Climate Pollution: Reducing My Footprint

BACKGROUNDER

Environmental Commissioner of Ontario

MARCH 2019

Abstract

Ontarians know that climate change is an urgent threat, and that we must dramatically reduce the climate pollution (the greenhouse gas emissions or GHGs) that we cause. This requires both individual and collective action. What choices do we have, as individuals, that really make a difference?

This backgrounder looks at one part of the answer: the lifestyle choices that most determine how much climate pollution each individual creates. Through such choices, the average Ontarian causes GHG emissions of about 11 tonnes (in carbon dioxide equivalents – CO_2e) per year. About half of those tonnes come from driving, home heating, air travel and eating beef. The other half come from waste, electricity and other goods and services that we buy, use or throw away. This backgrounder shows how much the average Ontarian emits in each category, and how individual choices increase or decrease those emissions.

For the average Ontarian, half the annual carbon footprint (tonnes of CO_2e per person) comes from:

1) Driving a gasoline or diesel-fueled vehicle
   - 2.2 tonnes, equivalent to driving 10,000 km alone in midsize gasoline car
2) Fossil fuels used for heating the average home
   - 1.7 tonnes, equivalent to heating a small one-bedroom home with natural gas
3) Air travel
   - 1.4 tonnes, equivalent to one economy class return flight between Toronto and Vancouver
4) Beef
   - 0.5 tonnes per person, equivalent to eating one small hamburger every other day

Of course, no individual is "the average Ontarian"; options differ for people in different parts of the province. People who live in urban areas will likely find some choices easier, more appealing or more practical than people in remote, rural, or suburban communities, and vice versa.

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Introduction

“What can I do to help?”

“How can I make a difference?”

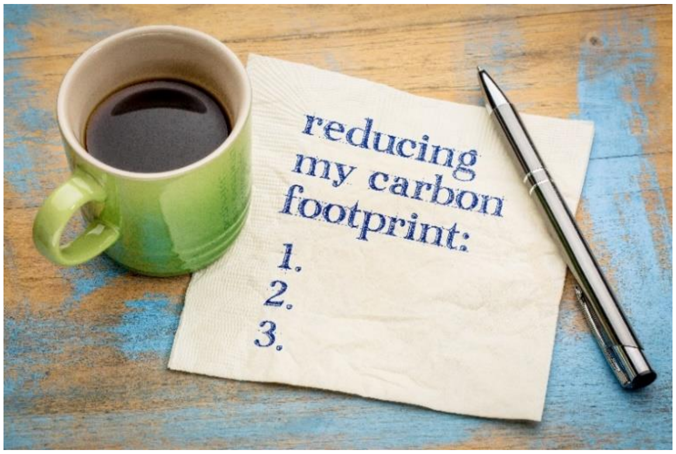
These are questions the Environmental Commissioner of Ontario (ECO) hears all the time about climate change. Our basic answer always calls for both individual and collective action.

Reducing one’s own individual carbon footprint, i.e., the climate pollution that each person causes, is a great place to start (though a terrible place to stop).

But how?

This backgrounder helps answer that question. Climate change is a potentially catastrophic problem that needs more than individual actions to solve. But individual actions do matter and, collectively, can make a big difference. Yet individuals who want to make low-carbon choices often do not have easily accessible information on the most effective ways to reduce their climate impacts. Ontarians know that, for example, driving less, turning down the thermostat and recycling can help; this backgrounder helps them know how much each choice matters.

1. The carbon footprint



A carbon footprint can be defined in different ways. In this backgrounder, an individual's carbon footprint is the sum of GHG emissions directly and indirectly caused by that person's lifestyle choices, including all of the products and services used in daily life (e.g., food, housing and transportation). The ECO has estimated the results for Ontarians using life-cycle assessment (LCA) and the best available data. For methodological details, see the appendix and the endnotes.

In general, the more you buy and travel, the larger your carbon footprint will be, and the more options you may have to reduce it significantly.

This backgrounder can help you estimate your own carbon footprint, and how it compares to your neighbours'.

Where should I start?

For many, it will be easiest to find meaningful reductions in your biggest emissions. That is,

- identify the largest contributors to your carbon footprint (i.e., your carbon "hotspots"), and
- do what you can to reduce your carbon footprint in those carbon hotspots!

The information in the ECO's factsheet and in this backgrounder can help you identify your carbon hotspots. An online calculator can also help you put together an estimate of your individual climate pollution. There are a number of such calculators, each with their own level of detail. Project Neutral,[1] an Ontario-based calculator, is an example. Use caution with any calculators from outside Ontario because our electricity supply has much lower emissions than the North American or world average. That means that out-of-province calculators are likely to give inaccurate results for Ontarians on any issues involving electricity, including electric vehicles.

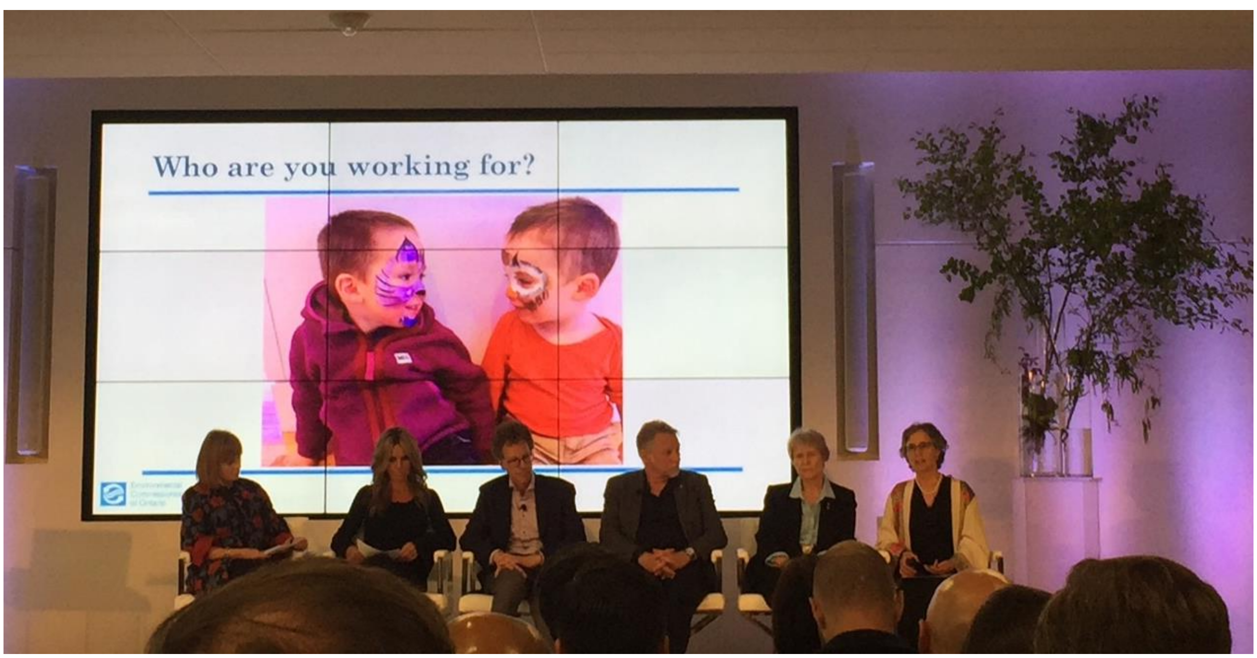
2. Lifestyle choices

This section examines the individual actions Ontarians can take to reduce their carbon footprint. In general, there are two main options:

1) consume less, or
2) choose lower carbon alternatives of the same type of good/service.

Top actions to reduce climate pollution? A poor list from MECP

The Ministry of the Environment, Conservation and Parks (MECP) has posted a list of actions to reduce one's "day-to-day life" GHG emissions.[2] Unfortunately, many of the environmental behaviours recommended on this list are unlikely to be very effective. For example, MECP's list excludes some options for major reductions in GHGs, such as choosing a zero-emission vehicle instead of a fossil-fuel powered vehicle, reducing air travel and cutting beef consumption. On the other hand, MECP's list features activities with negligible climate benefits, such as using reusable shopping bags. Moreover, due to the province's low-carbon electricity grid, MECP's suggested actions for reducing electricity use (e.g., "unplug electronics when you're not using them") are not likely to have a substantial impact on the carbon footprints of most Ontarians.



