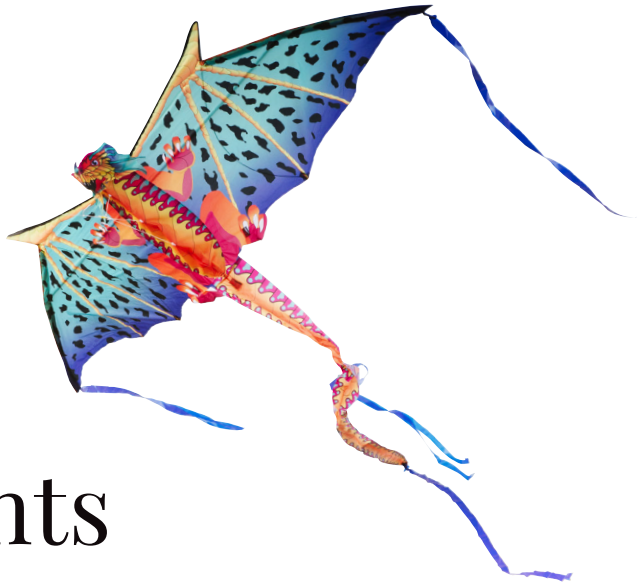
A JOINT REPORT *from* ASTHMA CANADA *and* BRUCE POWER

Clean Air Canada

Recognizing the role of nuclear power supporting coal phase-out to achieve long-term climate change goals



Contents

Asthma.ca
Asthma Canada

Asthma Canada is the only national, volunteer-driven charity, solely devoted to enhancing the quality of life for people living with asthma and respiratory allergies. For more than 40 years, Asthma Canada has proudly served as the national voice for Canadians living with asthma. We empower patients with evidence-based information, education programs and support asthma research in Canada. Our vision at Asthma Canada is a future without asthma.

Bruce Power

Bruce Power is Canada's first private nuclear generator, providing 30% of Ontario's power. Our eight units provide over 4,000 full-time, direct jobs to highly skilled employees and thousands more indirectly. We inject billions of dollars into Ontario's economy annually, while producing safe energy that produces zero carbon emissions.

Working Together

Bruce Power and the Asthma Society have a common desire to ensure people understand the relationship between electricity demand, human health and the climate. Ontario continues to be a leader in reducing electricity sector air emissions and improving air quality. It is imperative that Canada and the rest of the world continue to pursue energy strategies that improves human health and protects the environment.

Executive Summary

Canada's transition toward a low-carbon economy has begun. Ambitious targets have been set internationally and domestically, and the policy framework to guide the transition is being actively debated daily. Acting on climate change means reducing emissions and increasing climate resilience, all while helping Canada diversify its economy and generate well-paying jobs.

Protecting the environment and growing the economy go hand in hand. Electricity is so intricately woven into our everyday lives that, until the power fails, we don't realize how much we truly depend on it. Most of us spend little time thinking about where that power comes from or how it's generated, but it's those decisions that have a lasting impact on our health, well-being, and the environment.

In Canada, and around the world, almost 80 per cent of GHG emissions from human activities come from energy consuming activities such as transportation, energy and electricity production, heating and cooling of buildings, operation of appliances and equipment, production of goods, and the provision of services.[1]

To support this transition and to reduce GHG emissions, Canada has committed to phasing out its coal-fired electricity power plants by 2030. Canada has reduced its coal consumption by 24 per cent since 1990, and by 41 per cent since 2000.[2]

Clean air also does not need to come at the expense of the economy and jobs. Meeting energy demands in a clean and affordable way is possible, and Ontario is an excellent example of how. In the early-2000s, the provincial government committed to phasing

out coal from its energy mix portfolio — a goal met in April 2014 with the assistance of Bruce Power, which provided 70 per cent of the energy the province needed to achieve this goal, by returning Units 1-4 to service between 2003 and 2012. The initiative saw a significant reduction in the province's level of harmful GHG emissions, and the number of smog days plummeted from 53 in 2005 to just two since 2014.

The people of Ontario now have cleaner air from cleaner energy, while benefitting the economy in the process. A major part of this commitment was made possible through the refurbishment of Bruce A's four units. Then, in 2015, Bruce Power and the Independent Electricity System Operator (IESO) struck an agreement to extend the life of Bruce Power's units to 2064 through a Life-Extension Program, which began Jan. 1, 2016, and will run to 2053. By securing the future of the Bruce Power site, the annual economic impact of extending the life of the facility to 2064 will create and sustain 22,000 direct and indirect jobs annually, and $4 billion in annual provincial economic benefit through the direct and indirect spending in operational equipment, supplies, materials and labour income.

Over the next 20 years, as Bruce Power renews its fleet through its Major Component Replacement Project, as outlined in Ontario's Long-Term Energy Plan, additional economic benefits of 5,000 direct and indirect jobs will occur annually, while about $1 billion will be invested in the province's economy through equipment, supplies and materials. There is no other single, well-established project, facility or infrastructure program in Ontario that will have such a significant economic impact.

Coal phase-out also realized economic benefits for Ontarians through health care cost avoidance — in 2005 the Ontario Ministry of Energy indicated the benefits of coal phase-out would amount to about $70 billion through 2040. Global energy demands can be met with a combination of nuclear and renewables, which would sharply decrease GHG emissions, improve air quality, boost quality of life and benefit economies — just as Ontario has shown.

How do Canadians do their part to reduce climate change severity? We begin where we can win — by reducing emissions in our home province, and then thinking globally. The abolition of coal in power generation across the country is the place to begin. The combustion of coal pollutes the air, causing illness and death in more people than any other method of energy generation.[3]

The Province of Ontario has taken a bold leadership position by phasing out coal-generated electricity. Ontario recognizes the disease burden coal-generated electricity places on its present and future residents, and it is critical for other provinces and jurisdictions to follow Ontario's lead.

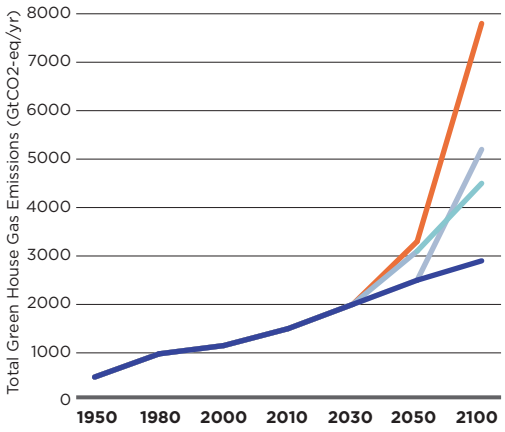
Global energy demand

Energy demand – the rate of usage often expressed in terawatt hours (TWh) — is influenced by population growth and improved quality of life. Over the last two centuries, the world has seen extensive technological and medical advances, which has resulted in the world's population growing to approximately seven billion, while it's predicted to approach nine billion by 2040.

As a result of this growth, global energy demand continues to rise annually. In 2017, global energy demand increased by 2.1 per cent compared with 0.9 per cent the previous year, and 0.9 per cent on average over the previous five years. This marked change was driven primarily by growth in China and India, which accounted for 40 per cent of the increased global demand.[4] Problematically, this rising energy demand is being met by the increased burning of fossil fuels, specifically coal, endangering the health and well-being of global citizens. Global coal demand rose in 2017 by one per cent to 3,790 Million Tonnes of Oil Equivalent (Mtoe) after two years of decline, the main change in global energy demand trends last year.[5]

In 2017, global energy-related CO_2 emissions grew by 1.4 per cent, an increase of 460 million tonnes (Mt) over the previous year, reaching a historic high of 32.2 gigatonnes (Gt).[6] As the world moves forward in addressing the growing demand for energy, it will be important to ensure that a balanced supply mix, with emissions-free options, are pursued. Decisions made on the energy fuel source must balance both the needs of today and future generations, without ignoring the correlation between air emissions, climate, and human health.

