# Climate Change in Canada and Ontario

## A Comprehensive Report

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# Climate Change in Canada and Ontario

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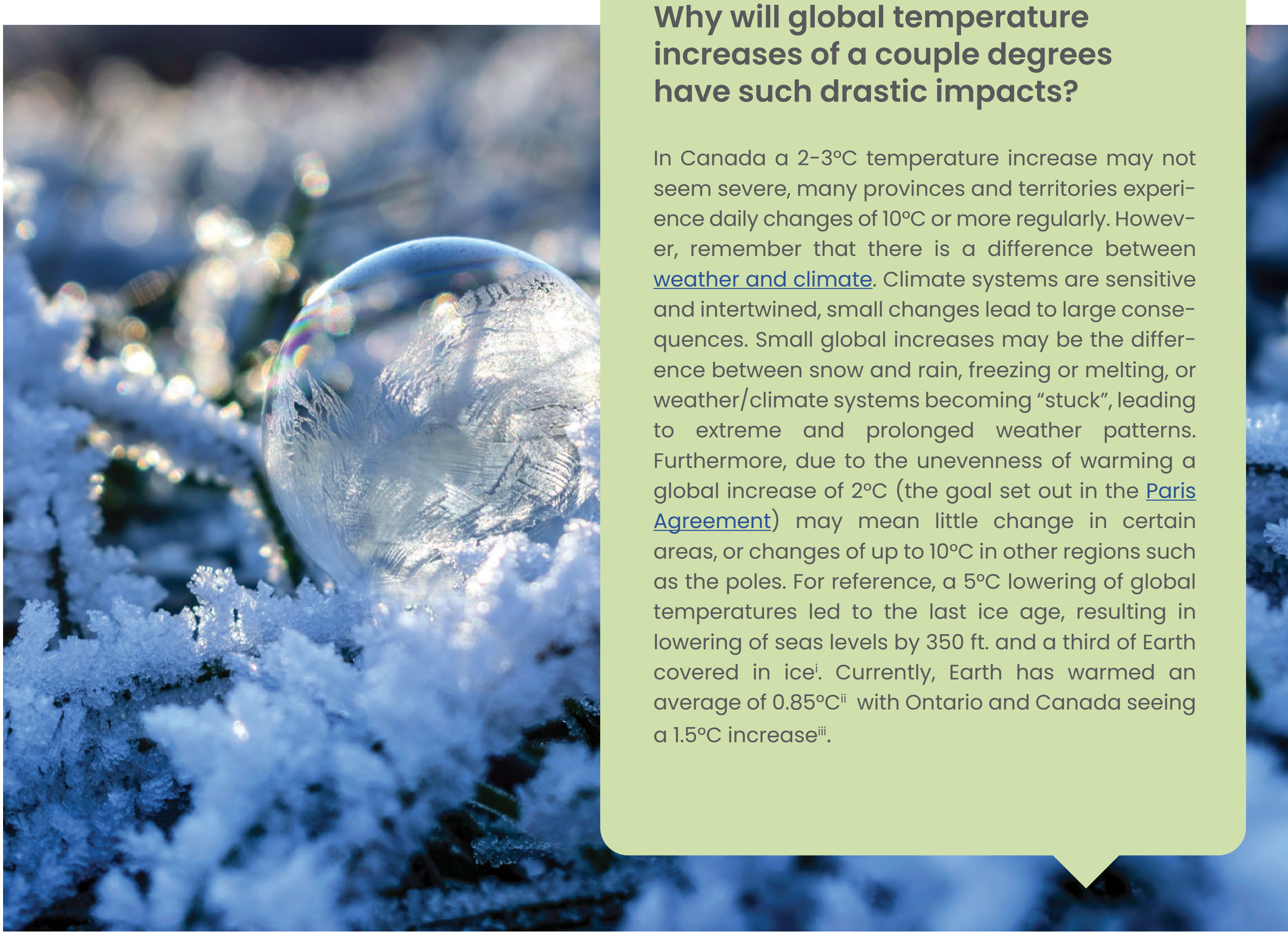
# Climate Change in Canada and Ontario

With the amount of climate change material available it can be difficult to identify relevant knowledge and its importance. To support continued learning this document outlines basic climate change information, starting globally and narrowing to focus on Canada and Ontario.



### Why will global temperature increases of a couple degrees have such drastic impacts?

In Canada a 2-3°C temperature increase may not seem severe, many provinces and territories experience daily changes of 10°C or more regularly. However, remember that there is a difference between weather and climate. Climate systems are sensitive and intertwined, small changes lead to large consequences. Small global increases may be the difference between snow and rain, freezing or melting, or weather/climate systems becoming "stuck", leading to extreme and prolonged weather patterns. Furthermore, due to the unevenness of warming a global increase of 2°C (the goal set out in the Paris Agreement) may mean little change in certain areas, or changes of up to 10°C in other regions such as the poles. For reference, a 5°C lowering of global temperatures led to the last ice age, resulting in lowering of seas levels by 350 ft. and a third of Earth covered in ice[i]. Currently, Earth has warmed an average of 0.85°C[ii] with Ontario and Canada seeing a 1.5°C increase[iii].

## A Little Bit about Greenhouse Gases (GHGs)

Before diving into climate change impacts and emissions take a look at the table below to become familiar with the main GHGs. Carbon dioxide and methane are the best known, though there are five gases and two types of gases that are classified as GHGs. For more information on how the GHG effect works review the document "Understanding the Greenhouse Gas Effect" within the toolkit.

| Greenhouse Gas | Primary Means of GHG Generation | Percent of Total Emissions (Canada)* | Global Warming Potentials (GWP)** | Lifetime in Atmosphere (years)*** |
|---|---|---|---|---|
| Carbon Dioxide | Fossil fuel combustion and biomass for energy. | 79% | 1 | Extremely variable (4-500)[viii] |
| Methane (primary component of natural gas) | Agriculture (livestock and nitrogen fertilizers), organics decomposition, oil and gas fugitive emissions (leaks, flaring, etc.) | 14% | 25 | Approximately 12 |
| Nitrous Oxide | Fertilizers, some industry processes, and transport | 5% | 298 | 114 |
| Sulphur hexafluoride | Insulates high voltage equipment | 1.9% | 22,800 | 3,200 |
| Nitrogen trifluoride | Used to manufacture semiconductors, photovoltaics, LCD panels. | | 17,200 | 740 |
| Hydrofluorocarbons (HFCs) | Refrigerants and some manufacturing (semiconductors) | | 2,447 (average) | 38 (average) |
| Perfluorocarbons (PFCs) | Electronics, manufacturing semiconductors, refrigerants, by-product of aluminum production. | | 10,100 (average) | 8,633 (average) |

*Taken from the "National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada", Part 1.
**GWP refers to the amount of "heat" that each gas can trap relative to one tonne of CO2; for example, one tonne of methane has the same heating ability as 25 tonnes of CO2 etc.
***The time GHGs spend in the atmosphere is different for each gas. GHGs take years to leave the atmosphere; though emissions are measured annually, billions of tonnes of GHGs remain in the atmosphere from previous years.

