Module 5

Climate Change Toolkit for Health Professionals

Climate Change Solutions with Immediate Health Benefits

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Authors: Ronald Macfarlane MSc and Kim Perrotta MHSc

Project Manager and Editor: Kim Perrotta MHSc, CAPE Executive Director

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Preface

This toolkit consists of eight modules which have been prepared as stand-alone documents that can be read by themselves, but they have also been prepared to complement one another. It has been designed as a tool for health professionals and students in the health care and public health sectors who want to engage more directly on the issue of climate change as educators with their patients, peers and communities, and/or as advocates for the policies, programs and practices needed to mitigate climate change and/or prepare for climate change in their workplaces and communities.

Module 1 – Climate Change – Science, Drivers & Global Response provides an introduction to climate science and discusses the human activities that are contributing to climate change, the international commitments that have been made to address it, and where we are in terms of complying with those commitments.

Module 2 – Global Health Impacts of Climate Change summarizes the direct and indirect health impacts that are occurring, and are predicted to result from, climate change, on a global scale.

Module 3 – Climate Change Health Impacts across Canada summarizes the direct and indirect health impacts that are occurring, and that are predicted to occur, in the different regions of Canada.

Module 4 – Greenhouse Gas Emissions in Canada by Sector and Region discusses the volume of greenhouse gases emitted, and the trends in those emissions, from different sectors in Canada at a national, provincial and territorial scale.

Module 5 – Climate Change Solutions with Immediate Health Benefits discusses climate solutions that can produce fairly immediate health co-benefits for the jurisdictions that implement them.

Module 6 – Taking Action on Climate Change at Health Care Facilities discusses the climate mitigation and adaptation policies, programs and practices that can be adopted and implemented by health care institutions to reduce their greenhouse gas emissions and prepare for climate change.

Module 7 – Preparing for Climate Change in our Communities discusses the climate adaptation policies and programs that can be developed by public health units or municipalities to minimize the health impacts associated with climate change.

Module 8 – Engaging in Climate Change as Health Professionals discusses the different ways in which health professionals can educate and engage their patients, the public, their peers, and their communities on the health impacts of climate change, and the policies and programs needed to mitigate climate change and prepare for it.

Module 5 – Climate Change Solutions with Immediate Health Benefits

Introduction

The Imperative – A Rapid Shift Away from Fossil Fuels

Current commitments by governments, including those of Canada, are insufficient to limit average global warming well below 2°C, let alone to meet the 1.5°C target in the 2015 Paris Agreement. At current global emission trends, a 1.5°C increase in average global temperatures is likely to occur between 2030 and 2052. To stay below 1.5°C, global greenhouse gas (GHG) emissions need to fall by about 45 percent from 2010 levels by 2030 and reach 'net zero' by 2050 (IPCC, 2019). It is imperative to accelerate the shift to non-carbon sources of energy in order to avoid the catastrophic health impacts that would be associated with 2°C of warming.

English: Highway 401 at the start of the primary Collector/Express system in Toronto. Photo by PL Tam.

The Lancet Countdown on health and climate change emphasizes that a transformation is needed in the way we generate power, travel, build communities, eat and grow our food (Watts et al, 2018). Strong and predictable carbon pricing, the rapid phase-out of coal, increased access to renewable energy, the promotion of healthy living through energy efficient buildings, low-cost active transportation and increased access to green space are among the strategic directions that will reduce the impact of climate change on health (Watts et al, 2015).

Health Benefits of Climate Action

Many actions to reduce GHGs have additional heath benefits (or co-benefits) associated with them (Haines and Ebi, 2019). For example, reducing GHGs from the production and burning of fossil fuels will usually reduce air pollution, thereby providing immediate health benefits. Actions taken to increase walking, cycling or the use of transit can increase levels of physical activity and reduce emissions of air pollutants, both of which can improve public

Table 1: Highlights of Health Co-benefits of Climate Actions

Action	Benefits for climate	Benefits for health
Energy use and production • Replacing fossil fuels with renewable energies • Reduce the demand for energy through energy efficiency and other measures • Improve energy efficiency in buildings	• Reduce emissions of carbon dioxide, black carbon, methane and other climate pollutants	• Improve air quality by reducing exposure to outdoor air pollution with a corresponding reduction in risk of cardiovascular disease, chronic and acute respiratory illnesses, lung cancer, and preterm birth • Improve indoor environments to reduce energy poverty and respiratory and cardiovascular illnesses
Transportation • Increase fuel efficiency • Use alternative fuels • Decrease the demand for motorized transportation • Give higher priority to active transportation and transit • Improve the cycling and walking environment	• Reduce emissions of climate pollutants by reducing vehicle travel and lowering emissions from vehicles	• Improve air quality with a corresponding reduction in health impacts (see above) • Increase physical activity which reduces the risk of all-cause mortality, cardiovascular disease, obesity, type II diabetes, and certain types of cancer • Fewer vehicle-related deaths and injuries from improved cycling and walking infrastructure
Buildings and communities • Increase urban density and diversity of land uses • Increase urban green spaces and forests	• Reduce emission of climate pollutants by reducing vehicle travel and emissions from vehicles • Reduce atmospheric carbon dioxide (**CO2**) by sequestering carbon in plants and soil and reducing cooling needs	• Improve air quality by reducing vehicle travel • Increase physical activity by fostering active travel • Reduce ambient temperatures and heat island effect with green space • Reduce noise pollution with increased green space • Improve mental health with increased access to green space • Improve water quality with increased green space
Food consumption • Shift diets to emphasize foods of plant origin • Reducing the amount of food that is wasted	• Lower CO2 and methane (**CH4**) emissions from energy-intensive livestock systems and less food waste	• Improve diets (less meat, more fruits and vegetables) which decreases risk of heart disease, stroke, colorectal cancer, diabetes and other diseases • Improve food security • Improve air quality by reducing CH4 emissions that contribute to ground-level ozone

(Source: Smith et al., 2014; WHO, 2011; WHO, 2018)

health, while reducing GHG emissions. Actions that increase the consumption of plant-based proteins, can reduce obesity and obesity-related chronic diseases, while reducing GHG emissions from the agricultural sector **(see also Table 1)**.

Health – Catalyst for Climate Action

Taking health and other co-benefits into account when deciding on the actions needed to implement climate solution makes the overall cost-effectiveness of these initiatives more visible. At times, the costs savings from health benefits alone can outweigh the costs of measures taken to reduce GHG emissions (Gouldson et al., 2018; Thompson et al, 2014; Markandya et al., 2018). This can make climate interventions more appealing to the public and decision-makers (Armstrong, 2012; Maibach et al., 2010; Workman, et al., 2018). This module provides information that the health community can use to strengthen the case for action on climate by highlighting the additional benefits to health that such action would bring.

Carbon Pricing Internalizes the Cost of GHG Emissions

Putting a price on carbon is a way to internalize the environmental and health cost created by the release of GHGs during the extraction, transportation, refining, and use of fossil fuels. It supports and complements sector-specific policies that will reduce the consumption of these fuels in Canada. Part of the revenues generated can also be used to facilitate the shift to a low-carbon economy and enable a just transition. At the same time, it is also necessary to ensure policy coherence and to remove subsidies and incentives that encourage the use of fossil fuels.

Health, Environment And Climate – The Connections

Our Air

Health Canada (2017) estimates that air pollution in Canada results in 14,400 premature deaths per year. In addition, about 10 million Canadians – or 32 per cent of the population – live within 500 metres of highways or 100 metres from major urban roads, exposing them to higher levels of air pollution from traffic (Brauer et al., 2013).

Air Pollution & Fossil Fuels

In addition to GHGs, fossil fuels emit various air pollutants when burned. Air pol-

Between 1990 and 2016, emissions from transportation increased by 42% … while emissions from the oil and gas sector increased by 70% ….

lution is linked to a wide range of adverse health outcomes including heart and lung disease, cancer in children, lung cancer, adverse birth outcomes, neurodevelopmental impacts, reduced cognitive function, dementia, and chronic conditions such as diabetes (TPH, 2014; Toronto 2017).

Chronic exposure to fine particulate matter (PM2.5) from the burning of fossil fuels, a major component of air pollution, is estimated to result in 7142 premature deaths per year in Canada with welfare-related costs valued at $53.5 billion:

- 345 of those deaths were attributed to coal-fired power plants,
- 105 to coal-related industries,
- 2762 to non-coal industries,
- 1063 to land-based transportation, and
- 1282 to the agricultural sector (Howard et al., 2018)

Fossil Fuel Extraction & Health

An air monitoring study conducted by Environment Canada found that pollution from the Alberta oil sands resulted in the creation of 45–84 tonnes per day of airborne particulate matter (PM). This compares to 67 tonnes per day from the greater Toronto area as a whole. The oil sands contribute a large proportion of PM in Edmonton's air and this pollution can travel as far as Ontario (Chung, 2016; Liggio et al., 2016).

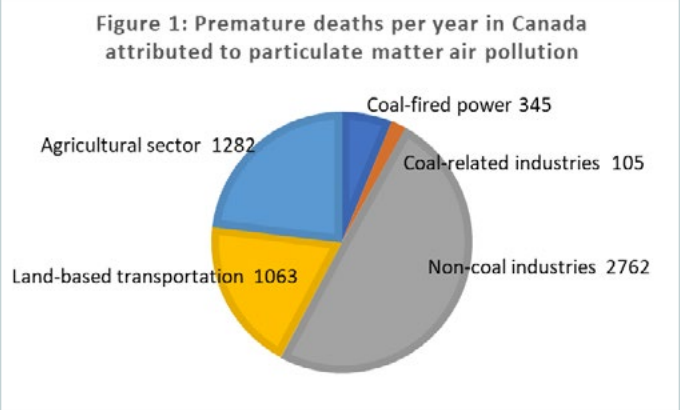

Figure 1: Premature deaths per year in Canada attributed to particulate matter air pollution.

There is mounting evidence of the adverse impacts of shale gas drilling (fracking). Pollutants from shale gas development include diesel PM, nitrogen oxides, hydrogen sulfide, volatile organic compounds and radon. Studies have found that emissions from gas wells can result in concentrations of air pollutants that exceed exposure guidelines for both carcinogenic and non-carcinogenic health risks. Fracking can also contaminate surface and groundwater (Glauser, 2014; Shonkoff et al. 2014).

Sources of Methane

The production, distribution and use of oil and gas also releases methane (CH_4), a short-lived climate pollutant with 84 times the warming potential of CO_2. Agriculture and food waste are also major sources of methane (Scovronick et al., 2015). In addition to being a GHG, methane contributes to the formation of ground-level ozone. Ground-level ozone contributes to a wide-range of adverse

Fossil fuel pump. Photo provided by Thinkstock.

impacts including: an increase in respiratory and cardiorespiratory mortality; an increase in asthma incidence and severity; adverse impacts on lung function growth, cognitive development and reproductive health, including preterm birth (TPH, 2014). In addition, the switch away from fossil fuels could result in less crop damage from ground-level ozone and fewer occupational injuries (WHO, 2018).