Fig. 1 **Varying predictions of GHG accumulation based on IPCC climate model scenarios**



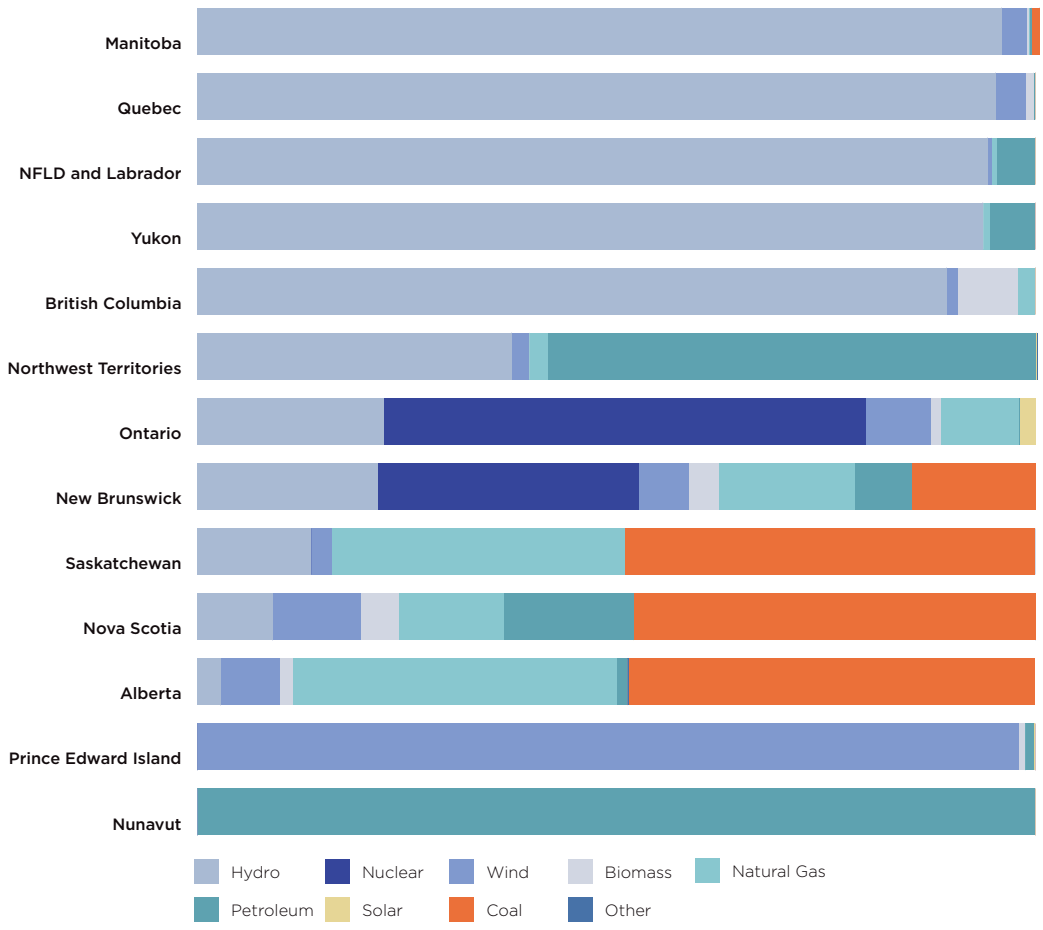
Canadian energy overview

Canada has committed to ambitious GHG reduction targets, which will necessitate a broad scope of policy initiatives impacting numerous sectors including transportation and energy.

Although Canada has already come a long way in reducing GHG emissions in the electricity sector, in large part due to the leadership exemplified by Ontario, which closed its last coal plant in 2014, some provinces such as Alberta and Saskatchewan remain primarily fossil fuel-burning regions, which reflect opportunities for change (Figure 2).

As can be seen in Figure 3 and Figure 4 the Carbon Intensity per Kilowatt-hour in Canada's

Fig. 2 **Electricity generation by fuel type — Canadian provinces**



fossil fuel-burning provinces are comparably higher than Ontario's grid, which is heavily reliant on clean nuclear power.

Learning from Ontario, which was the first jurisdiction in North America to end its use of coal-fired electricity when it closed the Thunder Bay Generating Station in April 2014, Canada stands at the edge of opportunity to create real change in its transition to a low-carbon economy. Serving as an example, Ontario, which undertook a multi-year effort that decreased the average Ontarian's environmental footprint and also resulted in a financial benefit to the province, represents a model for the rest of Canada. Much of this success was made possible by Ontario's nuclear industry — without it, phasing out coal would have been much more difficult.

If Canada is to achieve its 2030 reduction goals, any new generating sources added in the four fossil fuel-emitting provinces — Alberta, Saskatchewan, Nova Scotia, and New Brunswick — must be non-polluting. Any increase in carbon dioxide (CO_2), specifically from electricity generation, will be counterproductive to efforts to decarbonize transportation, heating via electrification, or other policy initiatives aimed at reducing GHG emissions.

As Canada moves to further decarbonize its energy production, Ontario — and its embrace of the virtually carbon-free nuclear industry — should serve as an example of how to achieve GHG emission reductions while ensuring reliable, low-cost power for its citizens.

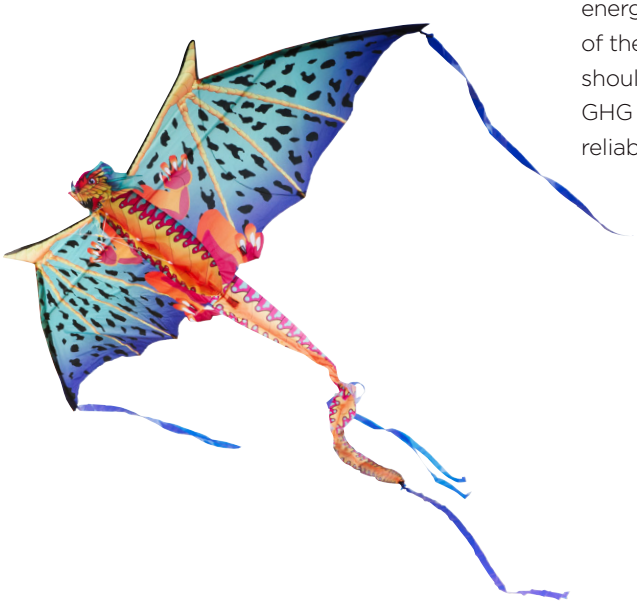


Fig. 3 **Carbon intensity per kilowatt hour (1990-2015) in four Canadian provinces**