2.1 Daily transportation

The most important direct contributor to the average Ontarian's footprint is the use of a personal vehicle that burns gasoline or diesel. How can Ontarians lower these emissions? In the short term, people can walk, bike, take public transit, or carpool. Ontarians tend to use their personal vehicles even for short trips (i.e., 1/5 of work commutes are 3 km or less, but more than 60% of these commuters still use personal vehicles).[3] Over a longer timeframe, options such as moving closer to work, or replacing personal vehicles with more fuel-efficient or zero-emission alternatives, can greatly reduce emissions.

Average emissions

There were about 12 million vehicles registered in Ontario in 2016; and almost all of them burned gasoline or diesel.[4] The National Inventory Report states that Ontario emitted 30.9 million tonnes of CO_2e from the use of vehicles in 2016.[5] About 77% of this total is associated with personal vehicles.[6] When taking into account the upstream emissions from fuel production, the climate pollution from the average person's daily transportation reaches 2.2 tonnes per person per year.[7]

Choosing a gas-guzzler? You will be locking in high emissions for 13 years!

As the average life expectancy of a personal vehicle in Canada is 13 years,[8] choosing a gas-guzzler is likely to have substantial climate impacts for that whole time. Even after you replace it, someone else is probably going to drive it. In 13 years, a large pick-up truck produces 28 tonnes of CO_2e more than the average gas car driven the same distance, and 67 tonnes more than an electric vehicle.[9]

Table 1. Examples of actions to reduce the GHG emissions from one's daily transportation, and the likely magnitudes of the benefits.[10]

Potential impact	Individual actions
Small (<0.1 t CO_2e)	Choose vehicle with reflective paint Empty vehicle of excess weight Park vehicle in the shade in hot weather Stop idling
Medium (0.1-0.5 t CO_2e)	Avoid quickly accelerating from stops Avoid speeding Choose high-efficiency vehicle Properly inflate tires Reduce use of air conditioner
Large (>0.5 t CO_2e)	Carpool Choose zero-emission vehicle Walk, bike or take public transit Work from home or move closer to work

2.2 Home heating

Home heating is often GHG intensive because the fuel most commonly used for Ontario residences is natural gas. As Ontario's population grows, the need for new homes will increase. Unless there is a shift to lower-carbon heating sources, there will also be an increase in the emissions associated with heating these buildings.

Average emissions

The typical Ontario house heated by a natural gas furnace emits close to five tonnes of emissions per year.[11] That is a little less than two tonnes per person, for those who live in individual houses.[12] However, many Ontarians use other energy sources for heating, and live in condos and apartments, which tend to be smaller, share common walls and use less heat. The average emissions from heating an Ontario home are therefore about 1.7 tonnes per person per year, including the upstream emissions from producing the heating fuel.[13]

There are three main options for individuals to reduce their GHG emissions from heating:

- reduce heating requirements by reducing the average temperature level in the home and/or reducing the amount of heat that leaks
- reduce GHGs from the heat supply by altering the method to heat and/or the fuel source (change to an energy-efficient furnace, switch to a low-carbon heating fuel, or install an electric heat pump),[14] and
- occupy less space per person, either by downsizing or by sharing space.[15]

Table 2. Examples of actions to reduce the GHG emissions from heating one's home, and the likely magnitudes of the benefits.[16]

Potential impact	Individual actions
Medium (0.1-0.5 t CO_2e)	Insulate home Lower average thermostat setting Seal leaks Upgrade to higher-efficiency furnace
Large (>0.5 t CO_2e)	Downsize or share home Switch to renewable natural gas, wood or electric heating

2.3 Air travel

Air travel is one of the fastest growing sources of GHG emissions, with an annual growth rate far higher than either population or gross domestic product.[17] Recent research shows that Canadians have the highest carbon footprint from international travel of any country.[18] A substantial portion of our international travel uses airplanes. Air travel can easily be the largest component of a person's carbon footprint. Although the GHG emissions per passenger kilometre[19] may be lower than those for single-person travel in cars and trucks, people tend to travel much farther using planes.

Average emissions

Transport Canada's 2017 Action Plan to Reduce Greenhouse Gas Emissions from Aviation includes data on the GHG emissions from the domestic and international operations of aircraft in Canada. In 2016, the emissions associated with passenger traffic reached about 17 million tonnes of in CO_2e, or 0.5 tonnes per capita (plus 0.2 tonnes in emissions from fuel production).[20] More than 99% of these emissions would likely have been CO_2, based on Canada's 2016 National Inventory Report estimates for domestic aviation.[21]

Airplanes generally burn jet fuel (jet kerosene and jet gasoline)[22] which produces CO_2. However, the climate impacts from flying are from more than the CO_2. When burned, jet fuel releases water vapour, particulate matter, and various other products of combustion.[23] Released high into the atmosphere, these emissions have an even more potent climate effect (i.e., in terms of radiative forcing).

According to a recent review published in Nature Communications, on average, the CO_2 emissions from fuel combustion in aircraft accounted for about 40% of the aviation-derived climate effect (radiative forcing) in 2011; the other 60% was from the other non-CO_2 emissions.[24] When taking into account the average radiative forcing effect of aircraft, the per capita annual emissions from air travel reach approximately 1.4 tonnes (similar to the round-trip emissions to fly economy class between Toronto and Vancouver).[25]

Emissions from domestic air travel in Ontario have not changed significantly from 1990 levels.[26] However, emissions from international flights originating in Canada have more than doubled.[27] The following graph gives examples of the carbon footprint of direct round-trip flights to the top 10 international destinations from Pearson International Airport in 2017.[28] These figures take into account not only the CO_2 emissions from fuel combustion, but also the full climate (i.e., radiative forcing) effects from air travel.

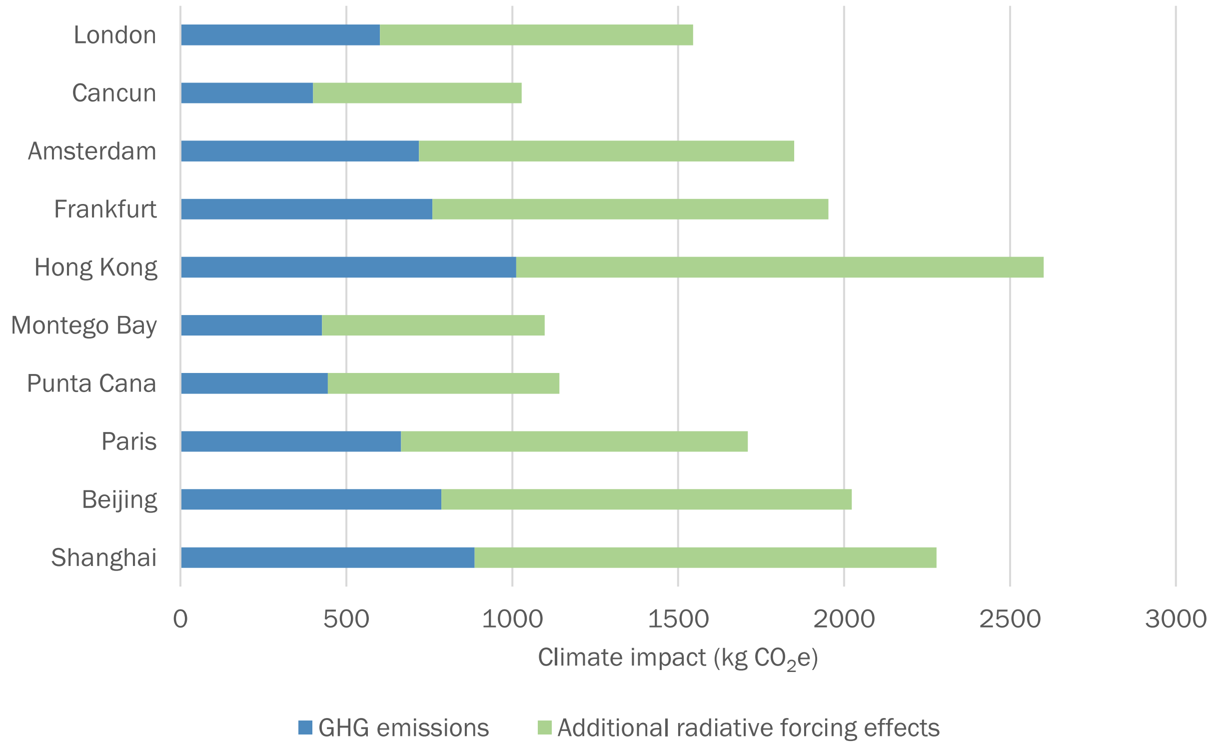


Figure 1. The carbon footprint of direct round-trip flights to the top 10 international destinations from Pearson International Airport in 2017. Estimates are based on results from the International Civil Aviation Organization's carbon emissions calculator and use of a radiative forcing multiplier of 2.6 relative to the CO_2 produced.[29]