These emissions can be reduced through the recovery and use of methane from coal mines and in oil and natural gas production and distribution. While flaring of methane from oil and gas production reduces the climate impact, it creates black carbon and other air pollutants including hydrogen sulphide and various volatile organic compounds such as benzene, toluene, ethyl-benzene and xylene that are of concern for health (CAPE, 2018; Scovronick et al., 2015).

Our Communities

Chronic diseases like diabetes, cancer and cardiovascular disease are the leading causes of death in Canada. Unhealthy diets, low physical activity, and higher rates of overweight and obesity are contributing factors to these (Tam, 2017).

Obesity & Health

Obesity increases the risk for premature death and chronic diseases, such as cardiovascular disease, cancer and diabetes. In Canada more than one quarter (25%) of people 18 years and older were living with obesity in 2015 (Tam, 2017). A study that looked at eight chronic diseases estimated the cost associated with obesity in Canada to be $4.6 billion in 2008. Another study that considered 18 diseases put that cost at $7.1 billion per year (PHAC and CIHI, 2011).

Many factors influence the prevalence of obesity. Transportation systems, urban design, land use, and food systems, which have a strong impact on GHG emissions, have a significant impact on obesity by influencing levels of physical activity and diet (Lowe, 2014; Swinburn et al., 2019).

Physical Activity & Health

Physical activity is associated with improved heart and mental health, healthy child development and aging, and re-

duced risk of premature deaths and various health conditions such as obesity, some cancers, diabetes, dementia and osteoporosis (Tam, 2017). The cost of physical inactivity in Canada was estimated at $6.8 billion in 2009 or 3.7% of health care costs. In 2013 only 10% of Canadian children and youth and 20% of Canadian adults met the Canadian Physical Activity Guidelines of a minimum of 60 minutes of moderate- to vigorous-intensity activity per day for children, and 150 minutes of moderate to vigorous physical activity each week for adults aged 18 and over (Tam, 2017; TPH 2012).

Community Design & Health

About three quarters of Canadians live in cities of 100,000 people or more. Improving the design of our communities can help reduce the rates of chronic diseases in Canada (Tam, 2017). Active neighbourhood design promotes physical activity and reduces dependence on automobile travel which reduces emissions of GHGs. At the same time, these neighbourhoods can improve access to nutritious foods, which are less carbon intensive in their production. Cities can curb GHG emissions by reducing energy use through changes in the urban fabric – housing, transit, land use, buildings. Reducing the distance between home, workplace, services and other amenities as well as improving transit and active transportation infrastructure help reduce the demand for automobile travel and thereby reduce transport-related emissions (Cohen, 2018; Tam, 2017).

Our Food

In the past 50 years, there have been large changes in both the way food is produced and what people eat. While these changes have improved access to food, they have also been accompanied by a shift to unhealthy diets that are calorie-dense, highly-processed, with a high proportion of animal products (Willett et al, 2019).

Factors that have promoted this shift in diets are numerous and intertwined. They include rapid urbanisation, increasing incomes, inadequate access to nutritious foods, and fiscal and agricultural policies (Lowe, 2014; Willett et al., 2019; Swinburn et al., 2019). This change in diets is contributing to the increasing burden of obesity and diet-related chronic diseases and environmental degradation, including climate change.

Healthy Diets & Climate

Studies that have analysed measures to reduce GHG emissions associated with food production have concluded that dietary changes towards diets rich in plant-derived foods and reduction in food waste would have the largest impact on GHG emissions (Ranganathan et al., 2016; Willet et al., 2019). Such a shift would promote health by shifting

food consumption patterns to conform with guidelines for a healthy diet and improve cardiovascular health (Friel et al., 2009; TPH, 2017; Health Canada, 2019).

Where Canada Stands

Canada's 2018 GHG inventory reports emissions of 704 megatonnes (Mt) of GHGs (CO_2eq). This is a 3.8% decrease GHG emission between 2005 and 2016 instead of the 15% needed. The two top emitting sectors were the oil and gas sector which was responsible for 26% of total emissions (183 Mt CO_2eq[1]) and the transportation sector which was responsible for 25% of total emissions (173 Mt). Emissions from other sectors ranged from 6 to 12% (41 to 81 Mt). The transportation sector was the largest contributing sector in eight of the provinces/territories (ECCC, 2018c). (See Module 4 for more details on emissions.)

Emissions in 2016 were more than 100 Mt higher than GHG emissions in 1990. While there have been decreases in emissions from electricity generation, heavy industry and waste, emissions have increased from vehicle travel, the production of crude oil, and the expansion of the oil sands. During this period, emissions from transportation increased by 42% while emissions from the oil and gas sector increased by 70% CO_2eq (ECCC, 2018c).

Canada has made some initial steps. In

The coal industry. Photo by Sam Jotham Sutharson on Unsplash

2015, the Canadian government indicated that it would reduce its GHG emissions by 30% of 2005 levels by 2030. Coal-fired power plants are scheduled to be closed by 2030 and there is a commitment to have 90% electricity generation from non-emitting sources by 2030. The federal government has instituted a carbon tax and many provinces and territories have introduced various carbon-pricing schemes. Improved fuel vehicle efficiency and energy efficiency requirements in appliance and buildings are among other initiatives that will reduce GHG emissions. However much more needs to be done, especially to address emissions from transportation and the oil and gas sector, if Canada is to achieve "net-zero" GHG emissions by 2050 as the

IPCC (2019) has identified as necessary.

Energy Production

Energy Transition

As the IPCC (2019) special report indicates an accelerated shift to non-carbon sources of energy is needed if average global warming is to be limited to well below 2°C. These include renewable energy such as wind and solar, geothermal energy, and micro-hydro[2]. In addition, smart grids, distributed/decentralised energy production, and increased energy productivity/efficiency are needed. During the transition, control of methane releases and the elimination of flaring from oil and gas production will also reduce the carbon footprint of energy production.

The transition to a low-carbon economy requires changes to the global energy system. In addition to carbon pricing, governments have a role in accelerating the creation of sustainable markets for low-carbon technologies and preventing investment in high-polluting technologies. Policies that support innovation, removal of institutional barriers, public spending reallocations, and policies that encourage investment in low-carbon infrastructure can contribute to the transition (IEA, 2015; OECD and World Bank, 2015).

Health & Coal Phase-Out

Coal-fired electricity releases more air pollutants, GHGs, and mercury than any other source of electricity. The Pembina Institute estimated that if all Canada's coal-fired plants were shut down after 40 years of operation (rather than 50) or by 2030, whichever was sooner, and coal power was replaced by two thirds renewables and one third best-in-class gas-power, additional health benefits valued at $5 billion would be created and GHG emissions would be reduced by an additional 31 Mt CO_2eq (Israël and Flanagan, 2016). The associated reduction in mercury emissions would result in $1.3 billion in health-related benefits. Encouraged by the advocacy work of CAPE, the Pembina Institute and environmental groups in Saskatchewan, New Brunswick and Nova Scotia over the last four years,

Biofuels are not necessarily low carbon.

While wastes, winter cover crops and sustainable forestry can be sources of biofuels, large scale conversion of land to crops for biofuels competes with land needed for food production and increases pressures to clear forests and other natural ecosystems for agriculture. "Avoiding increased use of bioenergy from energy and food crops is critical to a sustainable food future… Governments should phase out subsidies currently in place for bioenergy that is grown on dedicated land. Governments also need to correct 'flawed accounting' in renewable energy directives and emissions trading laws that treat bioenergy as 'carbon-neutral'" (Searchinger et al., 2018).

the federal government has passed legislation to phase-out of coal-fired power plants by 2030 (ECCC, 2018a).

Health & Low-carbon Energy

A report from the New Climate Institute estimated the co-benefits of climate action for the United States. It found that by 2030, current US commitments would prevent around 7,000 air pollution-related premature deaths each year and create an additional 470,000 full-time equivalent green jobs in the domestic renewable energy sector. It also found that if the US made the commitments required to meet the 2°C Paris Agreement target, an additional 20,000 air pollution-related premature deaths each year would be avoided and an additional 180,000 full-time equivalent green jobs would be created (Höhne et al., 2015).

Jacobson and colleagues (2017) explored the rapid transition to 80% wind, water and solar energy by 2030 and 100% by 2050 for 139 countries. They estimated that by 2050, such a shift could lead to USD $110 billion savings in annual health costs or nearly 4% of GDP, including a reduction of about 9,900 air pollution-related deaths in Canada. The cost of this investment could be recovered from the savings related to reduced air pollution and climate impacts in 4.1 years.

Beware - Low-Carbon Fuels

Transition away from fossil fuels can be associated with new or different challenges in environmental and health protection that require consideration and planning for mitigation. Conflicts can arise between climate change mitigation and air quality. For example, the use of diesel engines has been promoted because it emits less CO_2 than gasoline, but it contributes more to local air pollution. Similarly, the use of biofuel emits air pollutants which can impact local air quality (Scovronick et al., 2015). There are also concerns with methane emissions from large hydropower dams (Magill, 2014). Renewable energy technologies such as batteries and solar panels can expose workers to nano-materials and certain toxic materials. They also create wastes at the end of their life-cycle that need to be managed appropriately (Scovronick et al., 2015).

Energy Conservation

Conservation reduces the demand for energy. This means less energy needs to be produced which reduces pollution related to both production and use. It also reduces the overall need for power generation making the transition to renewable energy easier. In addition, meeting energy needs through energy efficiency

is often cheaper than building new power supply (Castro-Alvarez et al., 2018).

Untapped Potential in Canada

The International Energy Agency (IEA 2018) indicates that the Canadian energy system has large energy efficiency savings potential, especially in buildings, transportation and industry. For the past 15 years, energy demand has grown by an average of 0.8% per year. Without additional policies energy demand is expected to continue to grow at this rate. IEA (2018) projects that under current policies, GHG emissions in Canada would be 17.5% higher in 2050 than in 2016. Emission reductions modelled for Canada, based on economically and technically feasible energy efficiency investments alone, would result in a 30% decrease of GHG emissions in 2050 compared to 2016. More than 90% of avoided energy demand would be from reduced use of oil and gas (IEA, 2018).