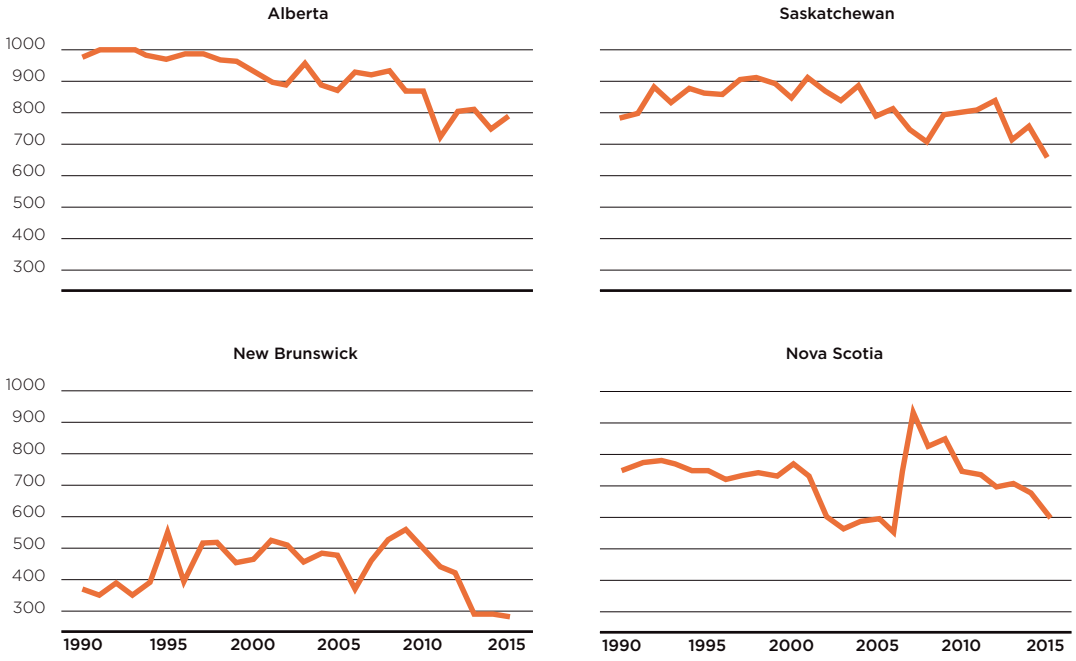
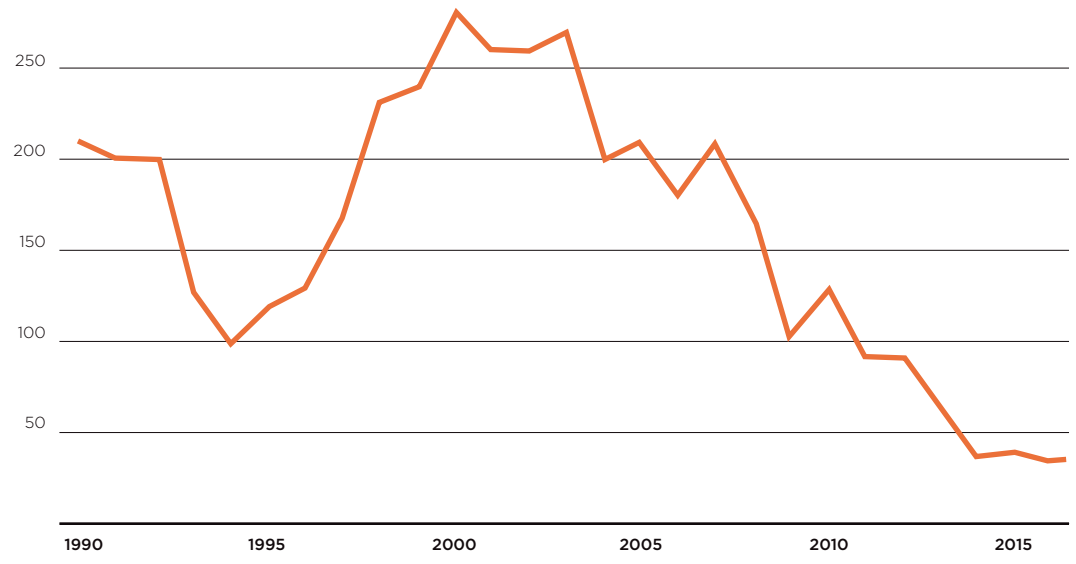


Fig. 4 **Carbon intensity per kilowatt hour (1990-2017) in Ontario**



FEDERAL GOVERNMENT'S PAN-CANADIAN FRAMEWORK ON CLIMATE CHANGE

The Paris Agreement, of which Canada was a key signatory, is a commitment to accelerate and intensify the actions and investments needed for a sustainable, low-carbon future, to limit global average temperature rise to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C.[7]

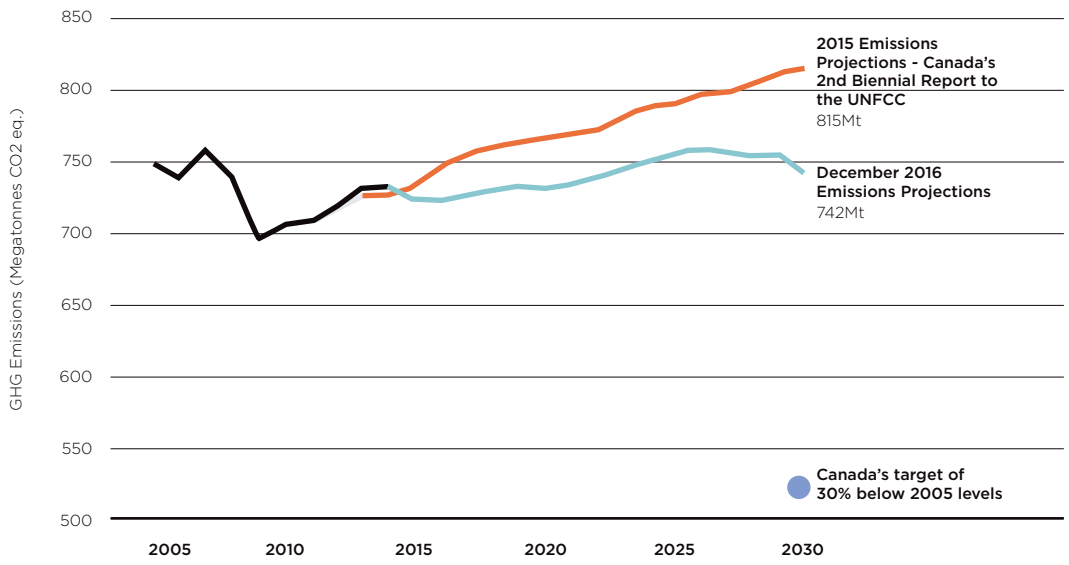
To help fulfill this global agreement, the Government of Canada published the *Pan-Canadian Framework on Clean Growth and Climate Change* in 2016.

The 'Pan-Canadian Framework on Clean Growth and Climate Change' is Canada's plan to meet its emissions reduction targets, grow the economy, and build resilience to a changing climate. The plan includes measures to achieve reductions across all sectors of the economy, including major investments in infrastructure and clean technology through the Low Carbon Economy Fund. The plan aims to drive innovation and growth by increasing technology development and adoption, to ensure Canadian businesses are competitive in the transition to a clean global economy. It also includes actions to advance climate change adaptation and build resilience to climate impacts across the country.

When First Ministers met in 2016 to ratify the agreements to take ambitious action in support of meeting or exceeding Canada's 2030 target of a 30 per cent reduction below 2005 levels of GHG emissions, optimism was high. In the years that followed, provincial government changes have created tenuous intergovernmental relations and differing ideas on how Canada should best pursue its climate change objectives.

The health and well-being of Canadian citizens, and our environment, will not wait while politicians decide on how best to conquer these challenges. Canada has the tools to achieve its objectives now and Ontario has already shown us the way.

Fig. 5 **Emission projections in Canada under Pan-Canadian framework**



Climate change and health

The World Health Organization declared in 2016 that climate change is the greatest public health threat of the 21st Century, due to its broad environmental and attendant health impacts including lungs and heart ailments/disease, and mental stress.[9] Regardless of where one lives, people with respiratory challenges will feel the effects of climate change. The rates of people with severe forms of asthma are climbing, with an estimated 150,000-250,000 patients in Canada.[10] Climate change will aggravate symptoms in many of these individuals, placing an added burden on the already stretched health care system, in addition to an increased personal burden on individuals.

ECONOMICS AND HEALTH IMPACTS OF CLIMATE CHANGE AND POOR AIR QUALITY

Air is a basic necessity for life, and the protection of its quality is vital. Various studies from around the world have concluded that combustion-related emissions, such as those produced in a variety of electricity generation processes, can cause substantial impacts to human health and the environment. Health risks associated with air pollutants vary from minor illness to premature death, and are largely associated with exposure to ozone and particulate matter.