There are a number of ways to reduce the GHG emissions from flights. Although all flights generate substantial emissions, short-distance flights (i.e., a few hundred km) are particularly carbon intensive on a per km basis, as far more fuel is expended per km during takeoff and landing than cruising. The timing of the flight is also important. Nighttime flights have a much larger climate impact than daytime flights due to the contrails produced by aircraft.[30] During the day, these contrails reflect sunlight back into space. At night, they trap heat in a similar manner to clouds. Nighttime flights in the winter are likely to have the most significant impact.[31]

Table 3. Examples of actions to reduce the GHG emissions from one's air travel, and the likely magnitudes of the benefits.[32]

Potential impact	Individual actions
Small (<0.1 t CO_2e)	Reduce weight of luggage
Large (>0.5 t CO_2e)	Avoid first- and business-class travel Avoid nighttime flights, especially in the winter

Carbon offsets

For those activities where it may be especially difficult for individuals to reduce emissions, such as flying, carbon offsets can mitigate those emissions that one causes. Carbon offsets are generated by offset projects that either reduce emissions, or sequester atmospheric carbon (i.e., CO_2 and methane) by pulling it out of the atmosphere and storing it. Examples include projects to capture landfill methane emissions and increase the amount of carbon sequestered in farming soils and trees. In principle, every tonne of GHG reduced or removed by an offset project compensates for the release of an extra tonne of GHG.

Carbon offset credits (or simply "offsets") measure the GHGs reduced or removed by an offset project. Offsets allow individuals and organizations to purchase reductions where it is both practical and cost-effective.

Some carbon offset projects have had problems in terms of quality control, which is why it is important to have an independent certification process that requires projects meet strict standards. These standards should ensure that the offsets are real, measurable, permanent, additional, independently verified, and unique. Only certified carbon offsets (e.g., Gold Standard)[33] should be purchased to better ensure that emissions are actually reduced. "Less Emissions"[34] and "Carbonzero"[35] are examples of companies that offer carbon offsets for purchase in Canada.

Offset projects often produce environmental and socio-economic co-benefits, such as cleaner air and water, and increased economic opportunities in rural and remote communities.

For more information about carbon offsets, please read Chapter 4 of the ECO's 2017 GHG report, Ontario's Climate Act: From Plan to Progress.[36]

2.4 Diet

The average Ontarian eats and drinks about 2 kg of food and beverages every day[37] and spends about $3,400 on food each year.[38] The emissions associated with food production and disposal are indirect but substantial.

Average emissions

The most recent detailed estimate of per capita "cradle-to-farm gate" emissions from a diet that follows the 2007 Canadian dietary guidelines is about 1.4 tonnes of CO_2e per year.[39] This is the best available approximation of the emissions from an average Ontario diet in 2019. There are some areas of uncertainty, but the following factors may offset each other:

- The average Ontarian consumes more high-emission meat and alternatives than recommended in the 2007 dietary guidelines, and fewer grains, fruits and vegetables.[40]
- Canadian per capita beef consumption has dropped by about one-third over the past 30 years,[41] and now makes up a lower proportion of "meat and alternatives" than it did in 2007.
- Current Canadian beef has a lower GHG intensity than the beef data used in the cited study.[42]

In agriculture, unlike most other sectors, the main GHGs emitted are not CO_2, but methane and nitrous oxide, which are far more potent GHGs. Methane is emitted from livestock manure management systems and from fermentation of food within live animals; nitrous oxide comes from chemical reactions that occur after fertilizer application.

As some foods are responsible for much greater emissions than others, individual food choices can have a substantial effect on the size of one's carbon footprint. For example, the following graph displays the average total footprint from common foods.

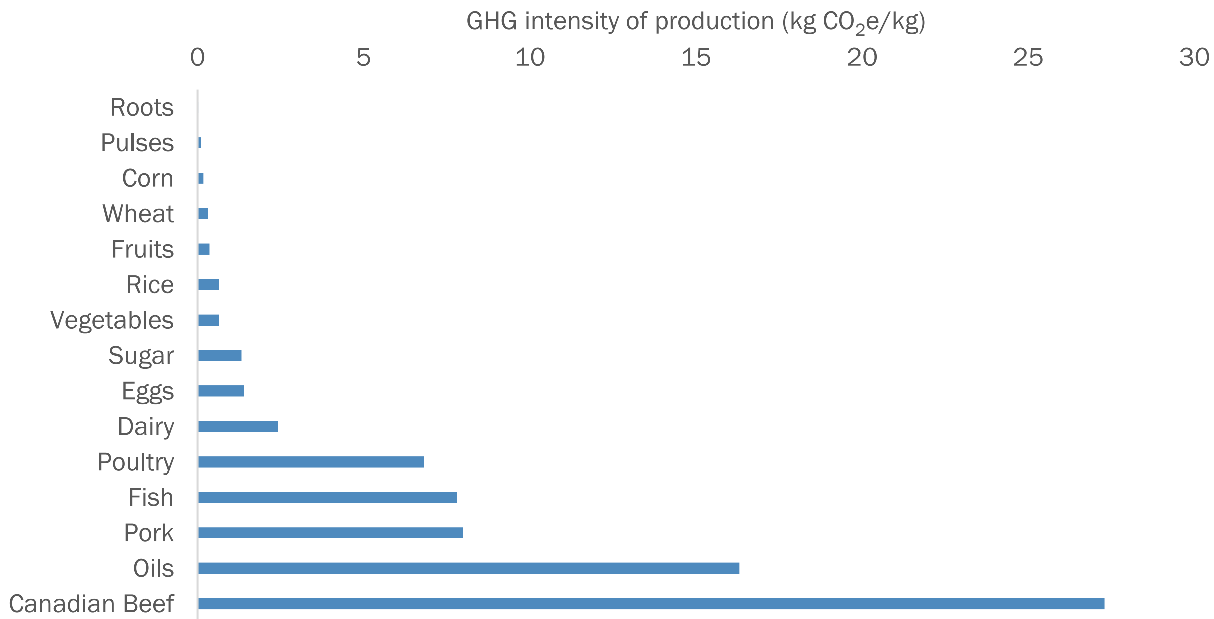


Figure 2. The GHG intensity of foods by category from the "cradle to the farm gate."[43]

Using the GHG intensity of Canadian beef, and the per capita consumption of beef in 2016, the average Ontarian creates about 0.5 tonnes of emissions per year just from eating beef. If, however, we had used a shorter time horizon (e.g., 20 years instead of 100) to calculate the climate impact of methane, the footprint of beef consumption would be more than double what is shown here.[44]

The most effective single action to reduce GHG emissions from the average Ontario diet is therefore to reduce beef consumption. Eliminating beef from the average Ontarian's diet would reduce a person's food-based emissions by more than one third. The typical Canadian beef hamburger has a carbon footprint of just over 3 kg CO_2e.[45]

Table 4. Examples of actions to reduce the GHG emissions from one's dietary choices, and the likely magnitudes of the benefits.[46]

Potential impact	Individual actions
Small (<0.1 t CO_2e)	Consume food produced locally and seasonally
Medium (0.1-0.5 t CO_2e)	Avoid food waste (see waste section)
Large (>0.5 t CO_2e)	Avoid beef consumption

What is your pet's pawprint?