Reducing Energy Use from Buildings

Buildings in Canada use about one third of primary energy production (IEA, 2018)[3]. Opportunities to reduce emissions include: increasing energy efficiency of buildings, lighting, appliances, and other energy-using equipment; requirements for net-zero energy ready buildings; passive energy design; green roofs; reusing

Solar Panel - Haliburton, ON. Photo by Kim Perrotta.

or renovating buildings rather than demolition to build new; retrofitting existing buildings; improving heating, ventilation and air conditioning (HVAC) systems, including district energy; installing more efficient water heaters; and improved lighting, automation and controls (Day et al., 2018; IEA, 2018; Scovronick et al., 2015).

IEA (2018) estimates that compared to today, by 2050 it would be possible to reduce GHG emissions from buildings by 60%. Emissions reductions would be achieved as households switch away from oil- and gas-based heating towards high-efficiency, electricity-based technologies. Improved building envelopes and switching to electric heat pumps could reduce space heating energy requirements by 85% by 2050 (IEA, 2018).

Requirements for public disclosure of energy ratings of buildings could serve as an incentive to improve performance. Increasing urban density, reducing the amount of floor space per occupant in homes and businesses, and decentralisation of energy production which reduces transmission losses, would also reduce energy requirements (IEA, 2018).

Health Benefits & Indoor Environment

Energy retrofit measures that reduce exposure to extreme heat, cold, mould and dampness and improve indoor air quality through better ventilation can reduce the risk of cardiovascular disease, strokes, asthma and other respiratory diseases. Immediate health gains of low-carbon housing include reduced energy costs to households, including reduced energy poverty, reduced illness, fewer medical visits and sick days off work and school (Thomson et al., 2013; Vardoulakis et al., 2015; WHO, 2011a). Interventions that improve thermal comfort lead to better general health, respiratory health, and mental health especially among people with chronic respiratory disease or with inadequate heating (Thomson et al., 2013; Scovronick et al., 2015).

An assessment of strategies to reduce GHG emissions from housing in the UK housing found that overall these would benefit health (Wilkinson et al., 2009). A strategy that combined improvements to the building envelope and ventilation, fuel switching, and behavioural changes was estimated to result in 850 fewer disability-adjusted life-years (DALYs) and a saving of 0·6 Mt of GHGs per million people per year. Another modelling study of building envelope and ventilation retrofits installed with adequate ventilation estimated a reduction in net mortality and morbidity of 2,241 quality-adjusted life-years (QALYs) per 10,000 persons over 50 years in England (Hamilton et al., 2015).

Health Benefits & Outdoor Air Quality

In addition to reducing energy costs, building energy efficiency measures improve outdoor air quality that are estimated to be worth approximately 8 to 22% of the value of the energy savings. Improved insulation in US homes alone could reduce GHG emissions by 110 Mt and prevent 320 deaths per year, a benefit estimated to be equivalent to US$12 to 390 per tonne of GHG reduced (Gouldson et al., 2015).

In the USA, LEED® certified buildings make up about 3.5% of commercial floor space. From 2000 to 2016, the improved environmental performance of these buildings is estimated to have accumulated US$1.28 billion in climate-related benefits and $2.68 billion in direct health benefits from reductions in air pollution. They prevented 172 to 405 premature deaths, 171 hospital admissions, 11,000 asthma exacerbations, 54,000 respiratory

Solar Panel on Multi-Unit Residence, Dundas, ON. Photo by Kim Perrotta.

symptoms, 21,000 lost days of work, and 16,000 lost days of school were during that period (MacNaughton et al., 2018).

Home Energy Retrofits & Energy Poverty

On average Canadian households spend around 3% of their income on energy. The National Energy Board (NEB) estimated that 8% of Canadian households spent more than 10% of their income on energy and thus were considered energy-poor in 2015. When the cost of fuel used for automobiles is included, the number of households classified as energy-poor doubles. Low-income households are twice as likely to experience energy poverty (IEA, 2018). Energy poverty is associated with an increased incidence of respiratory problems and mental stress. Children and the elderly are more vulnerable to these impacts. Improvements in the energy efficiency in housing and passenger cars allows households to meet energy needs at a lower cost, reducing the incidence of energy poverty. Low-income households are also likely to benefit most from improved energy efficiency of their homes (OECD and World Bank, 2015; WHO, 2011a).

Beware – Energy Retrofit Complications

It is necessary to ensure that energy retrofits are done properly; that adequate ventilation is maintained to prevent the risk of increasing concentrations of pollutants such as PM2.5, CO and radon and to avoid biological contamination such as mould (Vardoulakis et al., 2015). Improving energy efficiency of buildings, including heating and cooling, will also reduce pollution from electricity generation and heating fuel. However, such improvements can increase land and real estate values which then leads to population displacement and greater socio-economic disparities (Cohen, 2018).

In addition, market failure is a barrier to widespread adoption of energy efficiency in buildings. This includes inadequate information on the benefits and potential long-term savings. As well, an owner of

a rental property may not benefit from energy efficiency improvements. Policies and programs need to be put in place to ensure that up-front costs of energy efficiency retrofits or installation of more efficient heating are not a barrier to adoption of measures especially for lower income households and small businesses (Kossoy et al., 2015; OECD and World Bank, 2015).

Transportation

Transportation is a major and increasing source of GHG in Canada and globally. As mentioned above, the transportation sector accounts for about 25% of total GHG emissions (ECCC, 2018c) and at least 1,063 air-pollution related premature deaths per year in Canada (Howard et al., 2018). Action taken to reduce GHG emissions from transportation can lower emissions of several air pollutants. The magnitude of air quality co-benefits depends on the approach taken to reduce GHGs. Areas with more pollution would likely see greater co-benefits (USGCRP, 2018).

Streetcars on Spadina Avenue in Toronto. Photo by Kim Perrotta.

To successfully reduce the impact of transportation, there is a need to transition to low- or zero-emission vehicles, reduce the demand for motorised transportation, and shift a greater proportion of personal transportation to walking, cycling and transit (WHO, 2011b). Improved fuel efficiency in vehicles would also drive reductions of GHGs from transportation in Canada (IEA, 2018).

Reducing Emissions from Transportation

Improved fuel efficiency, low-emission vehicles such as hybrids, and electric vehicles are important ways to reduce the emissions of GHG emissions and air pollutants from the transportation sector. However, gains in efficiency can be lost as vehicle use and distance travelled increase. Therefore, it is equally important to reduce the distance travelled by motorized vehicles (Gouldson et al., 2018). An integrated approach to GHG emissions reduction, air quality improvement, and active travel will maximize the health benefits of actions taken (Brauer et al., 2013; Gouldson et al., 2018).

Approaches to promote greater active travel include: modifying existing infrastructure; changing land-use planning

processes to integrate active city principles; transportation demand management for passenger, freight and commercial vehicles; and road or distance-based pricing. Setting ambitious walking, cycling and transit policies and targets can catalyze actions (Brauer et al., 2013; Day et al 2018; Rodier et al., 2014; TPH, 2012; TPH, 2014). (See CAPE's Active Travel Toolkit for resources on the health benefits of active travel.)

Benefits of Transportation Policies

Co-benefits of actions to reduce emissions of GHG emissions from transportation include: reduced exposure to traffic-related pollution especially along transportation corridors; reduced crop damage and extreme weather; increased physical activity; reduced noise; fewer vehicle-related injuries and deaths; greater equity of a less-car dependent transportation system (Brauer et al., 2013; WHO, 2018). The outdoor air quality, physical activity, congestion and travel time co-benefits of actions to reduce GHGs from transportation have been well studied. Fewer studies are available on the co-benefits related to indoor air quality, ambient noise, and motor vehicle crashes. Overall, studies show that climate actions are associated with positive health and economic co-benefits, with the greatest benefit related to the increase in physical activity (Gouldson et al., 2018).

An electric car outlet. Photo by John Cameron Unsplash.

Transit, Health & Climate

A 2014 study of the Greater Toronto and Hamilton Area (GTHA) examined the health benefit of transit improvement in the region that would require an investment of $50 billion over 25 years (Mowatt et al., 2014). Without this investment, it was projected that emissions of PM2.5 and GHGs would increase by 27% and 30% respectively as traffic in the GHTA increased. It concluded that the transit investment could produce $2.2 billion in health-related benefits per year and prevent 328 premature deaths per year by improving air quality and increasing physical activity in the GTHA.

A study of land use, transit, and vehicle pricing policies in California estimated that distance-based vehicle pricing could increase walking by about 10% and cycling by about 17% with a 16% reduction in GHG emissions. It also estimated that transit expansion and supportive development patterns could in-

crease walking and cycling by 2-3% with a corresponding 4% decrease in vehicle distance traveled (Rodier et al., 2014).

Walking, Cycling & Health

Another study estimated that replacing short car trips with walking or cycling could help people meet physical activity guidelines and almost eliminate obesity in the US in the absence of dietary change and result in large reductions in GHG emissions (Higgins and Higgins, 2005 as cited in Lowe, 2014).

In 2006, 7.1% of trips in Toronto were taken by walking and 1.7% by cycling. It was estimated that these modes of transportation were preventing about 120 deaths per year and producing health benefits valued at $130 to $478 million per year. Savings in direct medical costs arising from residents staying active by walking and cycling are estimated to provide a further economic benefit of $110 to $160 million per year. Measures that would increase walking and cycling would add to these benefits (TPH, 2012).

Urban cycling can help health and climate change. Photo by Photo by Viktor Kern on Unsplash.

Active Travel, Health & Climate

The use of sustainable transportation approaches to climate mitigation can result in substantial health benefit. When Woodcock and colleagues (2009) examined different scenarios to reduce GHG emissions transportation in London, England, they concluded that a combination of lower-emission vehicles, reduced distance travelled, and increased active travel would maximise GHG emissions reductions. The shift to safe active travel provided more benefits to health than the adoption of low-emission vehicles alone. The authors estimated a reduction in 7,332 disability-adjusted life-years (DALYs) in one 1 year from increased active travel and 160 DALYs from the use of lower-emission motor vehicles; most of the health gains were related to reduction in ischaemic heart disease

(estimated to be between 10 and 19%).

Beware – Low Emission Vehicles

Historically, diesel has been promoted as a more climate friendly fuel than gasoline. Though use of diesel releases 20% less CO_2, diesel engines emit more nitrogen oxides (NO_x) and PM, including back carbon, resulting an increase in health risks (USGCRP, 2018). While electrical vehicles themselves do not emit carbon, if the electricity used is generated from coal or other fossil fuels, it may actually increase the release of GHG and air pollutants on a regional scale (Gouldson et al., 2018; Scovronick et al., 2015). Also, as noted above, gains related to increased fuel efficiency can be lost if vehicle use and distance travelled increase.