## What is a Tonne of GHGs?

GHGs are usually measured by the tonne, but unlike other sustainability related issues, such as waste, it is difficult to wrap our heads around GHG emissions and their impacts when we cannot directly see them. In Canada, the creation of a tonne of carbon dioxide can come from[ix]:

- A years worth of trash.
- Driving 4,500 km.
- Heating your home for 4 months.
- Powering your home for 7 months.
- Raising one cow for six months.
- One round trip from Toronto to London, England.

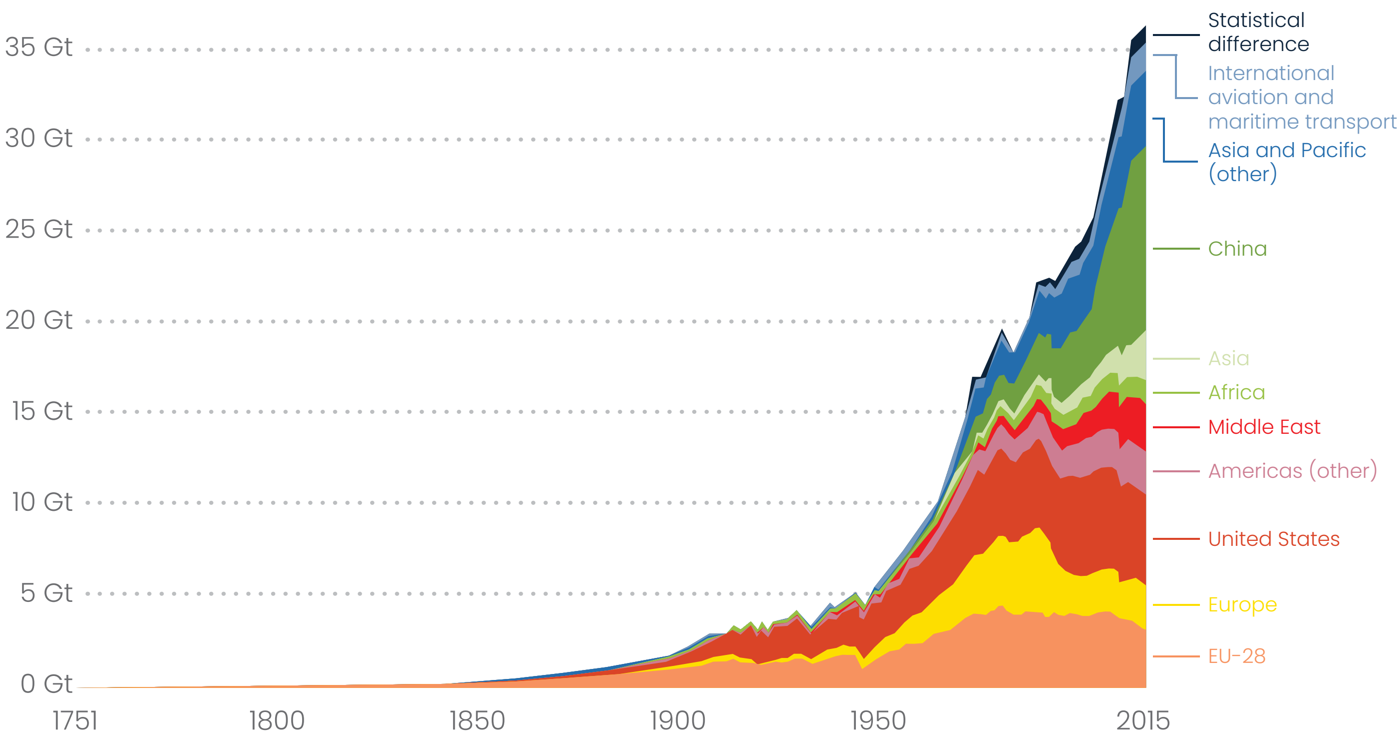
To help visualize this in another way one tonne of emissions can fill a space approximately 10 m x 10 m by 5 m (500 m³)[x] in size ; this is similar to an area the size of two school portable classrooms.

## Our Worlds Emissions

The world added just over 37 billion tonnes of GHG emissions in 2018[xi], this equates to approximately 1,160 tonnes per second. The chart below provides a timeline of global GHG contributions since 1751[xii].