The National Round Table on the Environment and the Economy concluded that the costs of climate change could represent about $5 billion per year by 2020 in Canada, and, depending on the levels of continued global emissions growth, could rise to $21 billion to $43 billion per year by 2050, or even higher under more extreme scenarios of climate change and public health.[11] Additionally, climate change will only compound the costs and health challenges that emerge due to poor air quality.

Climate change will bring about longer growing seasons with longer periods of active pollen production; longer dry periods and droughts, leading to more forest fires and wood smoke, as well as more dust and dust mites; more extreme weather conditions, leading to flooding and increased mould. It will also lead to a plant world under stress acting on its instinct to survive, and a greater production of plant pollen, leading to more problems for people suffering with ragweed, hay fever, and other respiratory challenges.

Studies, such as those discussed in this document, highlight some of the health care and air quality standard costs that may arise, should climate change and air quality go unaddressed. Using indicators such as emergency room visits, number of asthma related losses, hospital admissions, and reduction in minor illness cases, does the full impact of inaction become clear.

Health studies completed by the Pembina Institute estimate that, in 2014, pollution from coal power resulted in more than 20,000 asthma episodes and hundreds of emergency room visits and hospitalizations, costing the health care system over $800 million annually.[12]

Additionally, Environment and Climate Change Canada's Regulatory Impact Analysis Statement for its 2012 regulation to phase out coal-fired electricity, estimated that the regulation would result in cumulative health benefits of $4.2 billion from 2015-35 from reduced smog exposure, which is associated

with reduced risk of death, avoided emergency room visits, and hospitalization for respiratory or cardiovascular problems.[13]

In its report *No Breathing Room: National Illness Costs of Air Pollution,* the Canadian Medical Association (CMA) points to studies that provide, "Compelling evidence that exposure of young people to air pollution during the critical stages of lung development (up to 17 years of age) can cause irreversible damage." One of the impacts is reduced lung function, which is proportional to concentrations of air pollutants, in particular fine particulate matter (PM2.5).[14]

HUMAN IMPACT OF AIR EMISSIONS

Coal-fired Electricity
29% of GHGs worldwide

Air Pollution
3.7 million premature deaths per year, with coal a big contributor[18]

Aside from GHGs, other emissions produced from electricity generation that can have a negative impact on human health include common air contaminants such as dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), PM2.5, and ozone (O_3).[15]

These atmospheric emissions can have both acute and chronic health consequences as a result of inhaling the pollutants directly, or being exposed to them as they accumulate in the environment, as they are transferred along the food chain or as they impact the health of our ecosystems. Air pollution from burning coal affects numerous systems in the body – respiratory, cardiovascular, and the central nervous system. These impacts on human health result in loss of work days, increased hospital visits, chronic respiratory illnesses, and premature mortality, locally and regionally.

All of these take a measurable toll on society in terms of the well-being of the population, and the financial costs to the health care system.

HEALTH RISKS OF CLIMATE CHANGE

The most obvious direct impacts on human health from climate change is due to the projected increased risk of extreme weather events, such as heavy rains causing mudslides and floods, violent thunderstorms, and increased drought affecting water supplies, increasing the risk and intensity of wildfires. These climate-related weather events pose a direct physical threat to human health, as well as threats such as illnesses from water contamination, food and water shortages, and crowding in emergency shelters.

The Insurance Bureau of Canada has tracked a rise in insured losses due to extreme weather, from $400 million a year between 1983 and 2008, to around $1 billion in recent years, including more than $5 billion in 2016, the highest annual payout ever.[16]

Climate change also impacts air quality, linking in the various air pollution impacts on human health raised in this report. Climate change is projected to increase smog formation, wildfires, and pollen production. It might also lead to greater emissions of air contaminants due to changed personal behaviours, such as use of air conditioners and driving. All of these outcomes, many of which are described further throughout this report, are direct air impacts from coal power, and include increased risks to human health, such as cardiovascular and respiratory diseases, increased risk of certain cancers, worsening of allergies and asthma, and premature death.

Studies that attempt to tally the health care and welfare costs of health impacts related to climate change, have important shortcomings — most notably, they tend to focus on a limited number of specific health outcomes. However, reviewing the range of studies that probe the projected economic value of loss of life alone, they indicate climate change could cost between $6 billion and $88 billion (US) in 1990 dollars. This gives an indication of the magnitude of costs related to human health impacts due to climate.[17]

Table 1 **Pollutants and known health impacts**

Pollutant	Details	Health or Environmental Impact
Nitrogen Oxide (NOx)	Nitrogen oxides (NOx) consist of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a colourless, odourless gas, while NO_2 is a reddish-brown gas with a pungent and irritating odour. Nitric oxide is highly reactive, oxidizing rapidly in the atmosphere to form NO_2.	Nitrogen dioxide is a precursor to ground-level ozone, which can exacerbate asthma attacks. Nitrogen dioxide has a greater effect on people with pre-existing respiratory problems, and can increase the chance of respiratory illness by lowering resistance to infection. People afflicted with asthma and bronchitis are generally more sensitive. Exposure to very high levels of NOx makes breathing difficult, especially for people who already suffer from asthma or bronchitis. NOx emissions also contribute to acid deposition and excessive nutrient input to soils and aquatic systems.
Sulphur Dioxide (SOx)	Sulphur dioxide (SO_2) is a colourless gas that smells like burnt matches. Sulphur dioxide is oxidized in the atmosphere to form sulphuric acid aerosols or sulphates, which are one of the main components of airborne fine particulate matter.	At relatively high levels of exposure, SO_2 is a known cause of bronchoconstriction and worsened asthma symptoms, as it can react with other substances in the air to create particulate matter. There is some evidence that exposure to elevated SO_2 levels may increase hospital admissions and premature death.
Mercury	Mercury oxide (HgO) is a toxic, persistent, bio-accumulative substance. Mercury oxide exists in the atmosphere primarily in the gas phase, as atomic (elemental) vapour. In this form, it is generally resistant to reactions with other air contaminants.	Methylmercury accumulates in fish and other species, damaging the central nervous system of these animals and causing reproductive failure; this has been observed in loons and river otters. Human exposure to mercury is primarily by eating contaminated fish.
Particulate Matter	Fine particulate matter can include acid aerosols, metal fumes, organic chemicals, pollen and smoke. Particles can be emitted directly from combustion sources (referred to as 'primary PM'), as in the case of elemental carbon, or can be formed when emissions of sulfur dioxide and nitrogen oxides react with ammonia.	Particulate matter has been associated with hospitalizations and increased respiratory and cardiovascular mortality. It has also been associated with asthma exacerbation, inflammation, and changes in heart-rate variability. Exposure to particulate matter has also been associated with increased incidence of respiratory diseases, including chronic obstructive pulmonary disease, cancer, and pneumonia.
Greenhouse Gases	Globally, coal produces more GHG emissions than any other fossil fuel. Coal power emits at least twice as much greenhouse gases for the same amount of electricity generated as natural gas, the next highest major source of pollution as it pertains to electricity generation in Canada.	The impacts of climate change can be categorized into two groups, depending on the proximity in causation between climate change and the health impact: **Direct exposures:** Deaths and injuries resulting from violent storms, illnesses, and distress related to extreme heat events, along with other long-term health effects of direct exposures. I**ndirect exposures:** The results of changes induced by climate on other systems. For example, by creating conditions favourable to the occurrence of infectious disease outbreaks from food or water contamination, or the formation of smog.