While electrical vehicles will reduce the amount of GHGs and air pollutants and noise emitted, it is equally important to reduce the amount of vehicle travel. In addition to particles in the exhaust, vehicles emit particles from the friction between the tires and the road, use of brakes and engine wear. A switch to electrical vehicles would likely result in only about 1-3% reduction in PM2.5 (Gouldson et al., 2018). Also important to consider is that while electric and other low-emission vehicles will reduce GHGs and air pollution, by themselves, they will not provide the added benefit of increased physical activity that compact, mixed-use communities promote (Cohen, 2018).

Community Design And Land Use

The shape of our communities, including its green space, influences how we travel and the amount of physical activity we engage in. This has an impact on both climate emissions and health. As mentioned above, climate interventions that encourage more active travel will provide the most health benefits.

Community Design & Climate

The features of neighbourhood a person lives in influences the amount of GHGs emitted. Studies that have compared low-density development to high-density ones find that more compact communities use less energy, release fewer GHGs, and are less dependent on car for travel. An assessment of the proposed redevelopment of the West Don Lands neighbourhood in Toronto showed that transforming the area into a walkable neighbourhood would reduce GHG emissions from vehicle use by 60% compared to a low-density neighbourhood (TPH and UD4H, 2013).

A study of households' emissions in Toronto and the surrounding area

Sparks Street in Ottawa. Photo by Tony Webster.

found the lowest emissions were 1.31 t CO_2eq per capita for a dense inner-city neighbourhood with good access to public transportation, compared to 13.02 t CO_2eq per capita in an outlying suburban area (Vande-Weghe and Kennedy, 2007). It also found large variations within Toronto itself; census tracts in wealthy neighbourhoods, characterized by high automobile use and older, inefficient homes, had emissions as high as those of the suburbs. This suggests the neighbourhood and home people live in are important factors that influence a household's GHG emissions.

A study by the Urban Land Institute (ULI) showed that more compact development designed for lower reliance on automobiles could reduce vehicle distance travelled by 20-40%; residents of the most walkable neighborhoods drove 26 percent less than those living in more sprawling neighbourhoods (Flatow, undated).

Another study found that in employment areas with 50 to 75 employees per hectare (20-30 per acre) 90 percent of the employees use single-occupancy vehicles as their main source of transportation, while with densities of 300 employees per hectare (125 per acre), 65 percent of employees take public transit or walk to work. A shift from travel in automobiles to walking or transit occurs when residential densities are above 32 people per hectare (13 per acre) (Frank and Pivo, 1994).

A travel survey in the Québec City Region found that residents in the city centre (the highest residential density) had the lowest travel-related emissions. Residents living in the older denser suburbs, newer suburbs, and the least dense periphery produced 19%, 27%, and 70% more emissions respectively. A 10% increase in density was associated with a 1.2% reduction in emissions (Barla et al., 2011 as

Park in Halifax, Nova Scotia.
Photo by Kim Perrotta.

cited in Sallis and Spoon, 2015).

Mixed Land Uses & Climate

A study in the Puget Sound region (Washington State) found that greater residential density, land use mix and intersection density were associated with lower GHG emissions. A doubling of these factors was estimated to reduce transportation emissions by about 31 to 34% (Hong and Goodchild, 2014 as cited in Sallis and Spoon, 2015).

Various studies have compared residents of suburban neighbourhoods to residents of more urban neighbourhoods. These studies indicate that urban residents make twice as many trips walking, mostly for utilitarian travel (Gouldson et al., 2018). Levels of walking and cycling among residents of Toronto's core, which has a higher population density and shorter distances to local shops and services, are over three times higher than among residents of the suburbs (TPH, 2012).

Communities that are more walkable, have cycling infrastructure, and easy access to transit make it easier for people to get around through active modes of transportation (Designed to Move, 2015; TPH et al., 2014). (See CAPE's Active Travel Toolkit for more information and resources on how community design can affect active travel.)

Community Design & Health

In a health impact assessment of six cities, in which land-use density and diversity were increased and distances to public transport decreased, modelling predicted a reduction in diabetes, cardiovascular disease, and respiratory disease. The overall estimated health gains were 420-826 DALYs per 100,000 people. The modelling also showed a small increase in road trauma for cyclists and pedestrians (health loss of between 34 and 41 DALYs per 100,000 population) in moderate to highly motorized cities such as Melbourne, London, and Bos-

Example: City of Freiburg, Germany:

Over the past three decades, interventions in the City of Freiburg (Germany) tripled the number of bicycle trips, doubled public transport ridership, and decreased the share of trips by automobile from 38% to 32%, which has significantly reduced GHG emissions from transportation in the city. This was accomplished through the implementation of a number of transport and land-use policies which have encouraged more walking, cycling and public transport use. An extensive network of bicycle paths and lanes was built, thousands of bicycle parking spots were created, and the city centre became a pedestrian only zone. Transit was expanded and a land-use plan adopted that identified areas around public transport stops as places for higher density development. The city also introduced a transferable flat-rate monthly public transport pass (Buehler and Pucher, 2011).

ton (Gouldson et al., 2018). A review of the literature indicates that the health benefit of dedicated bike lanes ranges between USD$0.33-1.45 per kilometre (Gouldson et al., 2018).

Green Spaces, Climate & Health

Improving urban green spaces not only helps cities adapt to climate change it also contributes to climate mitigation. Urban greenery and tree canopies sequester and store carbon and by their cooling effects reduce energy use (Gouldson et al., 2018). There is increasing evidence of the health benefits of urban and peri-urban green space, including natural areas.

Green spaces such as parks or sports fields facilitate physical activity and relaxation. They can also provide safe routes for walking and cycling, either for travel or recreation, and may reduce child pedestrian injuries. They are associated with neighbourhood social cohesion and reductions in crime and violence. Additional benefits of urban green space include reduced exposure to noise and air pollution, reduced cardiovascular disease, depression, anxiety, and stress. Green spaces may also reduce health disparities as people living in deprived neighbourhoods benefit more from their presence (Gouldson et al., 2018; Scovronick et al., 2015, WHO, 2016).

A study in Toronto found that the health benefit of living in a neighbourhood with 10 more street trees was equivalent to the health benefit of having an extra $10,000 in income per year. People living in the more treed areas had better self-reported health and fewer cardio-metabolic conditions (Kardan et al., 2015). Urban forests within Hal-

ifax, Montreal Vancouver and Toronto provide environmental benefits of over $330 million per year. For example, the value of a tree in Toronto was estimated to be $7.95 per year, of which $1.87 was due to air quality improvements, $0.12 to carbon sequestration and $0.06 for reduction in energy-related pollution (Alexander and DePratto, 2014).

Beware - Community Design Complications

Increasing density may have some negative consequences. These include increased traffic congestion, increased risk of flooding due to reduced capacity to absorb rainfall, less green space and increased noise and air pollution (Gouldson et al., 2018).

Overall the health benefits of cycling more than outweigh the increased exposure to air pollution or the risk of collisions. Providing designated routes away from the roadside and/or ensuring that these shifts are made at large scales sufficient to reduce air pollution levels would reduce these risks. Providing safe walking and cycling infrastructure, such as protected cycle lanes, can also reduce the risk of collisions. Once active travel mode shares are high enough (20%), risks of collision are expected to decrease due to the "safety in number" effect (Gouldson et al., 2018).

The potential adverse impact of mix-use and density on road safety can be reduced by implementing road safety measures and increasing the availability of playgrounds, recreation facilities, parks, and open space. Overall if an integrated approach is taken that reduces traffic volumes and major thoroughfares, increases transit service, and provides safety measures to protect more vulnerable users, than this should result increased travel safety and reduced collisions (Gouldson et al., 2018).

While tree cover can reduce exposures to air pollution, in certain configurations, trees can trap the pollution in the breathing zone of people by reducing wind speeds and ventilation along street canyons (Scovronick et al., 2015). While urban greening may decrease health disparities, it may result in higher housing costs that reduce affordability (Gouldson et al., 2018).

Given the evidence that dense urban neighbourhoods with low carbon footprints are those that include both affordable housing and good access to transit, it is important to address these pressures which help cities reduce emissions while increasing quality of life (Cohen, 2018).

Promoting Climate-friendly Agriculture

To reduce the cost to farmers and consumers, fuels used in farming or fishing in Canada have been exempt from fuel taxes and are also exempt from the carbon tax (Canada, 2018a).

"Some farmers, particularly in the Prairies, are using different techniques that keep carbon in the soil. One witness estimated the value of this trapped or "sequestered" carbon at $1 billion, if carbon dioxide were valued at $15 a tonne" (Canada, 2018b).

If fuel tax exemptions were replaced by incentives for carbon sequestration, this would contribute to climate action in two ways – encouraging a reduction in fuel use and increasing the incentive for farmers to sequester carbon.

Agriculture And Food

In 2014, Canada's agriculture and agri-food sector accounted for 6.7% of Canada's gross domestic product (GDP) and one in eight (12.5%) jobs in Canada, employing 2.3 million people. Half of this sector's GHGs come from livestock, with the rest from crops and on-farm energy and transport (Canada, 2018b).

Climate Change & Food Production

The relationship between climate and food is multi-faceted. On one side, changes in the climate impacts agricultural production, and on the other, the way food is produced, how it is transported, the type of food that is eaten, and the amount that is wasted, contribute to climate change (Ranganathan et al., 2016; TPH, 2017). Globally, agriculture uses about 70% of freshwater, around 40% of land, and contributes up to 30% of greenhouse-gas emissions (Willett et al., 2019). The main GHGs from agricultural production are short-lived climate pollutants – methane and nitrous oxide (Scovronick et al., 2015).

There is a wide range of estimates of the contribution of agriculture and food to global GHG emissions (15-30%). Estimates that include on-farm energy use, land use change, food distribution, processing, retail, preparation and/or waste attribute a larger proportion of total GHGs to the food and agriculture sector (Willett et al., 2019; Swinburn et al., 2019).

Food & Climate

Emissions from agriculture (livestock and crop production) and forestry accounted for about 10% of Canada's GHG emissions in 2014. These are projected to remain relatively constant until 2030 (Canada, 2016). The EAT-Lancet Commission and the World Resources Institute

both indicate that achieving healthy diets for everyone requires a shift to healthy diets, with large reductions in food losses and waste, preservation of ecosystems and improvements in food production practices (Searchinger et al., 2018; Willet et al., 2019).