About half of Canadian households have pets,[47] and they are often considered an important part of the family. However, people might not be aware of their pet's potential carbon "pawprint." A number of studies have tried to estimate the average pawprint, and some estimates are very high. Canadians spend about $2.2 billion on pet food every year,[48] and just as for people, these food choices can have a big impact.

Overall, about 41% of Canadian households include at least one dog, and around 38% include at least one cat.[49] The most recent and detailed study of the GHG emissions from food eaten by dogs and cats is based on U.S. figures (see Okin 2017). Using the same data and assumptions, the ECO calculated that the carbon footprint of an average dog would be about 2/3 of a tonne of CO_2e/yr.[50] Four cats would have the average footprint of one dog. However, these estimates are likely rather too high, because they assume that the food consumed by the pet would have been fit for human consumption.

Some, perhaps most, meat considered unfit for human consumption is included in pet food. Given that this meat would have otherwise been discarded, how much of the GHG impact from producing this portion of pet food should be included in a pawprint? This is an important question, as there is a substantial impact from meat production. However, if this impact were to be excluded from the pawprint, it would need to be included in the footprint of the meat consumed (and wasted) by people.

The uncertainty associated with carbon pawprint estimates is very high, especially since Ontario does not track the proportion of pet food meat that has been categorized as unfit for human consumption.

2.5 Residential waste

Emissions from waste management are indirect, as they take place at landfills, biological and thermal treatment facilities, sorting and recycling facilities, and from the trucks that haul the waste. However, individuals can significantly reduce waste management emissions by cutting down on the amount of waste they produce, and keeping as much of that waste as possible out of landfill.

Average emissions

Ontario households generate about five million tonnes of waste every year.[51] Waste management emissions for the average Ontarian reach about 0.24 tonnes of CO_2e per year.[52] If we did not recycle, compost and anaerobically treat organics, the average Ontarian's waste management emissions (including the loss of upstream benefits from recycling) would double.[53]

It is particularly important to reduce food waste.[54] A report from the Commission for Environmental Cooperation estimated that Canadians waste about 400 kg of food per person per year, with 170 kg of the waste occurring at the consumer level.[55] A more recent detailed report from Second Harvest and Value Chain Management International calculates an even greater amount of food waste in Canada, reaching 1 tonne per person per year, including 140 kg of food wasted by consumers.[56]

In terms of GHG emissions, a recent study from the University of Waterloo estimated that about 12% of the emissions from the average Ontarian's diet is associated with avoidable household food waste.[57] About half of the food waste at the consumer level is considered "avoidable."[58] The upstream GHG reductions from eliminating the avoidable portion of this food waste would reach about 270 kg CO_2e per person per year.[59]

The carbon footprint of things we waste

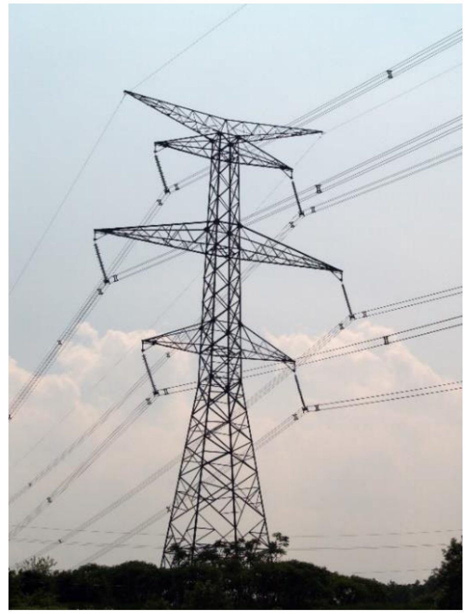
A substantial portion of what we buy is wasted (e.g., food goes bad, products returned to the store may be landfilled instead of resold). Supplying these products nevertheless results in GHG emissions. Reducing waste is an easy win for the climate, and saves money.

Table 5. Examples of actions to reduce the GHG emissions from one's waste generation, and the likely magnitudes of the benefits.

Potential impact	Individual actions
Medium	Compost organics at home or use green bin
(0.1-0.5 t CO_2e)	Recycle
	Reduce waste generation

2.6 Household electricity

Because of good public policy, Ontarians are in the fortunate position of having a very low-carbon intensity electricity grid, averaging 40 g CO_2e/kWh.[60] As a result, the most effective activities to reduce GHG pollution in Ontario are different from most other jurisdictions. For instance, although there are a number of environmental reasons to use energy-efficient lighting and reduce the use of electrically heated water, they are unlikely to produce GHG reductions in Ontario. (See our 2018 Energy Conservation Progress Report, Making Connections).[61]



The government expects electricity demand to grow due to increased population and the adoption of electric vehicles. Without using more energy efficient technologies, new electricity supply may be required. The carbon intensity of any new supply may not match that of existing generation sources.

Average emissions

Ontario households, with an average of 2.6 inhabitants,[62] use about 9,000 kWh of electricity per year.[63] This creates about 0.36 t CO_2e/yr per household, or 0.14 tonnes per person.[64]

Driving electrically → The Ontario advantage

Most Ontarians commute to work in a fossil-fuel powered vehicle. With Ontario's low-carbon electricity grid, the GHG benefits of switching from a fossil-fuel powered vehicle to an electric one are substantially larger than in most other Canadian jurisdictions. For example, an electric vehicle in Alberta, driven the same average annual distance as an Ontario one, generates about 3.4 tonnes of CO_2e per year (versus 0.8 tonnes in Ontario).[65]

Since Ontario's electricity supply has such a low-carbon intensity, does reducing electricity use have a climate benefit? Yes, especially at hours of peak demand.

Daily peak demand for electricity in Ontario takes place in the late afternoon and early evening, particularly on weekdays. Especially on hot or cold days, a substantial portion of peak demand is met by running natural gas plants that emit GHGs. Off peak, Ontario's electricity comes from nuclear and renewable sources. The timing of one's electricity use can have a significant impact because electricity from natural gas has a GHG intensity over 10 times the Ontario average. [66]

When Ontario has surplus low-carbon electricity, it can be:

- exported to markets with high-carbon-intensity electricity
- used to directly displace fossil fuels, and
- converted to other forms of stored energy (e.g., hydrogen) that displace fossil fuels. (See our 2018 Energy Conservation Report, Making Connections).[67]

Table 6. Examples of actions to reduce the GHG emissions from one's electricity use, and the likely magnitudes of the benefits.

Potential impact	Individual actions
Small (<0.1 t CO_2e)	Eliminate "vampire" power loads[68] Reduce use of air conditioner Replace appliances and electronics with Energy Star alternatives Replace incandescent lights with LED lights Use a clothesline
Medium (0.1-0.5 t CO_2e)	Install rooftop renewable energy systems

2.7 Other goods and services

All of the goods and services we buy result in emissions that occur before we buy them (e.g., during raw material extraction, processing, and transportation), during operation, and after we finish with them (waste management). The before (upstream) and after (downstream) emissions, including those associated with infrastructure and equipment, are together called "embodied" emissions (See Chapter 8 of the ECO's 2017 GHG Progress Report, Ontario's Climate Act: From Plan to Progress, for a more detailed description).

Although embodied emissions are indirect, individuals can reduce these emissions through their consumption and waste management patterns, such as:

- consuming less overall
- substituting products that provide the same or similar service but have fewer embodied emissions, and
- keeping waste out of landfills.

Table 7. The embodied emissions of some commonly purchased goods (excluding emissions from the operation/use stage).

Product	Lifetime (years)	Life-cycle GHG emissions (kg CO_2e)	GHG emissions per year (kg CO_2e /yr)
Cotton t-shirt	2	2[69]	1
Office task chair	8	72[70]	9
Double mattress	8	80[71]	10
Tablet computer	3	85[72]	28
Smartphone	2	60[73]	30
Laptop computer	3	375[74]	125
Typical vehicle	13	8,200[75]	630
Typical Ontario house	100	72,000[76]	720

One key step to reduce GHG emissions per year is to buy high-quality, durable goods, only when needed, and then make them last. A phone that is used for four years instead of two creates only half the annual emissions from its production.