HEALTH SAVINGS ONTARIO

Therefore, if air pollution is causing an economic burden, there are opportunities for savings if the right decisions are made. In 2005, Ontario's Ministry of Energy evaluated the health care savings to the province of phasing out coal in the short and long term. The study found, through 2040, Ontario will annually avoid more than 25,000 emergency room visits, 20,000 hospital admissions, and a staggering 8.1 million fewer minor illnesses with the shutdown of coal. This is estimated to have an annual financial benefit of $2.6 billion,[19] while the total accumulated savings will be about $70 billion between now and 2040. To put this in perspective, $70 billion is nearly enough money to run Ontario's entire health care system for 1.5 years (Figure 6).

Fig. 6 **Health care savings from Ontario's coal phase-out**

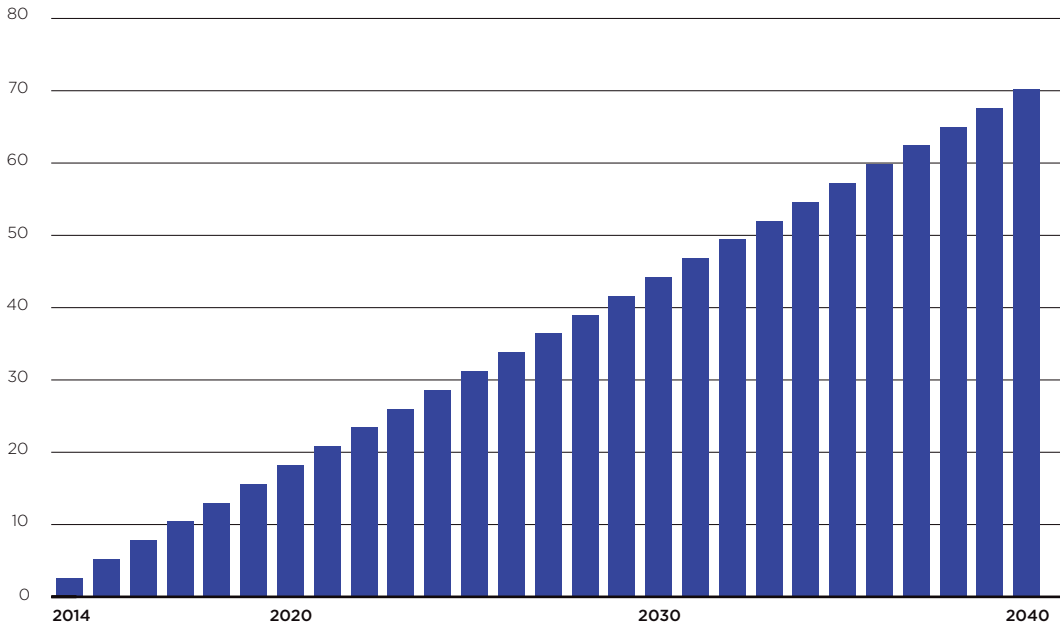
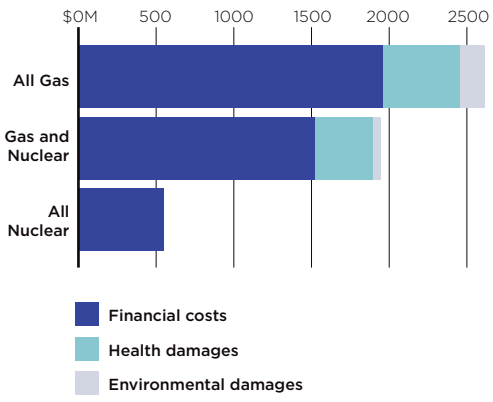


Fig. 7 **Avoiding health and environmental costs of various generating scenarios**



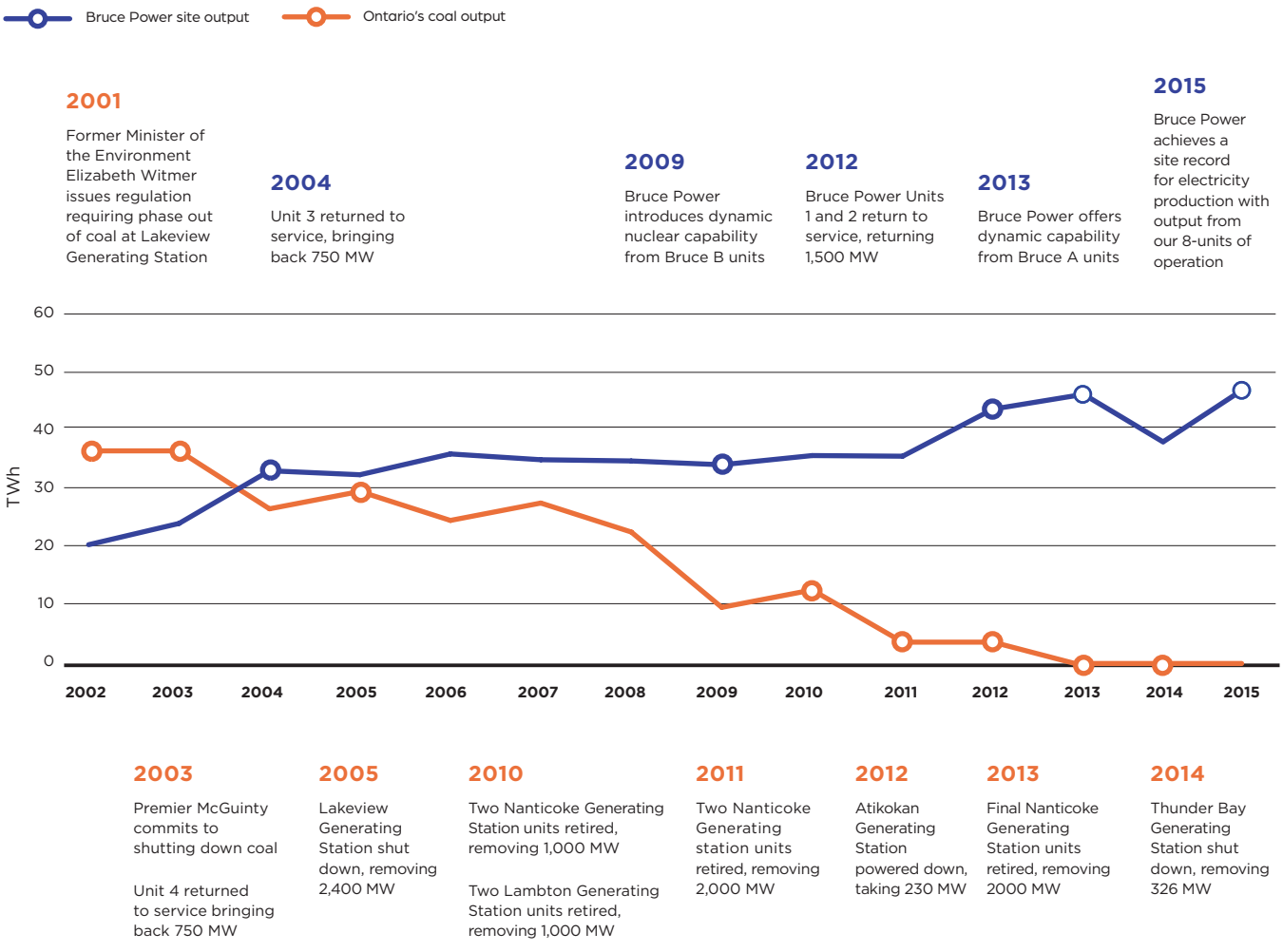
Methodology: Figure at left is derived from DSS Cost Benefit Analysis: Replacing Ontario's coal plants, Table I-4 (p. v).The all-nuclear data was specifically derived as follows:

- Subtract the Financial Costs value of the 'nuclear/ gas' column from that in the 'all gas' column.
- Assign the Health Damages and Environmental Damages values to zero, since these were assumed throughout the DSS report to be caused by the following air pollutants that nuclear plants do not produce or emit:
  - Sulphur dioxide
  - Nitrogen oxide
  - Particulates
  - Mercury

How did Ontario phase out coal?