The World Resources Institute estimates that the average American diet causes emissions of nearly 17 t CO_2eq per year – similar to the per capita emissions from energy use in the United States. While beef provide just 3% of calories, the production of beef uses about half of land-use and releases about half of the GHG emissions related to diets. Simply moving from eating beef, veal, or lamb to chicken or pork would greatly reduce GHG emissions (Searchinger et al., 2018). **(See Figure 2)**

Increasing the consumption of plant-derived foods while reducing meat, as appropriate, is an affordable approach to improving nutrition (TPH, 2017). The EAT-Lancet Commission identified a healthy diet as one that is rich in fruits, vegetables, and plant proteins with some animal proteins. Such a diet would mean more than a 50% global re-

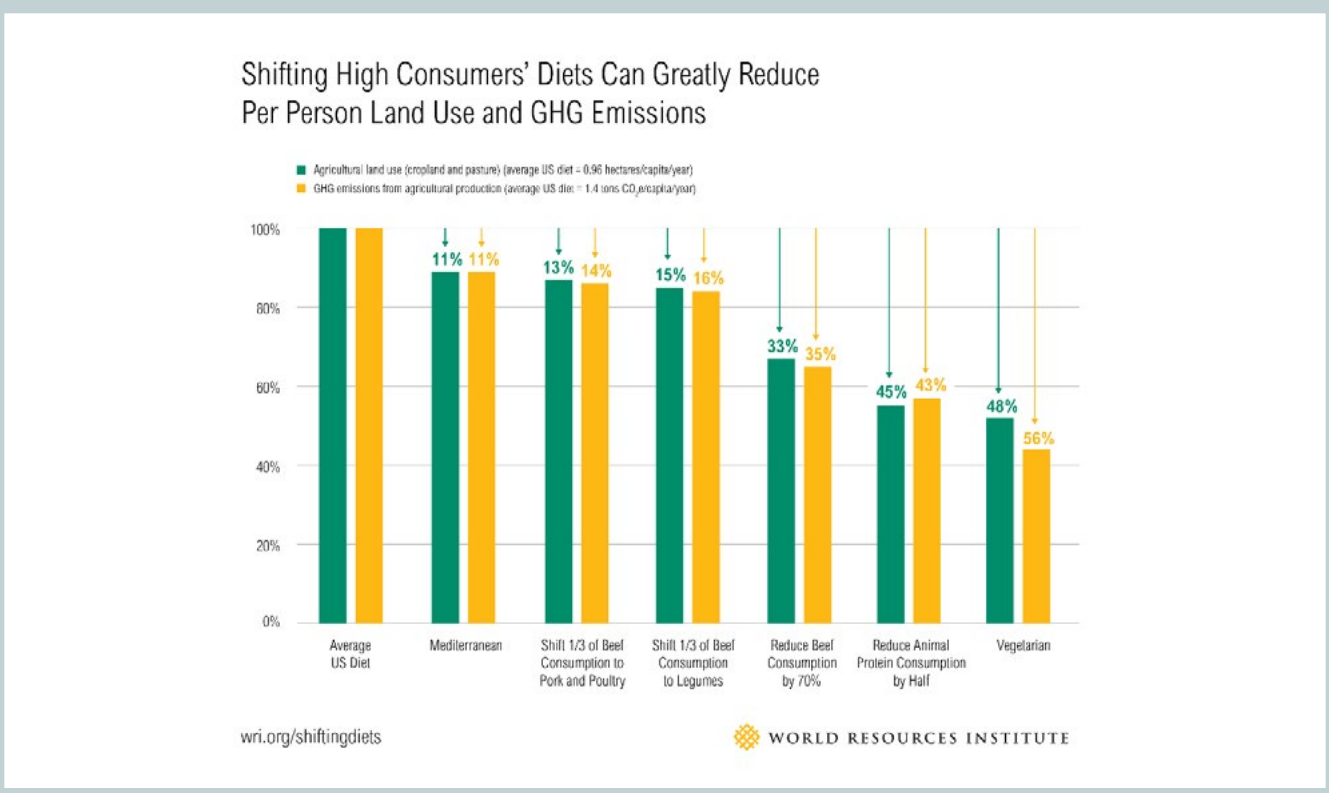

Figure 2: Impact of different diets on land use and carbon emissions Source: https://www.wri.org/blog/2016/04/sustainable-diets-what-you-need-know-12-charts

duction in consumption of unhealthy foods, such as red meat and sugar, and a 100% increase in consumption of healthier alternatives, including fruits, nuts, vegetables, and legumes (Willet et al., 2019).

Food & Health

Canadians eat more meat and fewer vegetables and fruits than is recommended for health. Lowering meat intake and increasing intake of foods of plant origin would be beneficial for the health of many people in Canada. Foods of plant origin are health protective in many ways and plant proteins, including pulses, legumes, nuts, and seeds, are good sources of magnesium, fibre, and unsaturated fats (TPH, 2017).

Child holding blueberry. Photo by Markus Spiske on Unsplash.

An assessment of diets in different regions of the world found that moving towards diets rich in plant-derived foods could reduce global mortality by 6 to 10% and food-related GHG emissions by 29 to 70% by 2050 (Springmann et al, 2016; Willet et al., 2019).

Milner and colleagues (2015) concluded that if the average UK dietary intake were optimised to comply with the WHO recommendations, it would reduce GHG emissions by 17%, and save almost 7 million years of life lost prematurely in the UK over the next 30 years and increase average life expectancy by over eight months. Greater reductions in GHGs with additional benefits to health would also be possible with a more substantial change in diets. However, diets that would reduce GHG emission reductions by more than 40% could compromise health by reducing the variety of foods eaten and limiting intake of healthy foods such as fruits and nuts. Aleksandrowicz and colleagues (2016) reviewed the available evidence and concluded that a higher reduction in GHGs is possible - as high as 70-80%.

Food Waste & Climate

Food loss and food waste occur at the production, handling and storage, processing, distribution and marketing and consumption stage. This loss and waste contribute to emissions of GHG – from the use of fossil fuels during the production and handling of food to the creation of

methane when waste food is disposed in landfills, the most common form of waste disposal in Canada (Boston et al., 2017). In Canada, landfill disposal contributes about 4% of GHGs, most of which is due to food waste.

In Canada, one third of food produced for human consumption is wasted: consumers account for 47% of this waste. The other 53% of wasted food is generated along the value chain when food is produced, processed, transported, sold, and prepared and served in commercial and institutional settings. About 60% of the food that is thrown out could have been eaten and considered avoidable food waste. Avoidable food waste can increase the cost of food by 10% or more (Boston et al., 2017; Gooch and Felfel, 2014).

Supportive Policies

Carbon Pricing Encourages Transformation

There is broad agreement that putting a price on carbon is essential if we are to transition to a low-carbon economy.

"Carbon pricing helps level the playing field between activities that impose climate change damages and low- or zero-emissions activities that do not. [Emphasis added] Carbon prices can gradually lead to structural transformations by enhancing the competitiveness of low-carbon firms and increasing the costs of emissions-intensive activities. Ensuring that carbon pricing schemes are fair requires policies and tem-

Approaches to Carbon Pricing

There are essentially two approaches to carbon pricing – a carbon tax and emissions trading (also known as cap and trade). They can be used independently or in combination.

- *A carbon tax sets a price on carbon emissions but does not set a target for the quantity of GHG emissions allowed. While they are no assurances that emissions will reduce, it provides more certainty on the price of carbon which helps businesses and others plan their investments accordingly. It is relatively easy to administer.*
- *An emission trading system (ETS) sets the maximum release of GHG that is allowed but does not set a price, which is set by the market. While it provides more certainty on the reductions to be achieved, the cost can fluctuate very widely. It is more difficult to administer and usually limited to certain industrial sectors of the economy.*

Regulations that set performance standards or limits on GHG emissions indirectly increase the price on carbon (Kossoy et al., 2015; OECD and World Bank, 2015).

porary protection measures that support a smooth transition for affected people" (OECD and World Bank, 2015: p.4).

The Canadian government has set a carbon price of $10 per t CO2eq in 2018 that will increase to $50 in 2022 (Canada, 2018a). While progress is being made globally, the carbon price in most jurisdictions, including Canada, are substantially lower than those needed to be consistent with the goal of the Paris Agreement. Various factors, including the make up of a national economy and the cost of alternative energy, influence the rate needed for a carbon tax to be effective in reaching the desired reduction in GHG emissions. Higher carbon prices will be needed to meet the 1.5°C global warming target. According to the High-Level Commission on Carbon Prices (2017), to meet the goals of the Paris Agreement, prices would need to be in the range of US$40-80 per t CO_2eq by 2020, rising to US$50-100 per t CO_2eq by 2030, as long as they were accompanied by other supportive policies (World Bank and Ecofys, 2018).[4]

Carbon Pricing, Economy & Equity

A common perception is that carbon pricing, either through a carbon tax or emissions trading scheme, will have a negative impact on the economy. Early evidence from California, British Columbia, and Québec suggests that the adoption of carbon pricing does not impede industrial growth, nor result in a shift of production to other jurisdictions (Carbon Pricing Leadership Coalition, 2016). In British Columbia the tax resulted in 5-15% reduction in GHG with no negative impact on the economic growth (Narassimhan et al., 2017). Sweden, which introduced a carbon tax in 1991 that is now approximately US$125 per tonne, has seen its GDP increase by 78% while GHG emissions decreased by 26% since that time (Sweden, 2019).

Concerns about equity impacts can be a barrier to the adoption of carbon pricing. However, negative effects can be mitigated through effective policy design and revenue redistribution. For example, British Columbia provides a tax credit for low-income households. A review found that, on average, the Low-Income Climate Action tax credit received was more

Taking into account uncollected tax on externalized costs such as air pollution, carbon emissions, transport fuels, and traffic congestion, the International Monetary Fund (IMF) estimated that Canada's fossil fuel subsidies were effectively $26 billion in 2011, $34 billion in 2013 and $46.4 billion in 2015 (Climate Scorecard, 2018; Touchette, 2015).

than the amount paid in the carbon tax by low-income households, making them better off overall (Kossoy et al., 2015; OECD and World Bank, 2015).

Fossil Fuels Subsidies

A price on carbon will encourage reduction in the use of fossil fuels and act as an incentive to invest and deploy lower-emitting sources of energy, including renewable energy. In contrast, fossil fuel subsidies and other incentives that encourage fossil fuel use, slow the transition to a low-carbon economy. Misaligned or counter-productive policies undermine the intent of carbon pricing and need to be scaled back. This will then provide a consistent signal to consumers, producers and investors (Funkhouser, 2018; World Bank and OECD, 2015).

While subsidies to the fossil fuel industry are declining, they continue to be substantial and larger than subsidies to renewable energy (Shirai and Adam, 2017). Between 2013-2015 Canada paid an average of $3.314 billion per year to the oil and gas industry in various forms of incentives or subsidies associated with production, field development, extraction, and exploration (Climate Scorecard, 2018).