Average emissions

It is very tricky to estimate the total emissions associated with the goods and services purchased by individuals. Not only is it difficult to add up the emissions from each individual item, there is the glaring issue of what should reasonably count as an emission resulting from an individual action. If you take a university course, bank or use police services, are you personally responsible for a portion of the emissions that these institutions produce? It is certainly easier to attribute emissions to an individual when a direct link to a purchase (or consumption decision) can be made, such as buying a new car.

Where should one draw the line?

No complete list exists of all the products an average Ontarian buys, so it is difficult to calculate the carbon footprint of these purchases. However, Statistics Canada collects and publishes detailed data on average Ontario household spending. One can estimate the remaining carbon footprint by multiplying the various spending amounts by GHG emission factors. These emission factors depict the magnitudes of emissions per dollar of spending in each spending category, and originate from economic input-output models that generate estimates of the environmental impacts of producing goods and services.[77]

Using this alternative method, emissions from consuming other goods and services reaches about four tonnes per person per year.[78]

An individual's level of emissions often changes dramatically with major life events and purchases, such as purchasing a house or vehicle, having a child, moving out of a family home, or undertaking major renovations. Good choices at times of major purchases have an outsized impact on a person's carbon footprint.

Table 8. Examples of actions to reduce the GHG emissions from one's product consumption, and the likely magnitudes of the benefits.[79]

Potential impact	Individual actions
Medium to Large	Choose durable products
(>0.1 t CO_2e)	Consume fewer products
	Repair and reuse products to make them last

3. But I’m not average

This backgrounder contains a lot of data on average GHG emissions per person. However, no one is truly “average,” and the carbon footprint of individuals varies enormously. Some people are responsible for far more emissions than others, and people in different parts of Ontario have different emission reduction options.

Daily transportation

A long daily commute, alone, in a large, inefficient vehicle

Walking, biking, carpooling, using public transit or driving a zero-emission vehicle

The average Ontarian creates 2.2 tonnes of emissions per year from driving, which is equivalent to driving about 10,000 km alone in a mid-sized gasoline-fueled vehicle.

Home heating

1 or 2 people living in a large, poorly insulated home, heated by an inefficient furnace and kept at a high temperature in the winter

Compact, well insulated home, heated by electricity and kept at "sweater temperature" in the winter

The average Ontarian creates 1.7 tonnes of emissions per year from home heating, which is equivalent to heating a small, 50-square-metre home with natural gas.

Air travel

Many long-distance flights per year in business class

Avoids flying by travelling by carpool, bus or train

The average Ontarian creates 1.4 tonnes of emissions per year from flying, which is equivalent to flying round trip in economy class, between Toronto and Vancouver.

Diet

A high-calorie diet that includes a lot of beef and imported foods

A plant-based diet comprised of local, seasonal foods

The average Ontarian creates 1.4 tonnes of emissions per year from their diet, which includes the equivalent of eating a small hamburger ever other day.

Waste management

Large volume of waste thrown in garbage

Low volume of waste, mostly composted and recycled

The average Ontarian creates 0.2 tonnes of emissions per year from residential waste sent to landfills.

Electricity use

Heavy electricity use during peak demand, particularly air conditioning on hot summer weekday afternoons

Rooftop solar, energy-efficient lighting and appliances, and reduced use of air conditioning during peak demand

The average Ontarian creates 0.1 tonnes of emissions per year from home electricity use.

Other goods and services

High consumption of goods and services (e.g., electronics, clothes, etc.)

Choosing durable products, and repairing and reusing them

The average Ontarian creates 4 tonnes of emissions per year from goods and services.

3.1 Emissions and income

There is a strong relationship between income, consumption, and the size of one's carbon footprint.[80] For example, Oxfam has estimated that the richest 10% of humans are responsible for about half of global "lifestyle consumption" emissions, while the poorest half of the world's population only emit 10% of these emissions.[81] Most Ontarians are within the richest 10% category, and therefore can do more than an average human to reduce emissions.

Even within Ontario, wealthier people, on average, have higher emissions than less wealthy ones. In Ontario, an average dollar of household spending creates personal emissions of about 500 g CO_2e, including upstream emissions.[82] However, some purchases are more GHG intensive than others. For example, the emissions from burning a dollar's worth of gasoline (about 1 litre in southern Ontario at the time of writing) are about five times as large as the average amount of GHG emissions from $1 of spending.[83]

That is one BIG footprint! The frequent flyer example

Spending money on flying creates particularly large climate impacts. For example, one extreme frequent flyer (exceeding 20 million miles)[84] is responsible for about 4,400 tonnes of CO_2e (taking into account the full radiative forcing effects from air travel). His emissions, just from flying, are as large as the annual per capita GHG emissions of close to 400 Ontarians.[85]

3.2 Emissions and location

Approximately 86% of Ontarians live in urban or suburban areas, with the remainder living in rural or remote communities.[86] People who live in different parts of Ontario tend to have different carbon footprints, and have different sets of low-carbon choices available to reduce them.

For example, people who live in low-density, car-dependent areas usually have much larger carbon footprints from their homes and transportation than people who live in dense urban areas.

Due largely to government decisions about infrastructure and land use planning, people who live in these areas tend to have long commutes and poor or no options for walking, cycling or transit. For those who drive long distances, carpooling, working from home and choosing efficient or electric vehicles (where possible) can provide disproportionately large emission reductions. In the longer term, increasing density can create compact, complete communities that provide more local services and amenities, reduce the need for driving, and make regular public transit economic. (See Chapter 4 of our 2019 Energy Conservation Progress Report, A Healthy, Happy, Prosperous Ontario).

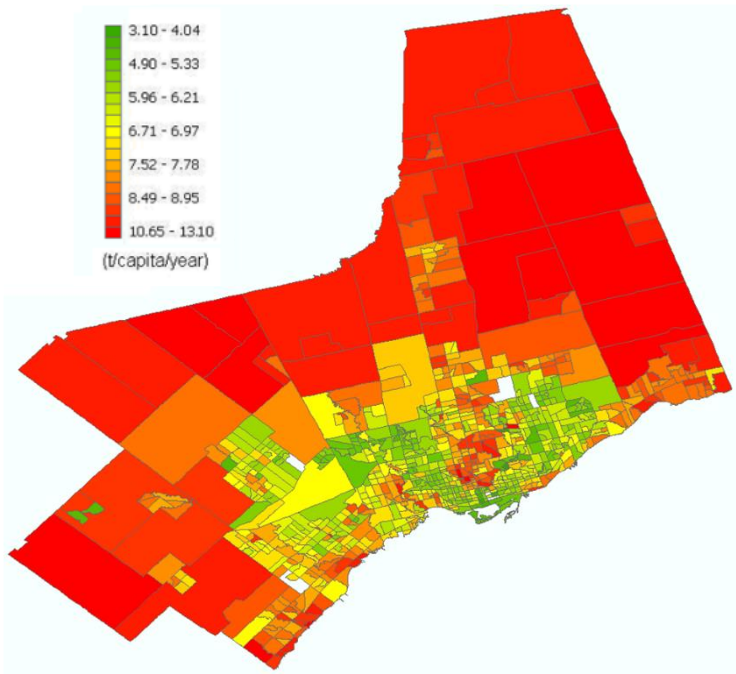


Figure 3. Annual per capita residential GHG emissions from combined residential activities in the Toronto Census Metropolitan Area, including total building operations, electricity use, building fuel use, total transportation, and transit.

Source: VandeWeghe, J. and Kennedy, C.A., “A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan Area,” J. Industrial Ecology (2007), 11(2) at 141.