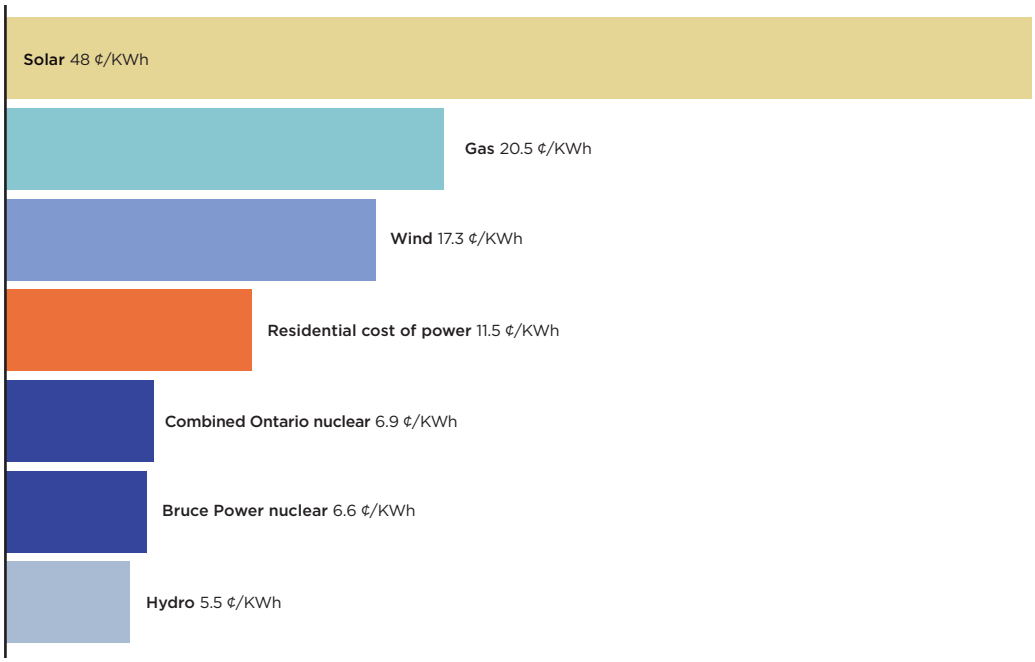
In the early-2000s, the Ontario government promised to completely phase out coal by 2015, and, in 2007, issued a legally binding regulation that would require any remaining coal burning plants to stop production no later than Dec. 31, 2014. All clean sources of electricity were required to ensure this goal was achieved, including additional generation from renewables and conservation. The bulk of this generation — 70 per cent of what was required to shut down coal — came from the Bruce Power site, which restarted four dormant nuclear units between 2003 and 2012. Figure 8 shows the evolution of events pertaining to the Bruce site in relation to coal phase-out.

Fig. 8 **Bruce Power site output and coal output**



Considered to be one of the most environmentally friendly methods of both generating electricity and in lifecycle operation (i.e. construction, operation and decommissioning), nuclear energy is one of the cleanest energy generation technologies available, and has been instrumental in helping Ontario transition to a low-carbon energy mix, shifting away from fossil fuel dependence. At the same, Ontario serves as an example of how this shift can be an economic driver while keeping prices competitive (Figure 9).

Fig. 9 **2017 electricity prices (cents/KWh)**



Role of Bruce Power nuclear

Nuclear power plays a critical role in meeting the energy and air quality needs of the province every day. Since 2013, nuclear accounted for more than 59 per cent of Ontario's electricity supply, with Bruce Power providing 30 per cent of the province's power and over half of its nuclear. A coal-free electricity supply mix has led to a significant reduction in harmful emissions, contributing to cleaner air and a healthier environment. Since 2001, Bruce Power has doubled the number of its operating units — from four to eight — contributing significantly to Ontario's agenda to phase out coal.

In fact, the increased energy from the Bruce Power site from 2003-12 accounted for 70 per cent of the energy Ontario needed to achieve its goal to shut down coal.

THEN

Bruce Output Down

On Oct. 16, 1997, Unit 1 was laid up by the former Ontario Hydro, taking 750 Megawatts (MW) of electricity off Ontario's grid. Unit 2 had been laid up two years earlier. Units 3 and 4 were both laid up in 1998. Many thought Bruce A would never return to service.

Coal Output Up

Following Units 1 and 2 being removed from service, combined with Units 3 and 4 in 1998, fossil fuel generation increased dramatically in Ontario — from 12% of the province's energy supply mix in 1995 to 29% in 2000.

NOW

Bruce Output Up

Nearly two decades later, Bruce Units 1 and 2 are producing low-cost, clean electricity, after being returned to service in 2012, while Units 3 and 4, returned in 2003 and 2004, have also demonstrated safe, reliable operations. The revitalization of Bruce A provides Ontario with an additional 3,000 MW of low-cost, clean electricity, while Bruce B continues to be counted on for 15% of Ontario's electricity.