Policies Harmful to Climate & Health

Current regulations as well as economic and financial policies continue to privilege carbon-intensive activities, rather than promoting sustainable development. Policies that reduce the cost of energy, especially fossil fuels, increase energy demand and associated GHG emissions. Other examples of climate-harmful subsidies include incentives for gas and diesel vehicle production, parking provisions, and agricultural support for animal husbandry (NCE, 2018; OECD and World Bank, 2015).

Over the last 70 years, urban planning,

The majority of emission reductions need to come from individuals and countries that have the highest emissions.

The World Bank (2019) estimates that in 2014 global GHG emissions were 4.97 tCO_2eq per person, while in Canada 15.12 tCO_2eq per person.

Oxfam (2105) estimated that the richest 10% of people were responsible for 49% of global emissions, while the poorest 50% released only about 10% of GHGs.

Just Transition Task Force

In 2018, the Canadian government created a Task Force on the Just Transition for Canadian Coal-Power Workers and Communities. A "just transition" aims to minimize the impact on workers and communities in the transition to a low-carbon economy. It involves workers and their communities to enable them to succeed and benefit from the transition (ECCC, 2018b).

transport and fiscal policies have all contributed to communities that make people reliant on automobiles for transportation. Fiscal policies, such as development charges, low fuel excise tax, and assistance to automotive and oil and gas industries, have encouraged automobile and fossil fuel use, as well as the creation of low-density communities (Blais, 2011; Gouldson et al., 2018; Lowe, 2014; Sewell, 2009).

Coady and colleagues (2017) estimated that on a global level, subsidies (including the cost of externalities) were 6.5% of global GDP at $4.9 trillion in 2013 and $5.3 trillion in 2015. Of these, 22% were societal costs of climate change and 46% were the costs of air pollution. Had such subsidies not been in place, global GHG emissions in 2013 could have been 21% lower and deaths from air pollution related to the use of fossil fuel 55% lower. At the same time, government revenues and social welfare would have increased by 4% and 2.2% of global GDP, respectively.

Ensuring a Just Transition: Fairness & Climate Reductions

To address fairness, it is important to know who is responsible for the GHG emisisons: Is it the producer or the consumer of the product or service? It could be argued that the consumer should bear this responsibility. However, producers also benefit from income or revenues related to their activities.

In addition, people or organisations have more control over emissions they control directly compared to indirect emissions such as those released during the production and distribution of a good or service. This suggests a joint-responsibility between producers and consumers. It is important that people and organizations who benefit from the production and consumption of goods and services that release GHGs each take their full share of the responsibility.

GHG Emissions Per Person

GHG emissions can be estimated based on production or consumption. The IPCC

Wind turbine by the ocean. Photo by Anna Jiménez Calaf on Unsplash.

compiles information on emissions from production which is useful to estimate the total amount of GHGs released into the atmosphere. From a production perspective, GHG emissions emitted per person (i.e. per capita) in Canada vary widely. Canada's average per capita GHG emissions was 20 t CO_2eq in 2016. Quebec had the lowest per capita emissions at 9.5 t CO_2eq while Saskatchewan had the highest at 69.5 t CO_2eq. The high per-capita emissions of Alberta and Saskatchewan reflect the GHG emissions from the oil and gas sector in those provinces; for products which are mostly exported. So, the per-capita GHG emissions in these provinces reflect the heavy emissions from industries in these provinces rather than from individual households.

A different measure is the carbon footprint which estimates releases of GHGs due to consumption. It takes into account both the emissions produced directly (for example fuel used) and those that were released during the production of the goods or services consumed (the emissions used during the extraction, refining, and distribution of the fuel) (Hoornweg et al., 2011). There is a strong association between income and carbon footprint: people and societies that have higher incomes have larger footprints (Simas et al., 2017; Wiedmann et al., 2015). Growing income inequality that is occurring increases this inequity (Kenner, 2016).

Transition to Low-Carbon Economy

The phase-out of fossil fuels will have major impacts on people and families involved in the fossil fuel industry, as well as communities where industry facilities are located. By using some of the revenues from carbon pricing and savings from the elimination of subsidies, we can ease the transition for workers and foster economic diversification to trans-

form the economies in their communities.

An Energy Transition Plan can provide a framework for strategic assistance, retraining and targeted social protection that will be needed. Involvement of energy companies, workers, and civil society in this process will also facilitate the transition (Gerasimchuk et al., 2018; NCE, 2018).

Potential for New Opportunities

The transition to a low-carbon economy, if managed well, offers the potential for new opportunities; it can support economic diversification, the creation of decent jobs, and more equitable growth. For example, in Australia's Port Augusta, workers were able to get an agreement to replace a dying coal-fired power station with a solar thermal plant. This allowed local energy workers to transfer their skills to the new technology and the community to remain an energy hub (NCE, 2018). As the Lancet Commission on health and climate change noted in its report: "Achieving a decarbonised global economy and securing the public health benefits it offers is no longer primarily a technical or economic question – it is now a political one" (Watts et al, 2015: p.1862).

References

- Active Living Research. Promoting Active Living in Rural Communities: Research Brief. (2015). Active Living Research, University of California, San Diego.
- Aleksandrowicz, Lukasz, Rosemary Green, Edward J. M. Joy, Pete Smith, and Andy Haines. The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. PLoS ONE 11.11 (2016): e0165797. DOI:10.1371/journal.pone.0165797.
- Alexander, Craig and Brian DePratto The Value of Urban Forests in Cities Across Canada. (2014). TD Economics. https://www.td.com/document/PDF/economics/special/UrbanForestsInCanadianCities.pdf.
- Armstrong, Ben, Oliver Bonnington, Zaid Chalabi, Michael Davies, Yvonne Doyle, James Goodwin, Judith Green, Shakoor Hajat, Ian Hamilton, Emma Hutchinson, Anna Mavrogianni, James Milner, Ai Milojevic, Roberto Picetti, Nirandeep Rehill, Christophe Sarran, Clive Shrubsole, Phil Symonds, Jonathon Taylor and Paul Wilkinson. The impact of home energy efficiency interventions and winter fuel payments on winter- and cold-related mortality and morbidity in England: a natural equipment mixed-methods study. Public Health Research 6.11 (2018). DOI: 10.3310/phr06110.
- Armstrong, Fiona. Our Uncashed Dividend The health benefits of climate action A briefing paper prepared by the Climate and Health Alliance and The Climate Institute (2012).
- Barla, P, LF Miranda-Moreno, and M Lee-Gosselin. Urban Travel CO2 Emissions and Land Use: A Case Study for Quebec City. Transportation Research Part D: Transport and Environment 16.6 (2011): 423-428. As cited in Sallis and Spoon 2015, op cit.
- Blais, Pamela. Perverse Cities: Hidden Subsidies, Wonky Policy, and Urban Sprawl. (2011). UBC Press, Vancouver.
- Buehler, Ralph, and John Pucher. Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital. International Journal of Sustainable Transportation 5 (2011): 43–70.
- Boston, Alex, Belinda Li and Tamara Shulman. Food Waste Management + Climate Action: National GHG Reduction Potential. (2017). Prepared for the National Zero Waste Council.
- Brauer, Michael, Conor Reynolds, and Perry Hystad. Traffic-related air pollution and health in Canada. CMAJ 185.18 (10 December 2013): 1557-8. DOI:10.1503/cmaj.121568.
- Canada Standing Senate Committee on Agriculture and Forestry. Feast or Famine: Impacts of climate change and carbon pricing on agriculture, agri-food and forestry. (2018b). The Senate, Ottawa.
- Canada. Greenhouse Gas Pollution Pricing Act S.C. 2018, c. 12, s. 186. (2018a). https://laws-lois.justice.gc.ca/eng/acts/G-11.55/FullText.html (Accessed 2019.01.30)
- Canada. Pan-Canadian Framework on Clean Growth and Climate Change – Canada's Plan to Address Climate Change and Grow the Economy. (2016). Government of Canada. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html
- Canadian Association of Physicians for the Environment (CAPE). Comments on AER DRAFT Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting and Directive 017: Measurement Requirements for Oil and Gas Operations. (2018) Comments to the Alberta Energy Regulator, May 27.

