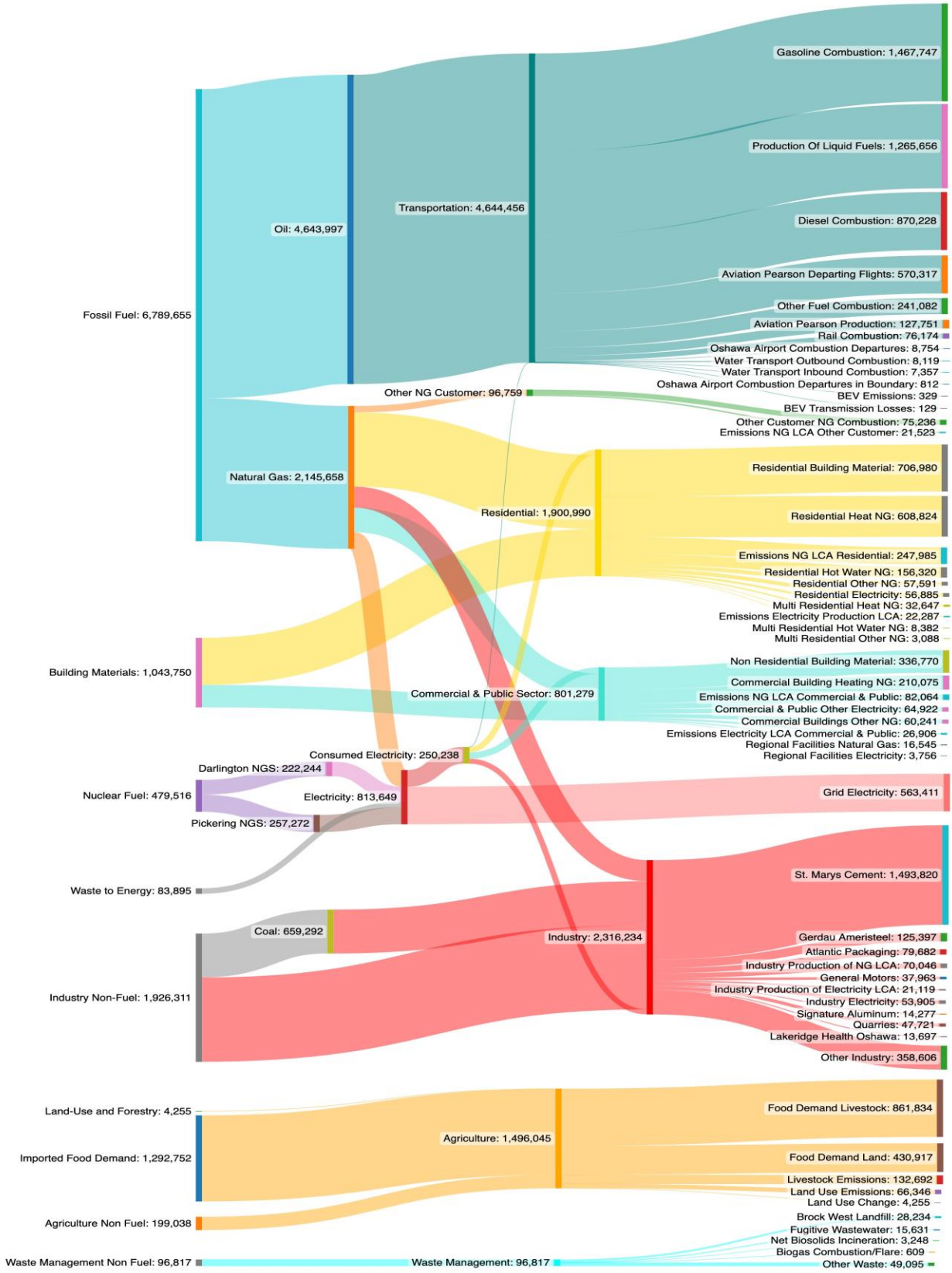
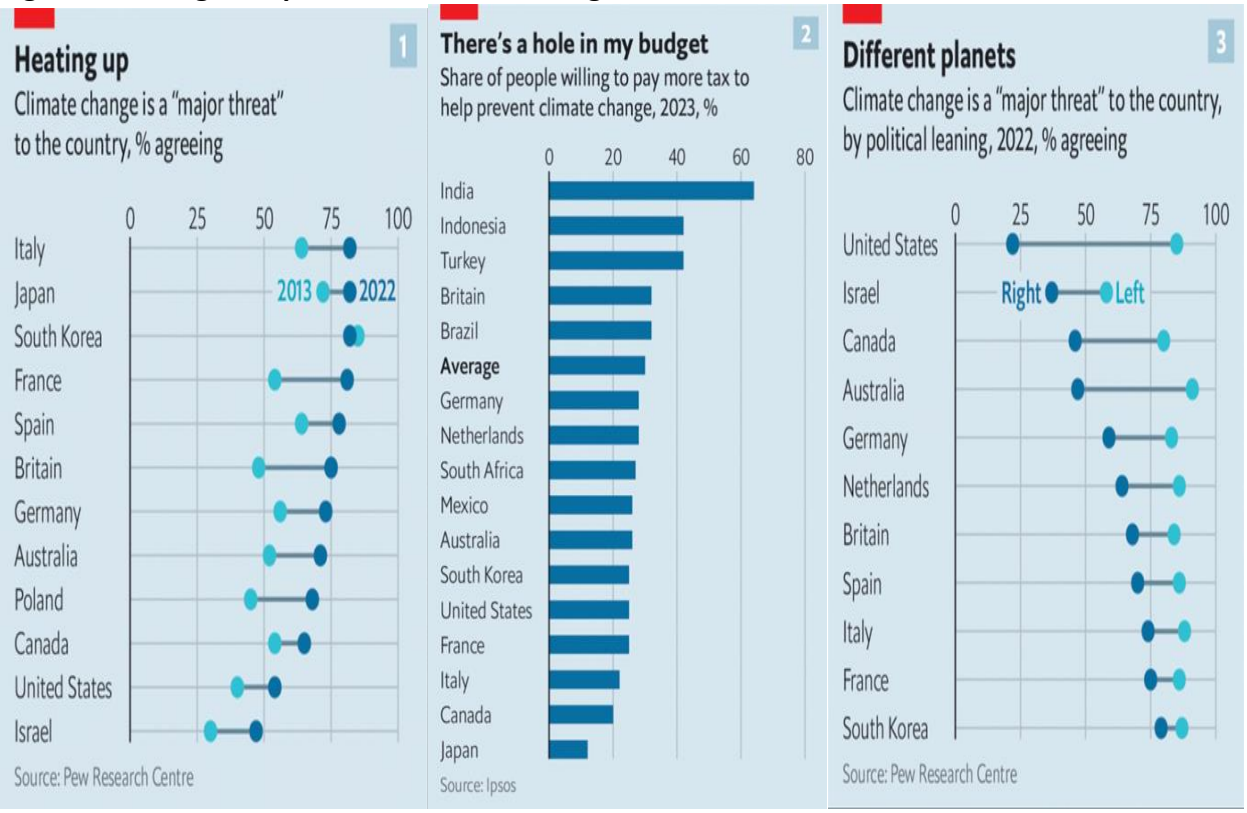