### Annual $CO_2$ emissions by world region

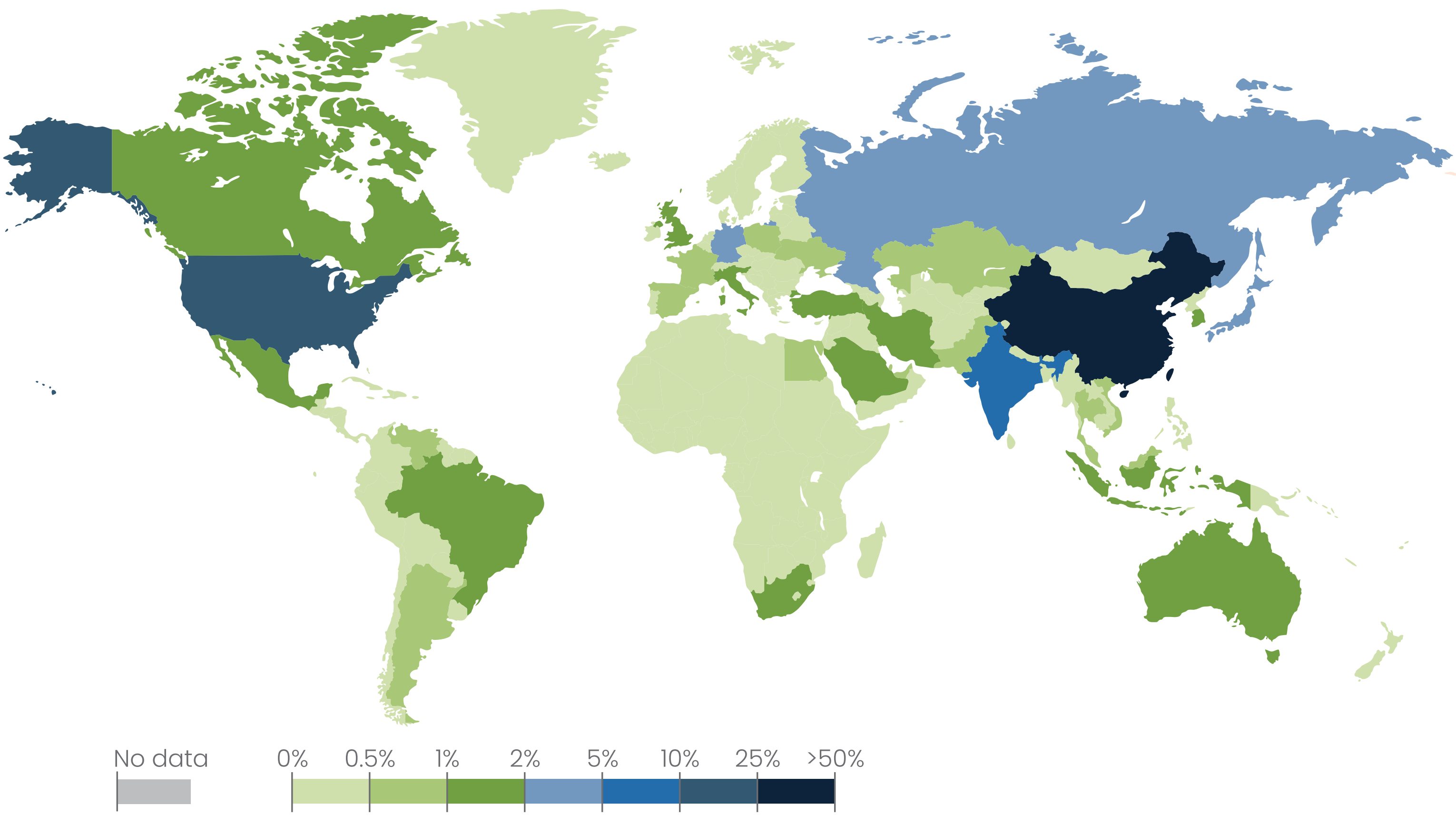
Annual carbon dioxide ($CO_2$) emissions measured in billion tonnes (Gt) per year




Source: Carbon Dioxide Information Analysis Center (CCIAC)

Globally, GHG output varies widely between countries. This [interactive graphic] shows what percent of global emissions each country is responsible for annually between 1751 and 2016; a snapshot of 2016 is provided below. In 2016, China was the largest emitter (29%), followed by the United States (15%), India (7%), and Russia (4.6%), with Canada emitting just over 1.5% of the global total. Generally, Canada ranks in the top 10 highest emitting countries.

**Annual share of global $CO_2$ emissions, 2016**

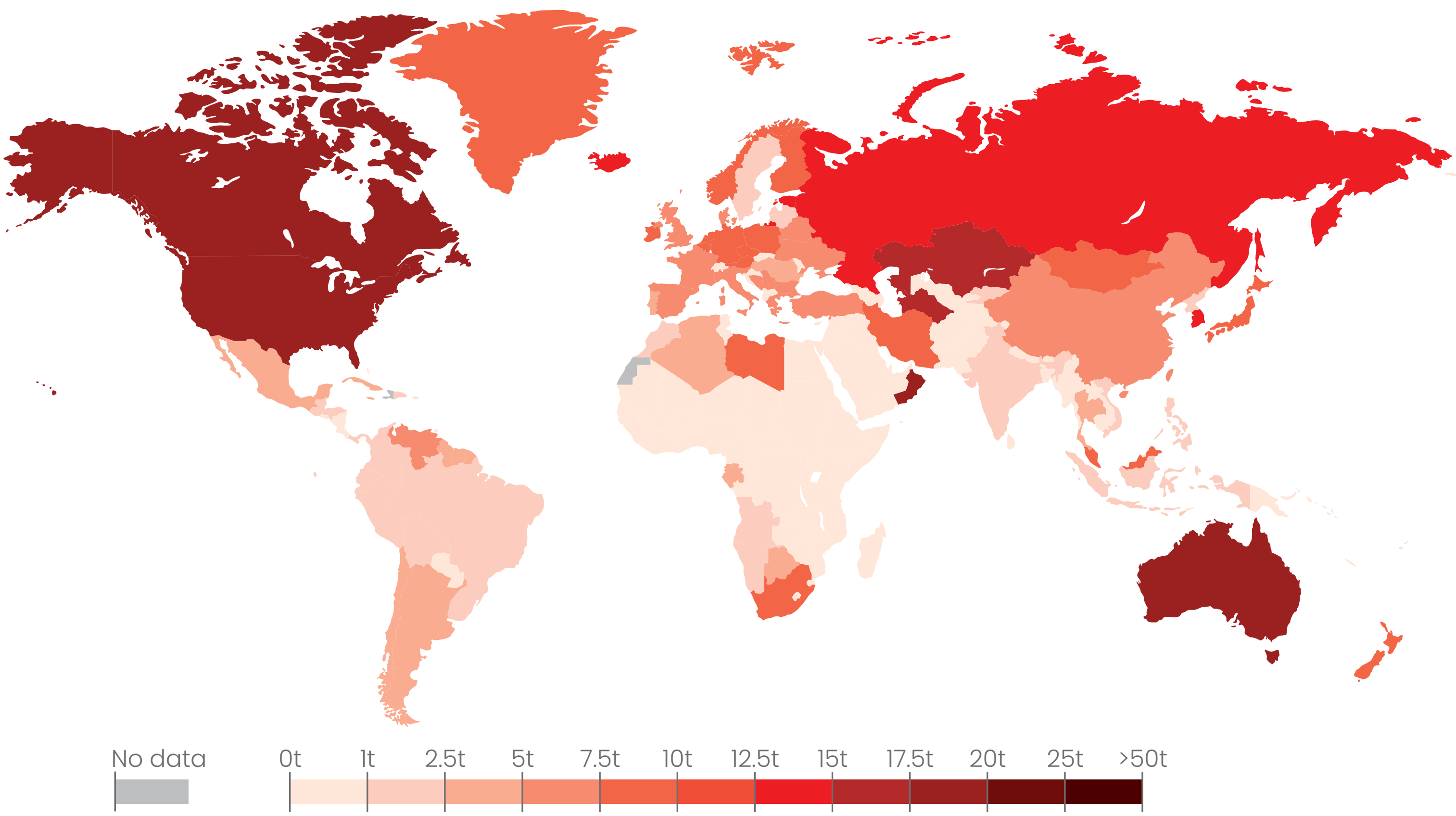



Adapted from: $CO_2$ and other Greenhouse Gas Emissions
https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions#the-long-run-history-cumulative-co2

Another way to visualize emissions is on a per capita basis to help put into perspective individual output. The graphic below depicts how many tonnes (average) each member of the population is responsible for per country.