For home heating, Ontario’s rural and remote communities tend to have older homes that are harder to keep warm than more modern homes built in accordance with stringent building codes. While 27% of Ontario homes are located in rural and remote communities (i.e., outside of census metropolitan areas), these communities have a higher percentage (34%) of all the Ontario homes built before 1960,[87] plus almost 60% of Ontario homes with an unknown date of construction.[88] On the other hand, there can be proportionately greater financial and comfort benefits from improving the energy efficiency of older homes (e.g., insulating and reducing heat leaks). (See Chapter 3 of our 2019 Energy Conservation Progress Report, A Healthy, Happy, Prosperous Ontario).

Electrically heated homes can also switch from baseboard heaters to heat pumps; oil-heated homes can switch to propane. People in rural and remote communities may have access to wind, solar and/or renewable biomass (e.g., wood) to reduce their use of fossil fuels for heating. They may also have space to compost food waste and/or feed it to animals and/or to grow local food.

Very remote communities may depend on dirty, noisy, high-emission diesel-generated electricity. In those communities, large emission reductions may be possible by improving electricity conservation, and/or from replacing diesel-generated electricity with grid electricity or with renewable electricity and storage.

4. Carbon hotspots

The average Ontarian causes GHG emissions of about 11 tonnes (in carbon dioxide equivalents – CO_2e) per year. The largest category discussed above is the *consumption of other goods and services by individuals*. However, this category (as with diet) is the result of many different individual choices.

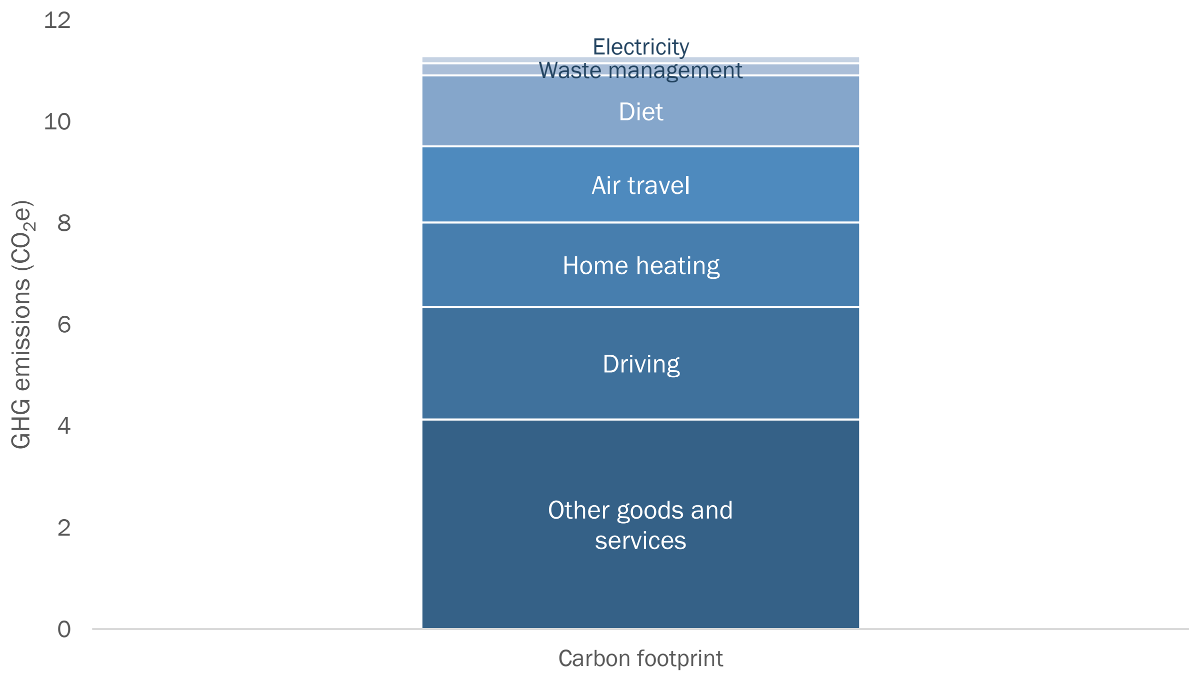


Figure 4. The ECO's estimated breakdown of the average Ontarian's carbon footprint, equal to about 11 tonnes of CO_2e per year.

Using the information provided in this document, one can identify carbon hotspots. These are the GHG-emitting activities that are largest and most important. More than half of the average Ontarian's annual carbon footprint comes from just four activities:

- Driving a gasoline- or diesel-fueled vehicle (2.2 tonnes, equivalent to driving alone 10,000 km in a midsize gasoline car)
- Home heating (1.7 tonnes, equivalent to heating a small one bedroom home with natural gas)
- Flying (1.4 tonnes, equivalent to one economy class return flight between Toronto and Vancouver)
- Eating beef (0.5 tonnes, which is equivalent to eating a small hamburger every other day)

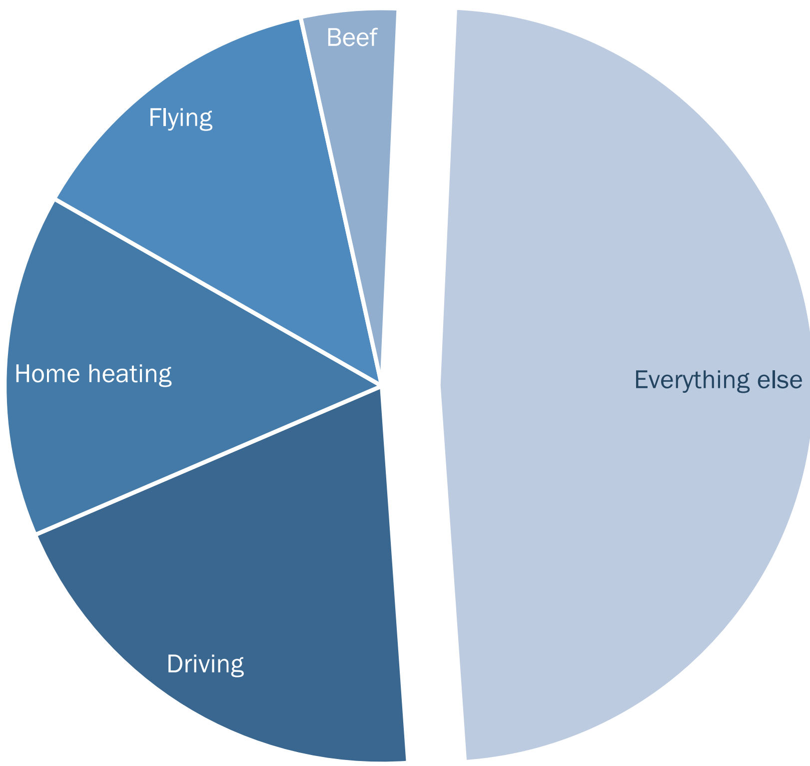


Figure 5. The ECO's estimated breakdown of the average Ontarian's carbon footprint, highlighting the four activities responsible for half of total emissions.

Of course, no individual is "the average Ontarian;" options differ for people in different parts of the province. People who live in urban areas will likely find some choices easier, more appealing or more practical than people in remote, rural, or suburban communities, and vice versa.

Climate change is everyone's problem, and we have to work together to solve it. That requires good government policies like making polluters pay for the damage caused.

Individual action is a great place to start, but it would be a terrible place to stop.

Appendix: How did we calculate the average carbon footprint of Ontarians?

According to Canada's National Inventory Report (NIR), Ontario's GHG emissions were 161 million tonnes of CO_2e in 2016. If divided by the 2016 population of 13.4 million, this translates into average per capita emissions of around 12 tonnes of CO_2e/year. This is useful as a rough approximation, but does not provide much guidance for individual action.

To more accurately estimate the carbon footprint of average Ontarians, the ECO has taken into account the following considerations:

1) The NIR total for Ontario only includes emissions that are produced directly within the geographical boundaries of Ontario (i.e., production-based emissions). Many of the products and services Ontarians consume have upstream (before we buy them) and downstream (after we discard them) emissions that take place outside Ontario. Following international rules, the NIR excludes important types of emissions that are affected by lifestyle choices and should be included in a carbon footprint, especially:

    - international air and marine travel
    - upstream emissions created outside Ontario to produce goods and services that are consumed in Ontario, and
    - emissions created outside Ontario from the decomposition of waste that was generated in Ontario but exported for disposal.