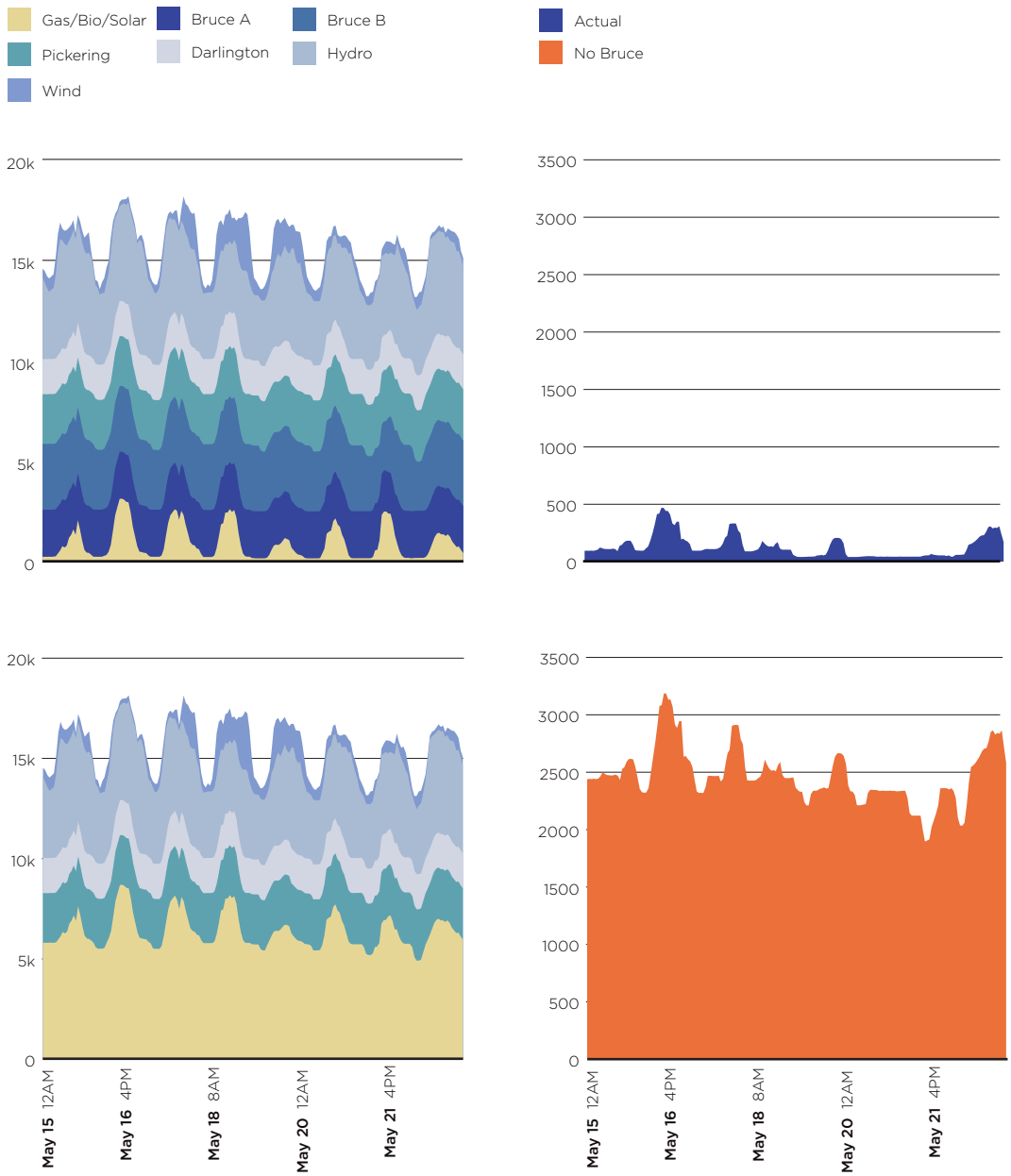
Coal Output Down

Over the past decade, Ontario reduced its use of coal by nearly 100 per cent, accounting for just 2% of the electricity supply mix in 2013, before being shut down for good in 2014. The result has been a 93% reduction in Ontario's sulphur emissions. In response, the number of smog days in the greater Toronto area dropped from 53 days in 2005 to just two since 2014.

ONTARIO WITHOUT BRUCE POWER

There's no doubt that Bruce Power played a fundamental role in helping Ontario achieve its coal phase out. An alternating generation scenario, such as that shown in Figure 10, demonstrates how Ontario's emissions would be drastically different without the vital role played by Bruce Power nuclear.

Fig. 10 **NOx emissions during typical shoulder season week (May 15 - 21), actual fuel mix vs Bruce replaced with combined cycle gas**



Ontario's leadership role in combating climate change

Ontario was once in a similar position as other fossil fuel burning provinces in Canada. Ontario's decision to phase out coal demonstrated a commitment to the health and well-being of its citizens. Ontario took on a leadership role to initiate this change, and had it not done so, its emissions relative to other provinces would not look the same as it does now.

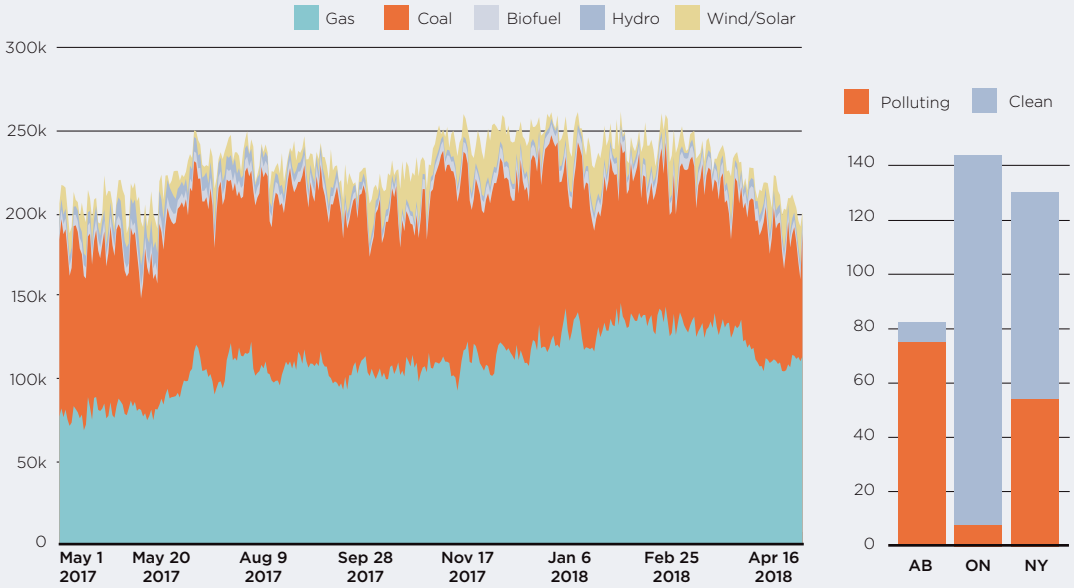
Other provinces are already taking steps to confront this challenge. For example, in November 2015, the Government of Alberta introduced the Climate Leadership Plan (CLP). It is a made-in-Alberta strategy to reduce carbon emissions while diversifying the economy, creating jobs, and protecting its health and environment. Alberta's CLP proposes replacing two-thirds of generation capacity with renewables.

As of 2016, about 40 per cent of Alberta's generation capacity is natural gas-fired, and 40 per cent comes from coal. However, coal-fired generation produces 51 per cent of Alberta's electricity.[21]

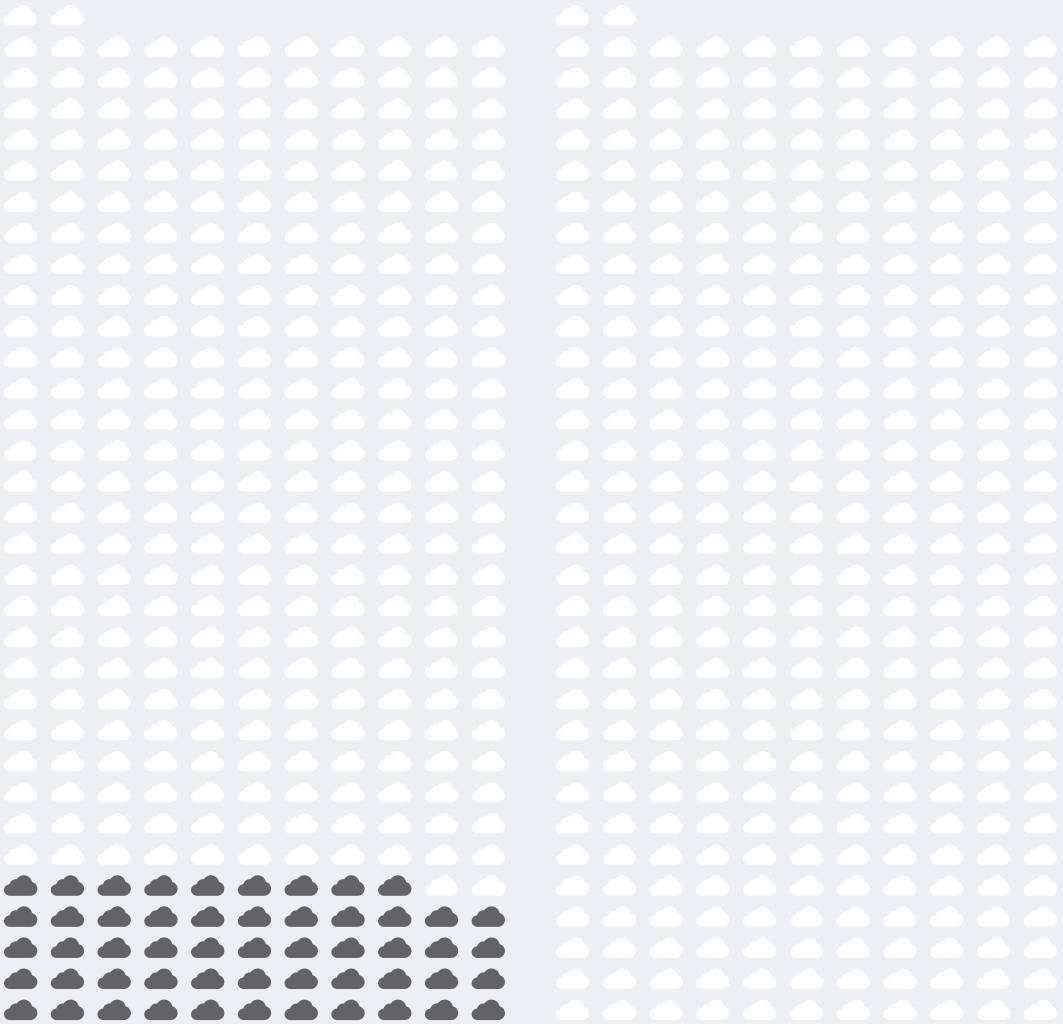
Figure 11 shows Alberta's supply mix and its relative CO_2 emissions. A large percentage of Alberta's fuel mix is polluting, compared to that of Ontario and New York (Figure 12).