### $CO_2$ emissions per capita, 2016

Average carbon dioxide ($CO_2$) emissions per capita measured in tonnes per year.




Adapted from: $CO_2$ and other Greenhouse Gas Emissions
https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions#the-long-run-history-cumulative-co2

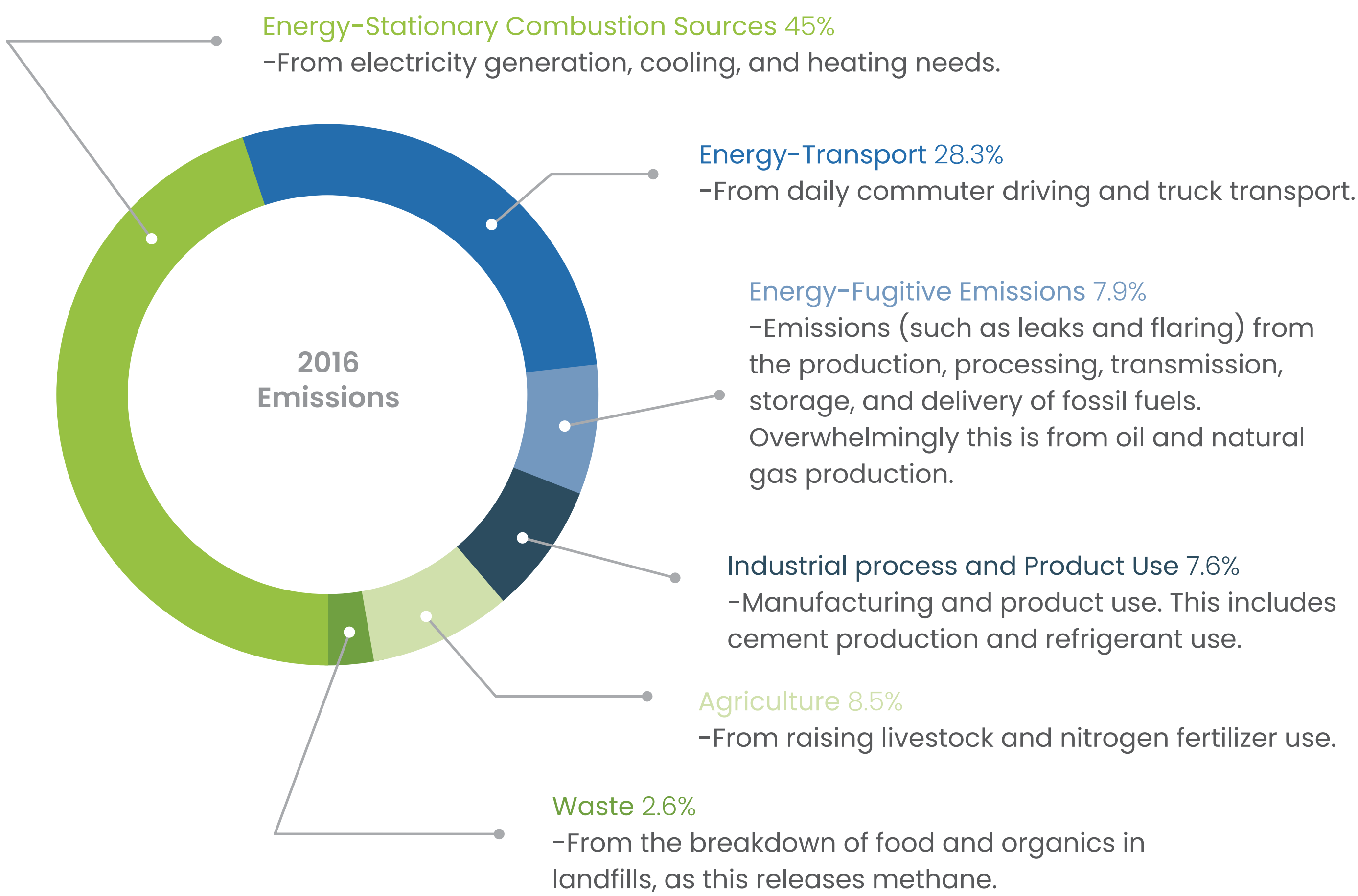
There are some notable contrasts between country and per capita emissions; for instance, China is the largest polluter but on a per capita basis is relatively low. Conversely, Canada generates under 2% of total emissions, but has one of the highest per capita emissions in the world. In Canada, this can be attributed to a few areas; heating of large living spaces, heavy reliance on single passenger commuting, the sprawl of communities, and oil and gas operations, primarily in Alberta[xiii]. On a per capita basis Canadians emit around 15.5 tonnes of $CO_2$ per year, this is very high relative to most of our economic peers.

Note the North-South divide, particularly within sub-Saharan Africa, South America, and South Asia, as well as a wealth divide[xiv].

## What about Canada?

Narrowing further to focus solely on Canada, 2016 saw GHG emissions of 704 mega (million) tonnes of carbon dioxide equivalent ($CO_2e$).