Figure 11: The global politics of climate change



The Economist, October 2023

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

The Government of Canada states, "Net-Zero emissions means that the economy[28] 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."[29]

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[30]. For high emitting sectors there is also discussion on use of 'Article 6' of the UNFCCC[31].

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."

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

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.

Recognizing the uncertainty and worries of 'greenwashing' the United Nations established an Expert Group on Net Zero Emissions Commitments of Non-State Entities (businesses and municipalities). The Expert Group issued its first report in 2022, Table A1.

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

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

[30] "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.

[31] 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.

For the purpose of this report, the net-zero emissions target by the Region of Durham[32] pertains to all GHG emissions that can reasonably be estimated ands 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.

Table A1: Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions.

Report from the United Nations' High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities

Five Principles

1. Ambition which delivers significant near— and medium —term emissions reductions on a path to global net zero by 2050
2. Demonstrated integrity by aligning commitments with actions and investments
3. Radical transparency in sharing relevant, non-competitive, comparable data on plans and progress
4. Established credibility through plans based in science and third-party accountability
5. Demonstrable commitment to both equity and justice in all actions

Ten Recommendations

1. Announce a Net Zero Pledge
2. Sett Net Zero Targets
3. Use Voluntary Credits
4. Create a Transition Plan
5. Phase out of Fossil Fuels and Scaling Up Renewable Energy
6. Align Lobbying and Advocacy
7. Include People and Nature in the Just Transition
8. Increase Transparency and Accountability
9. Invest in Just Transitions
10. Accelerate the Road to Regulation

The Expert Group also commented on current progress of emissions mitigation.