- Carbon Pricing Leadership Coalition. What is the Impact of Carbon Pricing on Competitiveness? Executive Briefing. (June 2016). World Bank Group, Washington D.C. http://pubdocs.worldbank.org/en/759561467228928508/CPLC-Competitiveness-print2.pdf
- Castro-Alvarez, Fernando, Shruti Vaidyanathan, Hannah Bastian, and Jen King. The 2018 International Energy Efficiency Scorecard. (2018). American Council for an Energy-Efficient Economy, Washington, D.C.
- Chung, Emily. 2016. Alberta's oilsands industry is a huge source of harmful air pollution, study says. CBC News (25 May). https://www.cbc.ca/news/technology/oilsands-soas-1.3599074 (Accessed 2019-02-10).
- Climate Scorecard. Canada Subsidies. (2018). https://www.climatescorecard.org/2018/01/canada-subsidies/ (Accessed 2019.01.30).
- Coady, David, Ian Parry, Louis Sears, and Baoping Shang. How Large Are Global Fossil Fuel Subsidies? World Development 91 (March 2017): 11-27. (Abstract)
- Cohen, Daniel Aldana. Climate Justice and the Right to the City. (2018). Penn Institute for Urban Research, Philadelphia. https://penniur.upenn.edu/uploads/media/Cohen.pdf
- Daniel, Kristie and Kim Perrotta. Prescribing Active Travel for Healthy People and a Healthy Planet: A Toolkit for Health Professionals. (2017). Canadian Association of Physicians for the Environment (CAPE).
- Day, Thomas, Sofia Gonzales-Zuñiga, Leonardo Nascimento, Niklas Höhne, Hanna Fekete, Sebastian Sterl, Frederic Hans, Antoine Warembourg, Anda Anica, andPieter van Breevoort. Climate Opportunity: More Jobs; Better Health; Liveable Cities – Quantifying the Benefits of Climate Change Mitigation Measures in Buildings, Transport and Energy Supply. (2018). NewClimate Institute, Berlin and Cologne.
- Designed to Move. Designed to Move: Active Cities – A guide for city leaders. 2015. Nike, Beaverton, Oregon.
- Environment and Climate Change Canada (ECCC). Canada's coal power phase-out reaches another milestone. (2018a). https://www.canada.ca/en/environment-climate-change/news/2018/12/canadas-coal-power-phase-out-reaches-another-milestone.html (Accessed 2019-02-24).
- Environment and Climate Change Canada (ECCC). Just transition task force. (2018b). https://www.canada.ca/en/environment-climate-change/news/2018/02/just_transition_taskforce.html (Accessed 2019-02-24).
- Environment and Climate Change Canada (ECCC). National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada Canada's Submission to the United Nations Framework Convention On Climate Change 2018. (2018c). ECCC. https://unfccc.int/documents/65715.
- Flatow, Dana. Density, Carbon Emissions, Transportation and Energy Efficiency. UTSoA - Seminar in Sustainable Architecture. University of Texas, Austin.
- Frank L. D. and G. Pivo. Impacts of Mixed use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking. Transportation Research Record 1466 (1994): 44-52.
- Friel, Sharon, Alan D Dangour, Tara Garnett, Karen Lock, Zaid Chalabi, Ian Roberts, Ainslie Butler, Colin D Butler, Jeff Waage, Anthony J McMichael, and Andy Haines. Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. Lancet 374 (2009): 2016–25.
- Funkhouser, David. How Much Do Renewables Actually Depend on Tax Breaks? (March 16, 2018) https://blogs.ei.columbia.edu/2018/03/16/how-much-do-renewables-actually-depend-on-tax-breaks/ (Accessed 2019-01-30).
- Gerasimchuk, Ivetta, Laura Merrill, Richard Bridle, Phil Gass, Lourdes Sanchez, Lucy Kitson, and Peter Wooders. Fossil Fuel Phase-Out and a Just Transition: Learning from stories of coal phase-outs. (2018). International Institute for Sustainable Development, Winnipeg.
- Glauser, Wendy. New legitimacy to concerns about fracking and health. CMAJ 186.8 (2014): E245-246.
- Gooch, Martin V. and Abdel Felfel. "$27 Billion" Revisited: The Cost of Canada's Annual Food Waste. (2014). Value Chain Management International, Oakville, Ontario.
- Gouldson, Andy, Andrew Sudmant, Haneen Khreis, and Effie Papargyropoulou. The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence. (2018). Coalition for Urban Transitions, London and Washington, DC. http://newclimateeconomy.net/content/cities-working-papers
- Haines, Andy and Kristie Ebi. The Imperative for Climate Action to Protect Health. New England Journal of Medicine 380.3 (2019): 263-73.
- Hamilton, Ian, James Milner, Zaid Chalabi, Payel Das, Benjamin Jones, Clive Shrubsole, Mike Davies, and Paul Wilkinson. Health effects of home energy efficiency interventions in England: a modelling study. BMJ Open 5 (2015): e007298. DOI:10.1136/bmjopen-2014-007298.
- Health Canada. Canada's Dietary Guidelines for Health Professionals and Policy Makers. (2019). Health Canada, Ottawa.
- Health Canada. Health Impacts of Air Pollution in Canada: An estimate of premature mortalities. (2017). Health Canada, Ottawa.
- Higgins, Paul AT and Millicent Higgins. A healthy reduction in oil consumption and carbon emissions. Energy Policy 33 (2005): 1-4 as cited in Lowe (2014) op. cit.
- High-Level Commission on Carbon Prices. Report of the High-Level Commission on Carbon Prices. (2017). World Bank, Washington, D.C.
- Höhne, Niklas, Thomas Day, Gesine Hänsel, and Hanna Fekete. Assessing the missed benefits of countries' national contributions: Results and methodology to quantify the possible co-benefits from ambitious greenhouse gas reductions of countries. (2015). NewClimate Institute for Climate Policy and Global Sustainability, Berlin and Cologne.
- Hong, J and A Goodchild. Land Use Policies and Transport Emissions: Modeling the Impact of Trip

Speed, Vehicle Characteristics and Residential Location. Transportation Research Part D: Transport and Environment 26 (2014): 47-51. As cited in Sallis and Spoon, 2015, op cit.
- Hoornweg, Daniel, Lorraine Sugar, and Claudia Lorena Trejos Gómez. Cities and greenhouse gas emissions: moving forward. Environment & Urbanization 23.1 (2011): 207–227.
- Howard, Courtney, Caren Rose, and Nicholas Rivers. Lancet Countdown 2018 Report: Briefing for Canadian Policymakers. (2018). The Lancet Countdown. http://www.lancetcountdown.org/media/1418/2018-lancet-countdown-policy-brief-canada.pdf
- International Energy Agency (IEA). Energy and Climate Change: World Energy Outlook Special Report. (2015). IEA, Paris.
- International Energy Agency (IEA). Energy Efficiency Potential in Canada to 2050. (2018). IEA, Paris.
- International Panel on Climate Change (IPCC). Global warming of 1.5C: An IPCC special report on the impacts of global warming of 1.5C: Summary for policy makers. (2019). IPCC, Geneva. www.ipcc.ch.
- Israël, Benjamin, and Erin Flanagan. Out with the Coal, in with the New: National benefits of an accelerated phase-out of coal-fired power. (2016). Pembina Institute, Calgary.
- Jacobson, Mark Z, Mark A Delucchi, Zack AF ..., and Alexander S Yachanin. 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. Joule 1.1 (2017): 108-121.
- Kardan, Omid, Peter Gozdyra, Bratislav Misic, Faisal Moola, Lyle J. Palmer, Tomáš Paus and Marc G. Berman. Neighborhood greenspace and health in a large urban center. Scientific Reports 5 (2015):11610. DOI: 10.1038/srep11610.
- Kenner, Dario. Reducing inequality and carbon footprints within countries. (2016) Global Sustainability Institute, Anglia Ruskin University, Cambridge.
- Kossoy, Alexandre, Grzegorz Peszko, Klaus Oppermann, Nicolai Prytz, Noémie Klein, Kornelis Blok, Long Lam, Lindee Wong, and Bram Borkent. State and Trends of Carbon Pricing 2015. (2015). World Bank, Washington, DC. DOI: 10.1596/ 978-1-4648-0725-1.
- Liggio, John, Shao-Meng Li, Katherine Hayden, Youssef M. Taha, Craig Stroud, Andrea Darlington, Brian D. Drollette, Mark Gordon, Patrick Lee, Peter Liu, Amy Leithead, Samar G. Moussa, Danny Wang, Jason O'Brien, Richard L. Mittermeier, Jeffrey R. Brook, Gang Lu, Ralf M. Staebler, Yuemei Han, Travis W. Tokarek, Hans D. Osthoff, Paul A. Makar, Junhua Zhang, Desiree L. Plata, and Drew R. Gentner. Oil sands operations as a large source of secondary organic aerosols. Nature 534 (2016): 91–94.
- Lowe, Melanie. Obesity and climate change mitigation in Australia: overview and analysis of policies with co-benefits Australian and New Zealand Journal of Public Health 38.1 (2014): 19-24.
- MacNaughton, P, X Cao, J Buonocore, J Cedeno-Laurent, J Spengler, A Bernstein, and J Allen. Energy savings, emission reductions, and health co-benefits of the green building movement. Journal of Exposure Science & Environmental Epidemiology 28.4 (2018): 307–318. https://doi.org/10.1038/s41370-017-0014-9.
- Magill, Bobby. Methane Emissions May Swell from behind Dams. Scientific American. (29 October 2014). https://www.scientificamerican.com/article/methane-emissions-may-swell-from-behind-dams/ (Accessed 2019-02-09).
- Maibach, Edward W, Matthew Nisbet, Paula Baldwin, Karen Akerlof and Guoqing Diao. Reframing climate change as a public health issue: an exploratory study of public reactions. BMC Public Health 10 (2010): 299-309.
- Markandya, Anil, Jon Sampedro, Steven J Smith, Rita Van Dingenen, Cristina Pizarro-Irizar, Iñaki Arto, and Mikel González-Eguino. Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study. Lancet Planetary Health 2 (2018): e126–33.
- Milner, James, Rosemary Green, Alan D Dangour, Andy Haines, Zaid Chalabi, Joseph Spadaro, Anil Markandya, and Paul Wilkinson. Health effects of adopting low greenhouse gas emission diets in the UK. BMJ Open 5 (2015): e007364. DOI:10.1136/bmjopen-2014-007364.
- Minneapolis. Welcome to Minneapolis 2040: The City's Comprehensive Plan. (2019). https://minneapolis2040.com/ (Accessed 2019.01.30).
- Mowatt, David, Charles Gardner, David McKeown, Ninh Tran, Brent Moloughney, and Gayle Bursey. Improving Health by Design in the Greater Toronto-Hamilton Area: A Report of Medical Officers of Health in the GTHA. (2014). Peel Health, Mississauga, Ontario.
- Narassimhan, Easwaran, Kelly S. Gallagher, Stefan Koester, and Julio Rivera Alejo. Carbon Pricing in Practice: A Review of the Evidence. (2017). Climate Policy Lab, Medford, Massachusetts.
- New Climate Economy (NCE). Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times. (2018). Global Commission on the Economy and Climate, c/o World Resources Institute, Washington, D.C.
- Organisation for Economic Cooperation and Development (OECD) and World Bank (WB). The FASTER Principles for Successful Carbon Pricing: An approach based on initial experience. (2015). OECD, Paris and WB, Washington, D.C.
- Oxfam. Extreme Carbon Inequality: Why the Paris climate deal must put the poorest, lowest emitting and most vulnerable people first. (2015). Oxafam, Nairobi.
- Public Health Agency of Canada (PHAC) and the Canadian Institute for Health Information (CIHI). Obesity in Canada. (2011). PHAC and CIHI, Ottawa.
- Ranganathan, Janet, Daniel Vennard, Richard Waite, Patrice Dumas, Brian Lipinski, Tim Searchinger, and GLOBAGRI-WRR. Shifting Diets for a Sustainable Food Future. 2016. World Resource Institute, Washington, D.C.
- Robins, Allison. Doing More with Less: Energy Efficiency Potential in Canada. (2017). The Conference Board of Canada, Ottawa.