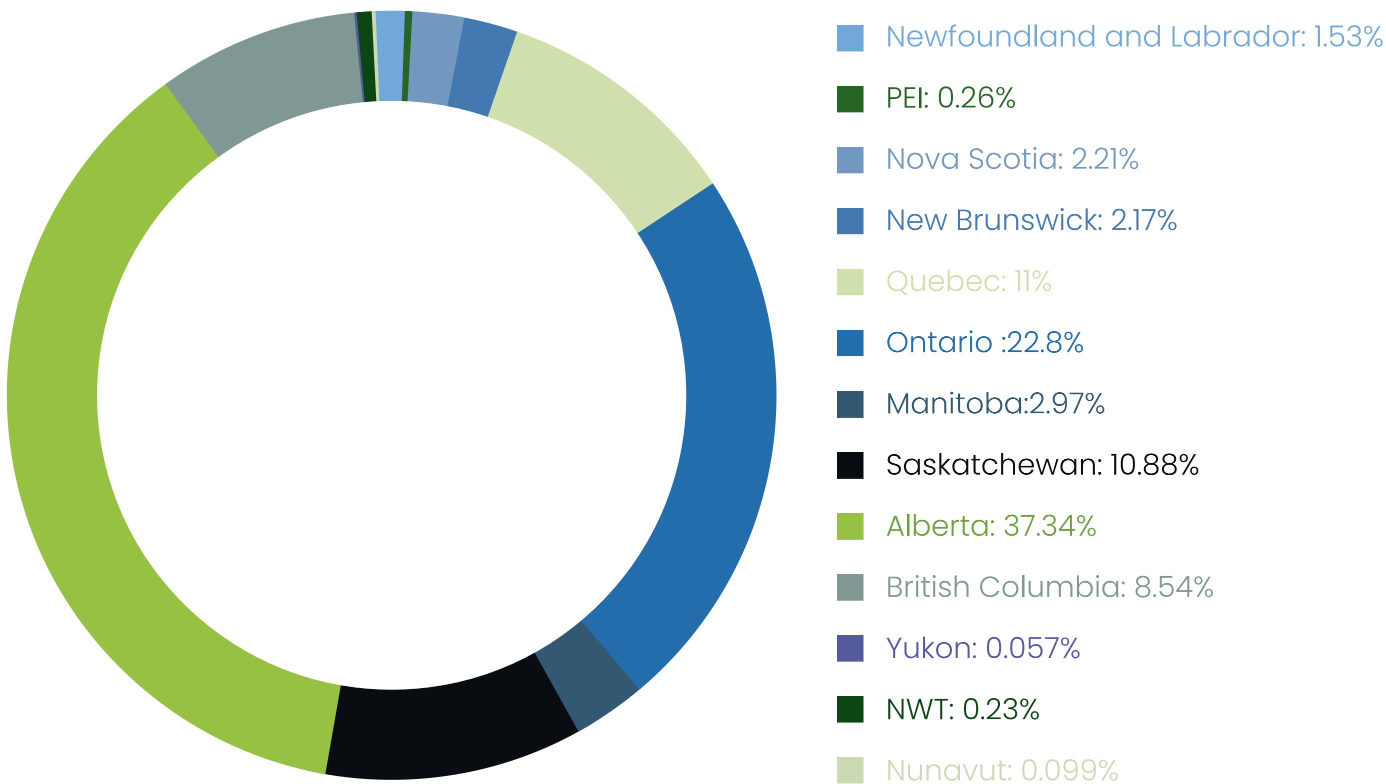
The pie graph below summarizes the sources of 2016 emissions.




Adapted from Canada's 2018 National Inventory Report, Part 1 Figure S-2
https://unfccc.int/documents/65715

Taking this further each province and territory contributes differently to Canada's GHG emissions output. Take a look at the pie graph below for more detail.

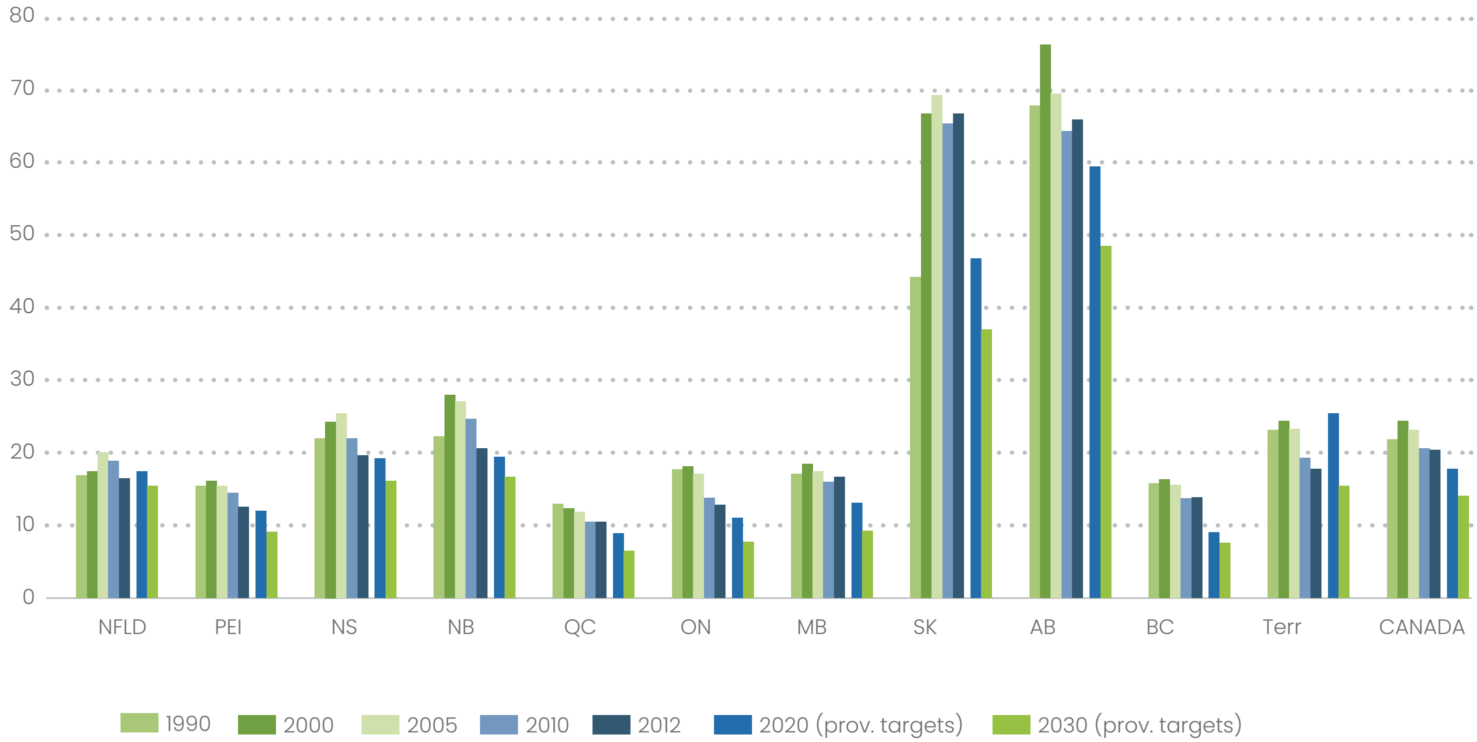
**GHG Emissions by Provinces/Territories, 2016**




Adapted from Canada's 2018 National Inventory Report, Part 1 Figure S-4
https://unfccc.int/documents/65715

The graph below outlines per capita emissions for Canada's provinces and territories. Saskatchewan and Alberta's high contributions come from their reliance on coal-fired electricity, oil sands, and heavy oil production[xv].