    On the other hand, the inventory includes emissions that take place in Ontario to produce goods for export markets. As in consumption-based GHG emission accounting (i.e., the emissions that result from what we consume),[89] the emissions associated with exports should be excluded from Ontarians' carbon footprints.

2) The GHG inventory that results from the lifestyle decisions of individuals includes the consumption of goods and services, with emissions taking place both within Ontario and outside of the province. Emissions that are not associated with this consumption (e.g., government spending) are excluded from the individual carbon footprint. Therefore, an average Ontarian's carbon footprint would be smaller than Ontario's per capita consumption-based emissions, most recently estimated at 19 tonnes of CO_2e per year.[90]

The GHGs resulting from individual actions can either be direct or indirect. Direct emissions originate from sources owned or controlled by the individual. Indirect emissions are a consequence of an individual's actions, but are from sources owned or controlled by someone else.

Only about one-third of Ontario's GHG emissions are directly released as a result of individual actions (approximately four t CO_2e/capita/year). The only two sources included in this category are emissions from the combustion of fossil fuels in vehicles (personal transportation) and those from furnaces (in residential buildings). Individuals who live in multiple-unit dwellings do not directly control the technologies used for residential heating. For simplification, the ECO's estimate categorizes all residential heating as a source of direct emissions.

Indirect emissions from individual actions include those from farming, resource extraction and processing, industrial production, landfills, the provision of services (e.g., banking, telecommunications), and electricity production.

How certain are these numbers?

In a full life-cycle approach, a person's carbon footprint includes the GHG emissions from the production, use and end-of-life stages of everything they consume. However, these cannot be calculated precisely yet. The goods and services that a person consumes uses materials and energy both directly and indirectly, including through inputs such as banking, insurance, the internet, infrastructure, etc., each of which has caused its own GHG emissions. Studies and estimates of both consumption and emissions are slowly improving but are still highly imperfect.

All calculations of carbon footprints are therefore approximate, and very sensitive to the scope of analysis, as well as to the assumptions made. This backgrounder summarizes the best available evidence for Ontarians as of early 2019.

Endnotes

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[11] Enbridge estimate cited by ECO (Environmental Commissioner of Ontario, Making Connections. Annual Energy Conservation Progress Report 2018, vol. 1 (Toronto, ECO 2018) at 123.).
[12] The average number of people comprising an Ontario household in 2016 is 2.6 (Statistics Canada. 2016. Census Profile, 2016 Census. Available at: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=&Code2=&Data=Count&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=35. Accessed on 18 March 2019.).
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[14] A number of emission sources associated with residential heating are outside one's direct control, including upstream natural gas leaks; and building code standards.
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https://www150.statcan.gc.ca/n1/pub/11-526-s/2010001/t006-eng.htm. Accessed on 18 March 2018.) shows that downsizing can have a big impact on a household's carbon footprint. For example, an Ontario dwelling with a floor space of less than 56 square metres (600 square feet) uses about half of the energy of one with a floor space of 93 to 139 square metres (1000 to 1500 square feet).

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[35] Available at: http://www.carbonzero.ca/.
[36] ECO 2017 Greenhouse Gas Progress Report available here: https://eco.on.ca/reports/2017-from-plan-to-progress/.
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[44] As well, this change in the time horizon would also increase our calculations for waste, as substantial amounts of methane are released from landfills.

[45] ECO calculations based on Legesse *et al*. (G. Legesse, K. A. Beauchemin, K. H. Ominski, E. J. McGeough, R. Kroebel. D. MacDonald, S. M. Little, and T. A. McAllister. 2015. Greenhouse gas emissions of Canadian beef production in 1981 as compared with 2011. Animal Production Science. http://dx.doi.org/10.1071/AN15386), assuming a 120 gram (approximately ¼ pound) raw hamburger patty.

[46] A number of emission sources associated with the food in our diets are outside of one's individual control. These include:

- the means of producing the food (with the exception of choosing between conventional and organic), and
- the means of transporting the food.

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https://docs.google.com/viewerng/viewer?url=http://www.cesarnet.ca/sites/default/files/pdf/publications/other/2015-GHGs-Waste-Mgmnt.pdf. Accessed on 18 March 2019. At 3.

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[60] Environment and Climate Change Canada, National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada. Part 3 at 69 (Ottawa: Pollutant Inventories and Reporting Division, 2018).

[61] Available at: https://eco.on.ca/reports/2018-making-connections/.

[62] Statistics Canada. 2016. Census Profile, 2016 Census. Available at: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=&Code2=&Data=Count&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=35. Accessed on 18 March 2019.

[63] "The Ontario Energy Board uses 750 kWh to represent the average monthly residential Ontario electricity usage for all homes." (Environmental Commissioner of Ontario, Making Connections. Annual Energy Conservation Progress Report 2018, vol. 1 (Toronto, ECO 2018) at 123.).

[64] The household GHG estimate for electricity use is calculated by multiplying the average GHG intensity of Ontario electricity (40 g CO_2e/kWh, from Environment and Climate Change Canada, National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada. Part 3 at 69 (Ottawa: Pollutant Inventories and Reporting Division, 2018).) by 9,000 kWh. The per capita estimate is obtained by dividing this result by 2.6 (the mean number of people in an Ontario household. Statistics Canada. 2016. Census Profile, 2016 Census. Available at: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=&Code2=&Data=Count&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=35. Accessed on 18 March 2019.).

[65] (S&T) Squared Consultants Inc, 2019. GHGenius 5.0d. Available at: https://ghgenius.ca/index.php/downloads/42-ghgenius-5-0d. Accessed on 21 March 2019.

[66] The average GHG intensity of electricity production from natural gas in Ontario is based on 2013-2016 production: 432 g CO_2e/kWh. This GHG intensity is over 10 times the average consumption intensity in 2016 (40 g CO_2e/kWh). These data were derived from the following source: Environment and Climate Change

Canada, National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada. Part 3 at 69 (Ottawa: Pollutant Inventories and Reporting Division, 2018).
[67] Available at: https://eco.on.ca/reports/2018-making-connections/.
[68] A "vampire" power load depicts an appliance or other device that consumes electricity when not in operation.
[69] Randolph Kirchain, Elsa Olivetti, T Reed Miller and Suzanne Greene. 2015. Sustainable Apparel Materials. Cambridge, MA: Materials Systems Laboratory, Massachusetts Institute of Technology, at 7.
[70] FIRA International. 2011. A study into the feasibility of benchmarking carbon footprints of furniture products. Available at: https://www.healthyworkstations.com/resources/Environment/FIRA.CarbonFootprint.pdf. Accessed on 19 March 2019.
[71] FIRA International. 2011. A study into the feasibility of benchmarking carbon footprints of furniture products. Available at: https://www.healthyworkstations.com/resources/Environment/FIRA.CarbonFootprint.pdf. Accessed on 19 March 2019.
[72] Apple. 2018. iPad Environmental Report. Available at: https://www.apple.com/euro/environment/pdf/g/generic/products/ipad/iPad_PER_mar2018.pdf. Accessed on 19 March 2019. Note: estimate includes only production, transportation and recycling emissions.
[73] Lotfi Belkhir and Ahmed Elmeligi. 2018. Assessing ICT global emissions footprint: Trends to 2040 & Recommendations. Journal of Cleaner Production 177:448-463.
[74] Lotfi Belkhir and Ahmed Elmeligi. 2018. Assessing ICT global emissions footprint: Trends to 2040 & Recommendations. Journal of Cleaner Production 177:448-463.
[75] (S&T) Squared Consultants Inc, 2019. GHGenius 5.0d. Available at: https://ghgenius.ca/index.php/downloads/42-ghgenius-5-0d. Accessed on 21 March 2019.
[76] Salazar, James, and Meil, Jamie. Prospects for carbon-neutral housing: The influence of greater wood use on the carbon footprint of a single-family residence. Journal of Cleaner Production. 17 (17) 2009. Pp. 1563-1517.
[77] These EIO models, such as EIO-LCA and the Eora global supply chain database, take indirect economic effects of production into account. For example, if an office furniture manufacturer receives an order to supply 1,000 pieces of furniture to a customer, the manufacturer would need to order inputs from its suppliers, who may then need to purchase furniture for the additional employees required to fulfill its order from that manufacturer. As a consequence, the original order for 1,000 pieces of furniture would result in a need to manufacture more than 1,000 pieces. EIO models track the overall economic effects of these chains of orders.
[78] The GHG emission intensities per dollar of spending (i.e., GHG emission factors) in various goods and services consumption categories were obtained from the CoolClimate Network household emissions calculator. The CoolClimate Network, which produced a household GHG emissions calculator, is a university - government - business - NGO partnership at the University of California, Berkeley. The GHG emissions calculator is available at: https://coolclimate.org/calculator. The GHG emission factors used in this calculator are based on those in the Comprehensive Environmental Data Archive for Economic and Environmental Systems Analysis (CEDA 3.0 Climate).
The GHG emission factors used to estimate the emissions from the product consumption category were obtained from the mean GHG emission factors for households with a gross annual household income of between $60,000 and $80,000 U.S. dollars (USD). This is likely reasonable, as the average total household expenditure in Ontario in 2016 is about equal to $70,000 USD. This claim is based on the 2016 Purchasing Power Parity (PPP) indicator (1.245 CAD/USD) from the OECD (https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm#indicator-chart), and the Statistics Canada 2016 data for the total household expenditure in Ontario ($88,953/household/yr). Using the 2016 PPP, $70,000 USD is about equal to $87,150 CAD. As the GHG emissions factors in the emissions calculator are based on USD, 2016 OECD purchasing power parity indictor data were used to alter these factors so that they reflected emissions per Canadian dollar of spending.
The ECO matched the goods and services consumption categories in the emissions calculator with the most appropriate matches in the Statistics Canada data on the average expenditure per Ontario household (2016).