- Total carbon dioxide (CO_2) emissions from fossil fuels and land use change remained high in 2022 and the first half of 2023. Fossil fuel CO_2 emissions increased 1% globally in 2022 compared to 2021, and global average concentrations continued rising through 2022 and the first half of 2023.

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

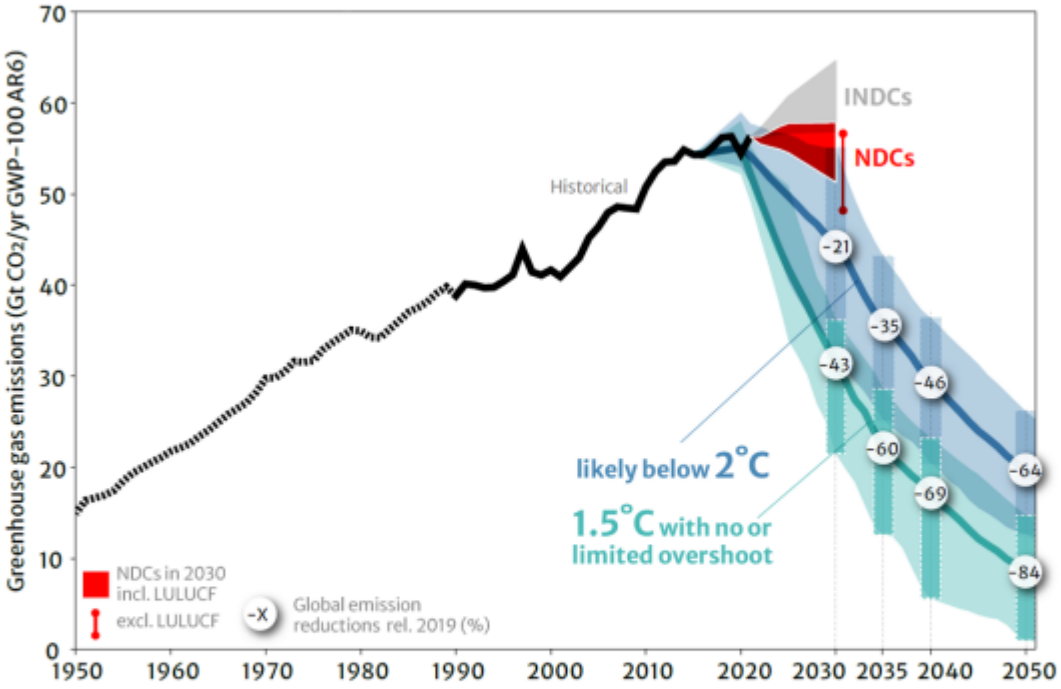
- The years from 2015 to 2022 were the eight warmest on record, and the chance of at least one year exceeding the warmest year on record in the next five years is 98%.
- It is estimated that current mitigation policies will lead to global warming of around 2.8 °C over this century compared to pre-industrial levels. Immediate and unprecedented reductions in greenhouse gas (GHG) emissions are needed to achieve the goals of the Paris Agreement.

The remaining carbon budget compatible with a 50% of chance of limiting global warming to 1.5°C continues to be depleted and has now been reduced to around 250 $GtCO_2$ based on a recent update of the IPCC estimate (Forster *et al.,* 2023). If total CO_2 emissions stay at current levels, then this remaining budget would be exhausted before 2030, inexorably leading to overshoot of 1.5°C global warming.

Annex 2: The Steep Path to Mitigating GHG Emissions

The first interim stocktaking of emission reductions was published by the UNFCCC September 2023.[33] Progress is insufficient to meet 1.5° C or 2.0° C targets. The figure below highlights the steep reductions required.