**Per capita emissions per province for 1990-2013 and projected levels for 2020 and 2030 targets**




Adapted from Figure 5 of By the Numbers: Canadian GHG Emissions
https://www.ivey.uwo.ca/cmsmedia/2112500/4462-ghg-emissions-report-v03f.pdf

## Ontario's GHG Contribution

Ontario is Canada's second highest GHG emitter, with Alberta taking the top spot. In 2016, Ontario emitted 160.6 million tonnes of CO2e, or just under 23% of Canada's total. Here is where Ontario's emissions came from[xvi]:

- 35% transportation
- 30% industry
- 21% buildings
- 12% waste and agriculture
- 3% electricity

Note: Due to rounding totals may add up to over 100%.

## Climate Change Impacts

The information above provides high-level details on global, Canadian, and provincial/territorial GHG emissions, but what are the consequences of these emissions? The following sections provide an overview of expected climate change impacts globally, in Canada, and Ontario.

## Climate Change Impacts - Global

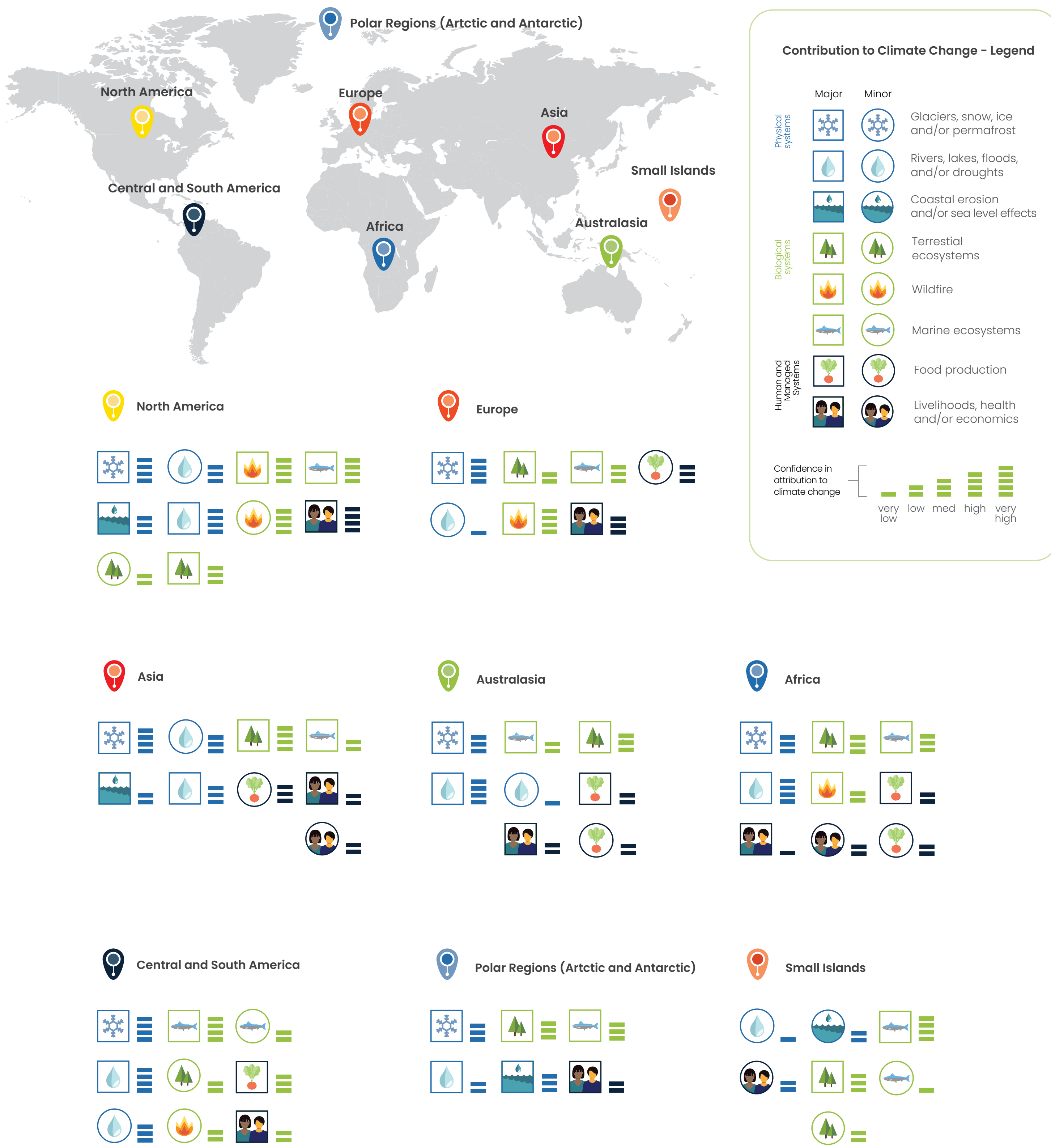
It's hard to understand the changes that will occur globally because of climate change, as there are multiple factors that contribute to future emissions levels and therefore total warming. Factors that are taken into consideration when analyzing impacts include population, economic activity, lifestyle, energy use, land use patterns, technology, and climate policy[xvii].

The diagram on the next page helps to visualize the current and expected overall global impacts of climate change.

### Why does climate change cause more extreme weather such as increased precipitation and droughts?

Warmer global temperatures mean a warmer atmosphere that is able to hold more water vapour from land (this reduces soil moisture) and water bodies; for every 1°C temperature increase the amount of moisture the atmosphere can hold rises by approximately 7%[iv]. Precipitation occurs when the atmosphere cools enough for water vapour to condense into a liquid. Increased levels of greenhouse gases (GHGs) means cooling is not as efficient, so regular precipitation as a result of condensation may not happen as often, or be very extreme when it does because of the added moisture. It's important to note that increased global temperature changes do not automatically result in extreme weather events, but it does increases the odds of occurrence.

## Widespread impacts attributed to climate change




Adapted from the Intergovernmental Panel on Climate Change "Climate Change 2014 Synthesis Report".
https://www.ipcc.ch/report/ar5/syr/

## Climate Change Impacts

In general, climate change will continue to affect the necessities of humans due to:

- Significant changes in food production.
- Impacts on glaciers, snow, and ice.
- Increased levels of flooding and drought.
- Changes in economic and overall livelihood of individuals because of changes to the natural environment.