- Rodier, Caroline J, Richard Lee, Brandon Haydu, and Nicholas J. Linesch. Active Travel Co-Benefits of Travel Demand Management Policies that Reduce Greenhouse Gas Emissions. (2014). Mineta Transportation Institute, San José, California.
- Sallis, James F, and Chad Spoon. Making the Case for Designing Active Cities. (2015). Active Living Research, University of California, San Diego.
- Scovronick, Noah, Heather Adair-Rohani, Alexander Balakanov, Nathan Borgford-Parnell, Michael Brauer, Diarmid Campbell-Lendrum, Andy Haines, Michal Krzyzanowski, Jonathan Patz, Annette Prüss-Ustün, Veerabhadran Ramanathan, Federico San Martini, Drew Shindell, and Oksana Tarasova. Reducing Global Health Risks Through mitigation of short-lived climate pollutants – Scoping report for policymakers. (2015). World Health Organization, Geneva.
- Searchinger, Tim, Richard Waite, Craig Hanson, Janet Ranganathan, and Patrice Dumas. Creating a Sustainable Food Future: Synthesis Report. (2018). World Resources Institute, Washington, D.C.
- Sewell, John. Shape of the Suburbs: Understanding Toronto's Sprawl. (2009). University of Toronto Press, Toronto.
- Shirai, Toshiyuki and Zakia Adam. Commentary: Fossil-fuel consumption subsidies are down, but not out. (20 December 2017). https://www.iea.org/newsroom/news/2017/december/commentary-fossil-fuel-consumption-subsidies-are-down-but-not-out.html (Accessed 2019-02-07).
- Shonkoff SB, Hays J, Finkel ML. Environmental public health dimensions of shale and tight gas development. Environmental Health Perspectives 122 (2014): 787–795. http://dx.doi.org/10.1289/ehp.1307866.
- Simas, Moana, Stefan Pauliuk, Richard Wood, Edgar G. Hertwich, and Konstantin Stadler. Correlation between production and consumption-based environmental indicators: The link to affluence and the effect on ranking environmental performance of countries. Ecological Indicators 76 (2017): 317–323.
- Sisson, Patrick. Can Minneapolis's radical rezoning be a national model? Curbed (27 November 2018). https://www.curbed.com/2018/11/27/18113208/minneapolis-real-estate-rent-development-2040-zoning (Accessed 2019-01-30).
- Smith, K.R., A. Woodward, D. Campbell-Lendrum, D.D. Chadee, Y. Honda, Q. Liu, J.M. Olwoch, B. Revich, and R. Sauerborn. Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Field, C.B., et al editors. (2014). Cambridge University Press: 709-754.
- Springmann, Marco, H. Charles, J. Godfraya, Mike Raynera, and Peter Scarborough. Analysis and valuation of the health and climate change co-benefits of dietary change. PNAS 12, 113.15 (2016): 4146-4151. www.pnas.org/cgi/doi/10.1073/pnas.1523119113.
- Sweden. Sweden's carbon tax. (2019). https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/ (Accessed 2019.01.30).
- Swinburn, Boyd A, Vivica I Kraak, Steven Allender, Vincent J Atkins, Phillip I Baker, Jessica R Bogard, Hannah Brinsden, Alejandro Calvillo, Olivier De Schutter, Raji Devarajan, Majid Ezzati, Sharon Friel, Shifalika Goenka, Ross A Hammond, Gerard Hastings, Corinna Hawkes, Mario Herrero, Peter S Hovmand, Mark Howden, Lindsay M Jaacks, Ariadne B Kapetanaki, Matt Kasman, Harriet V Kuhnlein, Shiriki K Kumanyika, Bagher Larijani, Tim Lobstein, Michael W Long, Victor K R Matsudo, Susanna D H Mills, Gareth Morgan, Alexandra Morshed, Patricia M Nece, An Pan, David W Patterson, Gary Sacks, Meera Shekar, Geoff L Simmons, Warren Smit, Ali Tootee, Stefanie Vandevijvere, Wilma E Waterlander, Luke Wolfenden, and William H Dietz. The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. (2019). Lancet. Published Online January 27, 2019 http://dx.doi.org/10.1016/S0140-6736(18)32822-8
- Tam, Theresa. The Chief Public Health Officer's Report on the State of Public Health in Canada, 2017: Designing Healthy Living. (2017). Public Health Agency of Canada, Ottawa and Winnipeg.
- Thompson, Tammy M., Sebastian Rausch, Rebecca K. Saari and Noelle E. Selin. A systems approach to evaluating the air quality co-benefits of US carbon policies. Nature Climate Change 4 (October 2014): 917-923.
- Thomson, H; S Thomas, E Sellstrom, and M Petticrew. Housing improvements for health and associated socio-economic outcomes. The Cochrane database of systematic reviews 2.2 (2013). DOI: 10.1002/14651858.CD008657.pub2.
- Toronto. Avoiding the TRAP: Traffic-Related Air Pollution in Toronto and Options for Reducing Exposure. Technical Report. (2017). City of Toronto. https://www.toronto.ca/legdocs/mmis/2017/hl/bgrd/backgroundfile-108070.pdf
- Toronto Public Health (TPH) and Urban Design for Health (UD4H). A Health and Environment-Enhanced Land Use Planning Tool: Highlights. (2013). City of Toronto.
- Toronto Public Health (TPH), City of Toronto Planning, City of Toronto Transportation Services and Gladki Planning Associates. Active City: Designing for Health. (2014). City of Toronto.
- Toronto Public Health (TPH). Diets for a Cool Planet: Healthy, Sustainable Diets for Toronto. (2017). City of Toronto.
- Toronto Public Health (TPH). Path to Healthier Air: Toronto Air Pollution Burden of Illness Update. Technical Report. (2014). City of Toronto.
- Toronto Public Health (TPH). Road to Health: Improving Walking and Cycling in Toronto. (2012). City of Toronto.
- Touchette, Yanick. G20 subsidies to oil, gas and coal production: Canada. 2015. Overseas Development Institute, London.
- U.S. Global Change Research Program (USGCRP). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II edited by Reidmiller, DR, CW Avery, DR Easterling, KE Kunkel, KLM Lewis,

TK Maycock, and BC Stewart. (2018). USGCRP, Washington, DC, DOI: 10.7930/NCA4.2018.
- UITP. Mobility in Cities Database Synthesis Report. (June 2015). International Association of Public Transport, Brussels.
- VandeWeghe, Jared R and Christopher Kennedy. A spatial analysis of residential greenhouse gas emissions in the Toronto census metropolitan area. Journal of Industrial Ecology 11.2 (2007): 133–144.
- Vardoulakis, Sotiris, Chrysanthi Dimitroulopoulou, John Thornes, Ka-Man Lai, Jonathon Taylor, Isabella Myers, Clare Heaviside, Anna Mavrogianni, Clive Shrubsole, Zaid Chalabi, Michael Davies, and Paul Wilkinson. Impact of climate change on the domestic indoor environment and associated health risks in the UK. Environment International 85 (2015): 299–313.
- Watts, Nick, W Neil Adger, Paolo Agnolucci, Jason Blackstock, Peter Byass, Wenjia Cai, Sarah Chaytor, Tim Colbourn, Mat Collins, Adam Cooper, Peter M Cox, Joanna Depledge, Paul Drummond, Paul Ekins, Victor Galaz, Delia Grace, Hilary Graham, Michael Grubb, Andy Haines, Ian Hamilton, Alasdair Hunter, Xujia Jiang, Moxuan Li, Ilan Kelman, Lu Liang, Melissa Lott, Robert Lowe, Yong Luo, Georgina Mace, Mark Maslin, Maria Nilsson, Tadj Oreszczyn, Steve Pye, Tara Quinn, My Svensdotter, Sergey Venevsky, Koko Warner, Bing Xu, Jun Yang, Yongyuan Yin, Chaoqing Yu, Qiang Zhang, Peng Gong, Hugh Montgomery, and Anthony Costello. Health and climate change: policy responses to protect public health. Lancet 386 (2015): 1861–914.
- Wiedmann, Thomas O, Heinz Schandl, Manfred Lenzen, Daniel Moran, Sangwon Suh, James West, and Keiichiro Kanemoto. The material footprint of nations. PNAS 112.20 (2015): 6271-6276.
- Wilkinson, Paul, Kirk R Smith, Michael Davies, Heather Adair, Ben G Armstrong, Mark Barrett, Nigel Bruce, Andy Haines, Ian Hamilton, Tadj Oreszczyn, Ian Ridley, Cathryn Tonne, and Zaid Chalabi. Public health benefits of strategies to reduce greenhouse-gas emissions: household energy. Lancet 374 (2009): 1917–29. DOI:10.1016/S0140-6736(09)61713-X.
- Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, David Tilman, Fabrice DeClerck, Amanda Wood, Malin Jonell, Michael Clark, Line J Gordon, Jessica Fanzo, Corinna Hawkes, Rami Zurayk, Juan A Rivera, Wim De Vries, Lindiwe Majele Sibanda, Ashkan Afshin, Abhishek Chaudhary, Mario Herrero, Rina Agustina, Francesco Branca, Anna Lartey, Shenggen Fan, Beatrice Crona, Elizabeth Fox, Victoria Bignet, Max Troell, Therese Lindahl, Sudhvir Singh, Sarah E Cornell, K Srinath Reddy, Sunita Narain, Sania Nishtar, and Christopher J L Murray. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet (2019). Published online January 16, 2019. http://dx.doi.org/10.1016/S0140-6736(18)31788-4.
- Woodcock, James, Phil Edwards, Cathryn Tonne, Ben G Armstrong, Olu Ashiru, David Banister, Sean Beevers, Zaid Chalabi, Zohir Chowdhury, Aaron Cohen, Oscar H Franco, Andy Haines, Robin Hickman, Graeme Lindsay, Ishaan Mittal, Dinesh Mohan, Geetam Tiwari, Alistair Woodward, and Ian Robert. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Lancet 374 (2009): 1930–43. DOI:10.1016/S0140-6736(09)61714-1.
- World Bank. CO2 emissions (metric tons per capita). https://data.worldbank.org/indicator/EN.ATM.CO2E.PC (Accessed 2019.03.09).
- World Bank and Ecofys. State and Trends of Carbon Pricing 2018. (2018). World Bank, Washington, DC.
- Workman, Annabelle, Grant Blashki, Kathryn J. Bowen, David J. Karoly, and John Wiseman. The Political Economy of Health Co-Benefits: Embedding Health in the Climate Change Agenda. Int. J. Environ. Res. Public Health 15 (2018): 674-93.
- World Health Organization (WHO). Health and climate change: COP24 special report. (2018). WHO, Geneva.
- World Health Organization (WHO). Health in the green economy: health co-benefits of climate change mitigation – housing sector. (2011a). WHO, Geneva.
- World Health Organization (WHO). Health in the green economy: health co-benefits of climate change mitigation – transport sector. (2011b). WHO, Geneva.
- World Health Organization (WHO). Urban green spaces and health. (2016). WHO Regional Office for Europe, Copenhagen.

Endnotes

- 1. CO_2eq: Carbon dioxide equivalent – converts greenhouse gases to the same warming potential as CO_2
- 2. Micro-hydro is a type of hydroelectric power that typically produces from 5 kW to 100 kW of electricity using the natural flow of water. https://en.wikipedia.org/wiki/Micro_hydro (accessed 2019-02-25).
- 3. Primary energy refers to energy sources in their natural or original form, such as coal, oil, natural gas, wind, water, and sun. Secondary energy refers to energy that has undergone some form of transformation from its primary form to the form in which it is used, such as coal to electricity, crude oil to gasoline, or hydro to electricity (Robins, 2017).
- 4. The range reflects in part that, to be effective, carbon prices need to be higher in high-income countries as compared to low- and middle-income countries.

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