Historical emissions from 1950, projected emissions in 2030 based on nationally determined contributions, and emission reductions required by the Sixth Assessment Report of the Intergovernmental Panel on Climate Change



		Reductions from 2019 emission levels (%)			
		2030	2035	2040	2050
Limit warming to1.5°C (>50%) with no or limited overshoot	GHG	43 [34-60]	60 [49-77]	69 [58-90]	84 [73-98]
	CO_2	48 [36-69]	65 [50-96]	80 [61-109]	99 [79-119]
Limit warming to 2°C (>67%)	GHG	21 [1-42]	35 [22-55]	46 [34-63]	64 [53-77]
	CO_2	22 [1-44]	37 [21-59]	51 [36-70]	73 [55-90]

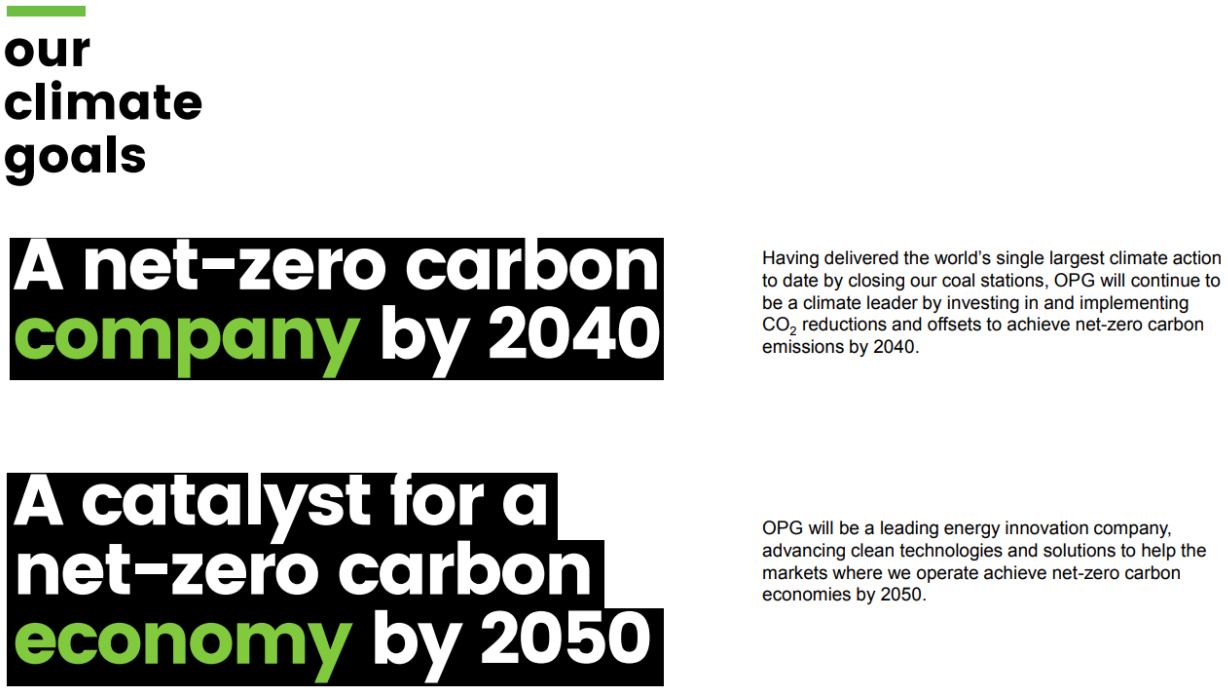
[33] https://unfccc.int/sites/default/files/resource/sb2023_09_adv.pdf

Annex 3: Regional Partners in the Net Zero Challenge

Ontario Power Generation (Headquarters moving to Durham Region in 2024) and Ontario Tech University are key partners in Durham Region's goal of net zero. Both organizations have committed to net zero by 2040, and both include 'direct' and 'indirect' emissions, *i.e.*, Scopes 1, 2 and 3, in their targets. For both organizations this will require, for all intents and purposes, a net zero transportation system in the region by 2040 (or large carbon offset purchases).

OPG and Ontario Tech together, for example, likely have more than 25,000 students, staff and service contractors travelling to their facilities every day. Today this travel generates more than 300 tonne CO_2 per day[34]. Transportation emissions associated with the two employers alone are likely more than 200,000 tonnes CO_2 per year[35].

Ontario Power Generation defines 'Net-zero' as achieving an overall balance between direct carbon emissions produced and carbon emissions taken out of the atmosphere.



[34] Direct: 100,00t/year. Indirect: 100,000 t/year (25,000 daily trips, at 75 km return, 80% by ICE vehicle at 200g/km, from IEA)

[35] Offsetting these transportation emissions today would cost about $10 million per year (@ typical $100/tonne offset cost)

defining net-zero

'Net-zero' refers to achieving an overall balance between direct carbon emissions produced and carbon emissions taken out of the atmosphere.

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