Note the diagram does not state if these changes will be positive or negative effects, though the impacts of climate change are anticipated to be overwhelmingly negative.

## What to Expect in Canada and Ontario

Understanding the global consequences of climate change provides an overall representation of how the world may change, but the effects seen in Canada and Ontario are unique, and may not mirror global impacts. The table below outlines the impacts Canada and Ontario have experienced and future predicted changes. For more information as to how these areas will affect post-institutional stakeholders take a look at the document "The Non-Financial Impacts of Climate Change" within the toolkit.

Keep in mind it is very difficult to quantitatively estimate future impacts due to multiple factors that influence global emissions. To try to account for this scientists use different Representative Concentration Pathways (RCPs). There are four RCPs, 2.6, 4.5, 6.0, and 8.5, each provides a different climate future, or scenario, based on anticipated global emissions and actions. When global climate change predictions have large associated ranges it may be because scientists are looking at multiple RCPs at once, or a certain RCP simply has a large range of values associated with different impacts.

## Climate Change Impacts

| Impact | Canada* | Ontario |
|---|---|---|
| Temperature | • Average increase of 1.5°C since 1950 [xviii]<br>• Predicted increase of 2-6°C by 2050 [xix] | • Average increase of 1.5°C since 1948 [xx].<br>• Predicted increase between 2.4-6°C by 2050 vs 1990. Drastic temperature increases expected in winter vs summer. |
| Drought | • Increased frequency and severity will continue [xxi]. | • Not as vulnerable as other areas in Canada due to Great Lake protection, though Northern Ontario shows increased vulnerability [xxii]. |
| Rain | • General increase from 1948-2012 [xxiii].<br>• Predicted increase of 5.2% - 10.6% vs 1990 by end of century [xxiv]. | • General increase vs 1990 [xxv].<br>• Depending on the region in Ontario, drastic increases or decreases are predicted, though generally more precipitation in the form of rain is expected in the winter [xxvi]. |
| Snow | • Can expect from 9.1% - 37.8% increase vs 1990 by 2100 [xxvii].<br>• Generally, winter precipitation is increasing in the North and decreasing in the South [xxviii]. | • No significant changes observed [xxix].<br>• Depending on the emissions scenario and region in Ontario, increases or decreases may be observed. Certain areas expected to increase a minimum of 25 mm, while others can expect significant decreases. |
| Heat Extremes (days over 30°C before humidity) | • An overall trend observed since 1990 that is anticipated to continue [xxx]. | • Predicted increases from 8 days in 1990 to 16 in 2050 and 41 in 2080 [xxxi]. |
| Cold Extremes | • Decreases noted since the 1950's and will continue into the future [xxxii]. | • Continued projected decrease [xxxiii] |
| Air Quality | • The impact current climate change has had on Canadian air quality is unclear [xxxiv].<br>• Increased air pollution including smoke and particulate from wildfires is anticipated, as is increased production of pollen and other allergens [xxxv]. | • Air quality in Ontario has significantly improved over the past decade [xxxvi].<br>• Increased warming and heat waves will reduce overall air quality, which may lead to increased health risks. |
| Disease and Illness | • Range of vector-borne diseases (ex. Lyme disease) has increased due to warmer overall temperatures that create longer transmission seasons, new, potentially invasive species have adapted to warmer temperatures [xxxvii].<br>• Increases in allergies, heat stroke, respiratory illnesses, vector-borne diseases, and overall cardiovascular impacts [xxxviii].<br>• Increases in forests and wildlife disease. | • Similar to Canada, increases in Lyme disease and others, such as West Nile continue to move North, with increased transmission seasons [xxxix].<br>• Continued increases of enhanced allergies, respiratory, and cardiovascular issues.<br>• Increases in forests and wildlife disease. |

*The Prairie Climate Centre has done a good job of working to quantify climate change impacts in Canadian cities. https://climateatlas.ca/sites/default/files/cityreports/CityReport_Canada.pdf

## Where can I find more information on Canada's Emissions?

Every year Canada submits a national inventory report (NIR) (http://www.publications.gc.ca/site/eng/9.506002/publication.html) to the United Nations Framework Convention on Climate Change. The three-part report covers Canada's GHG emissions and is available every April. The NIR lags by two years due to complexity of data and calculations (the 2019 report will cover emissions from 2017). The NIR is the main source of Canada's emissions factors.

The NIR contains:

- GHG trends and an annual overview of Canada's emissions.
- Sector emissions.
- Calculation methodologies.
- Emissions factors for each sector.
- Provincial and territorial emission summaries.
- Electricity generation information.

### Extreme warming is seen in the Arctic versus the rest of the globe, why is this?

The increased sensitivity of Earth's polar regions is called polar amplification[v]. There are multiple contributing factors to this amplification, but it's thought the greatest contributor is that the atmosphere of the poles is much more stable versus other areas of the planet. This stability causes reduced vertical air movement meaning air (and therefore GHGs) cannot move up to high altitudes and escape into space as easily[vi]. The albedo effect also contributes to increased warming; snow and ice (light) are good at reflecting incoming energy from the sun versus land and water (dark), which absorb energy that leads to heating surrounding areas. As increased temperatures lead to melting of snow and ice, more exposure of darker land and water occurs, creating a feedback loop of melting. Finally, heat is also transported to the poles by warmer, moist air from other areas and weather systems[vii].

## How Can We Control Emissions?

There are two primary ways to stabilize or reduce GHG emissions, a carbon tax, or cap and trade. The table below outlines key basic details on each method, referencing Ontario throughout.