Endnote Table 1. Matching the goods spending categories in the CoolClimate Network household emissions calculator with the Statistics Canada household expenditure categories

GHG emissions per $ of expenditure (kg CO_2e/$)	ClimateCare Network Household Emissions Calculator Spending Categories	Statistics Canada Expenditure Categories
0.41	Furniture and appliances	Household furnishings and equipment
0.42	Clothing	Clothing and accessories
0.42	Entertainment	Recreation
0.26	Paper, office, and reading	Reading materials and other printed matter; Stationary (excluding school supplies); Other paper supplies
0.49	Personal care and cleaning	Personal care
0.53	Auto parts	Tires, batteries, and other parts and supplies for vehicles
0.29	Medical	Prescribed medicines and pharmaceutical products; Prescription eyewear; Non-prescription eye wear and other eye-care goods; Non-prescribed medicines, pharmaceutical products, health care supplies and equipment

Endnote Table 2. Matching the services spending categories in the CoolClimate household emissions calculator with the Statistics Canada household expenditure categories

GHG emissions per $ of expenditure (kg CO_2e/$)	ClimateCare Network Household Emissions Calculator Spending Categories	Statistics Canada Expenditure Categories
0.22	Health Care	Health care practitioners (excluding general practitioners and specialists); Weight control programs, smoking cessation programs and other medical services; Health insurance premiums; Private health insurance plan premiums; Hospital care, nursing homes and other residential care facilities
0.23	Information and communication	Communications
0.15	Medical	Health care by general practitioners and specialists; Eye-care services (e.g., surgery, exams); Dental services
0.32	Vehicle service	Maintenance and repair of vehicles
0.14	Personal business and finance	Financial services
0.68	Household maintenance and repair	Tenants' repairs and improvements; Repairs and maintenance for owned living quarters; Condominium fees for owned living quarters
0.37	Organizations and charity	Charitable contributions
0.33	Other services	Education; Other miscellaneous goods and services

The per capita annual emissions from these categories were added to the emissions associated with the production of the average vehicle sold in Ontario, as well as those emissions from the production of a single detached house.

(S&T) Squared Consultants Inc, 2019. GHGenius 5.0d. Available at: https://ghgenius.ca/index.php/downloads/42-ghgenius-5-0d. Accessed on 21 March 2019.
Salazar, James, and Meil, Jamie. Prospects for carbon-neutral housing: The influence of greater wood use on the carbon footprint of a single-family residence. Journal of Cleaner Production. 17 (17) 2009. Pp. 1563-1517.

[79] A number of emission sources associated with product consumption are outside of one's direct control. These include:

- the emissions associated with producing the products, and
- the means of transporting the products.

[80] Daniel Moran, Keiichiro Kanemoto, Magnus Jiborn, Richard Wood, Johannes Többen and Karen C. Seto. 2018. Carbon footprints of 13 000 cities. Environmental Research Letters 13(6):064041.

[81] Oxfam. 2015. Oxfam Media Briefing. Extreme carbon inequality. Available at: https://www.oxfam.org/sites/www.oxfam.org/files/file_attachments/mb-extreme-carbon-inequality-021215-en.pdf. Accessed on 19 March 2019. At 1.

[82] This estimate is based on the 2016 Ontario household consumption of $62,183, which is equal to $23,917 per person, and the per capita GHG emissions of the province. Source: Statistics Canada. Survey of Household Spending, 2016. Available at: https://www150.statcan.gc.ca/n1/daily-quotidien/171213/dq171213b-eng.htm. Accessed on 19 March 2019.

[83] The average emissions from burning gasoline (excluding upstream emissions) are approximately 2.45 kg CO_2e/litre. Source: (S&T) Squared Consultants Inc, 2019. GHGenius 5.0d. Available at: https://ghgenius.ca/index.php/downloads/42-ghgenius-5-0d. Accessed on 21 March 2019.

[84] Zach Honig. The World's Most Frequent Flyer Just Hit Another Major Milestone. 8 February 2018. Available at: https://thepointsguy.com/2018/02/tom-stuker-19-million/. Accessed on 19 March 2017.

[85] These calculations were undertaken using the following assumptions and data: (1) the average one-way trip taken by the frequent flyer record holder was 5704 km, equal to the flight distance between Toronto and London, England (International Civil Aviation Organization. Carbon emissions calculator. Available at: https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx. Accessed on 1 March 2019); (2) the CO_2 emissions from this flight are approximately those estimated by ICAO's Carbon Emissions Calculator (International Civil Aviation Organization. Carbon emissions calculator. Available at: https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx. Accessed on 1 March 2019); (3) the radiative forcing multiplier is 2.57, based on Kärcher 2018 [Bernd Kärcher. 2018. Formation and radiative forcing of contrail cirrus. Nature Communications 9:1824 | DOI: 10.1038/s41467-018-04068-0.]; and (4) the per capita emissions of Ontario is approximately 12 tonnes, based on 2016 figures [NIR 2018].

[86] Statistics Canada. 2011. Canada's rural population since 1851, Census in Brief, Catalogue No. 98-310-X2011003. Available at: https://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-310-x/98-310-x2011003_2-eng.cfm. Accessed on 19 March 2019.

[87] Statistics Canada. Table 39-10-0045-01 Number of residential properties, by period of construction and residency status, provinces of British Columbia and Ontario and their census metropolitan areas. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3910004501. Accessed on 19 March 2019.

[88] Statistics Canada. Table 39-10-0045-01 Number of residential properties, by period of construction and residency status, provinces of British Columbia and Ontario and their census metropolitan areas. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3910004501. Accessed on 19 March 2019. Note: this statistic includes homes where the construction date is "not applicable."

[89] Brett Dolter, Peter A. Victor. 2016. Casting a long shadow: Demand-based accounting of Canada's greenhouse gas emissions responsibility. Ecological Economics 127:156-164.

[90] A 2016 estimate of Ontario's 2009 consumption-based emissions amounts to a per capita estimate of about 19 tonnes of CO_2e. Brett Dolter, Peter A. Victor. 2016. Casting a long shadow: Demand-based accounting of Canada's greenhouse gas emissions responsibility. Ecological Economics 127:156-164.