| | Cap and Trade | Carbon Tax |
|---|---|---|
| How it Works | • Governments sets a maximum amount (cap) of GHGs it is allowed to emit per year; In Ontario, this was based on best estimates of 2017 GHG emissions and equaled 1.42 million tonnes [xl].<br>• Mandatory participants must purchase allowances; each allowance permitted participants to emit one tonne of $CO_2e$. As time goes on, fewer allowances would be available, in other words, the cap lowers. Ontario's cap would decrease 4%/year from 2017-2020.<br>• Mandatory participants (https://www.ontario.ca/page/cap-and-trade) anonymously bid for allowances as well as how much they are willing to pay for one tonne of $CO_2e$. A minimum price per tonne (called an auction reserve price) was included to ensure there was not a market collapse in the event of a surplus of allowances (this occurred in Europe).<br>• Participants paid for a certain number of allowances, if they emitted more than the number of allowances they could purchase additional allowances from other participants. Furthermore, participants who overbought may sell allowances.<br>• Money raised went toward funding goals set out in Ontario's Climate Change Action Plan to meet 2020 and 2030 emission targets.<br>• In general, cap and trade was meant to create a decreasing emissions cap and increase investment in low carbon tech by making it more expensive to emit and therefore, emissions reductions more financial feasible [xli].<br>• Some participants may pass on costs to consumers, such as increases in gasoline or natural gas costs.<br>• Total Ontario emissions estimated to be covered by cap and trade: 82% [xlii] | • The government taxes industries and businesses that consume or distribute fossil fuels. The tax rate for each fuel is different, higher taxes are imposed on fuels that on a per unit basis (such as litre or $m^3$) have higher emissions.<br>• In Ontario an output based pricing system will be applied to facilities that emit over 50,000 tonnes of $CO_2e$/year.<br>• The federal carbon tax will be imposed on Ontario, New Brunswick, Saskatche-wan, Manitoba, Yukon, and Nunavut.<br>• Tax rates for fuels can be found at https://www.fin.gc.ca/n18/-data/18-097_1-eng.asp.<br>• 90% of funds raised are anticipated to be returned to Canadians as rebates to incentivize emissions reducing behaviour. The remaining 10% will be distributed among municipalities, schools, post-secondary, institutions, municipalities, non-profits, indigenous communities etc. for GHG reduction initiatives. |
| Price | Flexible: Price based on auction results. | Inflexible: Price set by government. |
| Are Emissions Capped? | Yes | No |
| Pros | • Puts a quantitative number on total emissions.<br>• Can coordinate with other governments for larger markets that can reduce allowance costs for participants. | • Fewer regulations.<br>• Easier administration and monitoring. |
| Cons | • Difficult to understand.<br>• Complex administration.<br>• Extensive regulations required.<br>• Impact on fossil fuel prices may not be enough to sway consumer behaviour change [xliii] . | • No quantitative cap on emissions can make target achievement more uncertain.<br>• More direct impacts that could lead to opposition [xliv]. |
| Where is it used? (incomplete list) | New Zealand, Quebec, California, Kazakhstan, Republic of Korea, Iceland, Norway, Liechtentein, Switzerland, China (certain provinces), European Union. | Portugal, British Columbia, Alberta, South Africa, Zimbabwe, India, Chile, Iceland, some EU members. |
| Does it work? | Most experts agree that as long as it is well designed, transparent, and accountable both mechanisms can be effective, as long as the price is high enough to incentivize action and low enough to prevent leakage (see below). Revenue distribution and the percent of emissions covered are also key success factors. It is also important to learn from the experiences of other countries who have implemented either option. | |
| Similarities | • Both generate government revenue.<br>• Both correct a failure (polluting is free; costs are not internal to polluters).<br>• Both put a price on emissions to correct the market failure and create incentives for low-carbon solutions.<br>• Both reduce emissions by encouraging lowest cost emissions reductions. | |

It’s important to introduce the concept of carbon leakage when discussing GHG pricing policy. Leakage occurs when a GHG pricing mechanism, such as cap and trade or a carbon tax, causes business and industry to move their goods and services to other areas with potentially less strict emissions regulations to avoid added costs. This can create what looks to be a reduction in emissions in the area where emissions are regulated, but in reality global emissions may not have changed, or increased due to less rigid regulations and enforcement. In order to combat this, governments typically ease into GHG pricing, for example, by providing free allowances for cap and trade, or increasing carbon taxes over time. This was a worry with British Columbia’s cement industry, and the province is working to provide incentives and investment support during this transition.

## Individual Efforts

The consequences of anthropogenic climate change may feel very overwhelming and lead to a mindset that individuals cannot have meaningful impacts. This could not be further from the truth. Below are suggestions for climate change advocacy and actions individuals can take in their daily lives.

- **Work to reduce the heating bill**. Natural gas for home heating is usually an individual’s second largest source of emissions. Program for home temperature reductions while at work during winter months, close vents and doors that are not often used, cover windows with inexpensive films to reduce draft, or invest in a Smart Thermostat

- **Transportation is key.** Vehicle use is the largest component of individuals GHGs output in Ontario (approximately 50%). There are a variety of different options to help reduce transportation emissions;
    - Consider an electric vehicle or hybrid as the next purchase if the budget permits, or consider a smaller vehicle.
    - Reduce highway speed for a more efficient drive.
    - Carpool/ride share to work.
    - If travelling under 5 km, and the weather permits, ride a bike as this has shown to significantly improve local air quality while reducing road congestion.

- **Get food out of the garbage!** If the City offers organics pickup use it, it is one of the easiest ways to reduce your carbon footprint. If this is not possible try backyard composting, it’s very easy and requires minimal work.

**(continued)**

## Individual Efforts (continued)

• **Reduce intake of red meat and dairy**. Reduction of cattle-based products are targeted for many reasons:

  - • The amount of methane generated from livestock, particularly cattle; as a result, emissions from red meat are estimated to be 150% higher versus chicken or fish.
  - • The land use change from (potentially) forested land to barren land for livestock roaming.
  - • The resources required to raise livestock, particularly their feed, also requires land. This brings up a basic sustainability concept of should humans be using fertile land for animal feed when there continues to be food shortages that are anticipated to worsen.
  - • Fertilizers (nitrogen based) that release nitrous oxide are required for feed crops.
  - • The substantial water needed for livestock and feed.
  - • Keep in mind this does not mean transitioning to becoming a vegetarian or vegan, but simply reducing total intake.

• **Talk to government officials and express thoughts**. As cliché as it sounds if individuals do not voice their opinions and ideas others will assume there is no issue or a lack of interest. Continual pressure is required in order for positive change. For example, the Environmental Registry of Ontario allows Ontarians to voice their opinions to the government on environmental, conservation, sustainability, and climate change related legislation.

• **Speak with the wallet.** The largest impact an individual can have is by how they spend their money. Government, industry, and business will take notice as soon as the bottom line is impacted in either a positive or a negative way. If there is a good or service that was purchased (or not purchased) for a specific sustainability-related reason let them know, others probably feel the same way. This will garner attention; for example, Aardvark Straws, who began creating paper straws in 2007, was in part due to the image zoos, aquariums, and cruise ships desired to promote to their customers.

## Visualizing Impacts

It's hard to put into perspective the impact a changing climate can have. Photographers have spent decades collecting before and after images to capture what climate change looks like in real time. To see what impacts climate change has had take a look at the link below.

- • NASA's Images of Change (drag the curtain left or right to see full impacts)

# Notes:

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