Canadian energy demands can be met with a combination of emissions free generating resources, which would sharply decrease greenhouse gases released into the atmosphere, improve air quality, boost quality of life, and benefit economies — just as Ontario has shown.

Fig. 11 /12 **Alberta Annual Generation / CO_2 Emissions (in bilion KWh), Compared with NY, ON**



Over the past decade, greenhouse gas emissions in Ontario's electricity sector have been reduced by more than 80 per cent. Over 95 per cent of electricity generated in Ontario comes from non-greenhouse gas emitting resources.



2005
53 smog days

2015
0 smog days

Lifecycle emission GHG rates

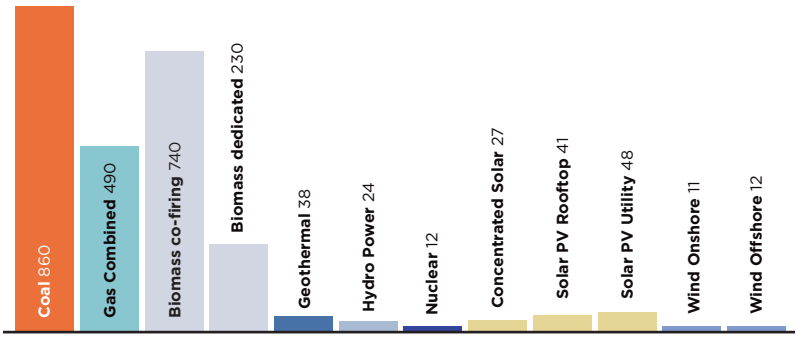
All electricity generation technologies emit greenhouse gases at some point in their lifecycle, creating a carbon footprint. Fossil-fuelled generation has a high carbon footprint, with most emissions produced during plant operation. Nuclear and renewable generation generally have a low carbon footprint because most emissions are caused indirectly, such as during the construction of the technology itself.

Additionally, the estimation of GHG emissions for various methods of energy production often involves the use of lifecycle assessments (LCAs) that consider energy requirements and emissions associated with all aspects of an energy generating facility or system, including construction, operation (energy production), and decommissioning. When looking at the impact energy creation has on the climate, it is important to evaluate the entire lifecycle to fully understand where emissions are being added to the atmosphere.

The overall process for the primary energy sources of coal, natural gas, wind, solar, hydroelectric, and nuclear can be seen in Figure 13. When trying to achieve this ideal balance of environment and human quality of life, one should typically look for an energy option that has low lifecycle emissions. Lifecycle analyses are the most inclusive evaluations that can be called upon to make informed decisions as they look at the entire industrial process, from emissions at resource exploration to waste disposal.

For coal and natural gas facilities, the majority of GHG emissions occur during the production of energy as fuel resources are consumed. For other methods of energy production, the mining and processing of resources, the production of equipment, or the construction of facilities may represent the most emission-intensive stages. Although nuclear and renewable resources such as wind, solar and hydro are often regarded as emission-free energy sources because GHGs are not directly emitted during the electricity generating stages, standard operating and maintenance activities require energy inputs, many of which involve the use of fossil fuels.[22]

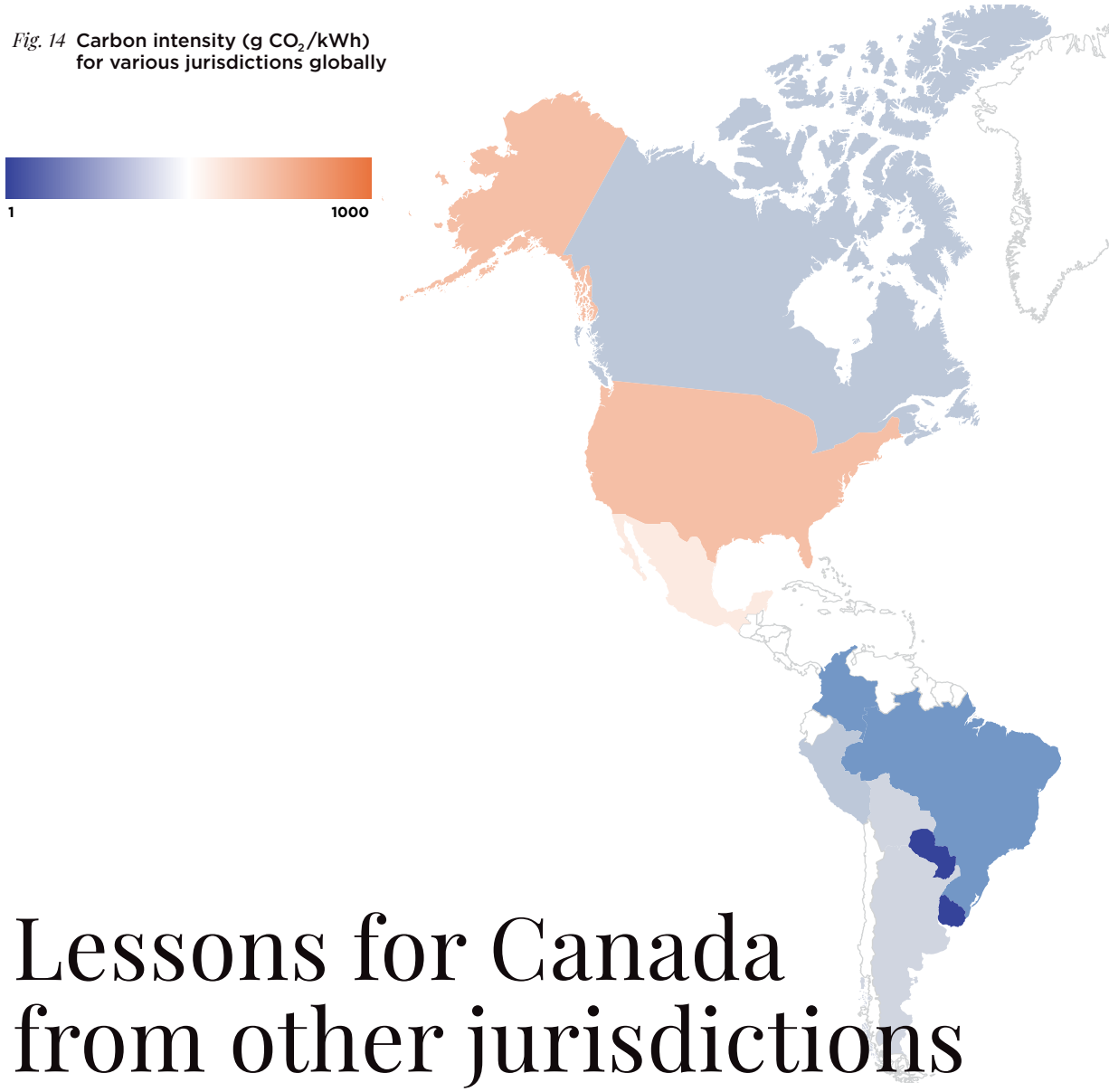
Fig. 13 **Lifecycle emissions of electricity supply technologies (gCO_2eg/KWh)**



The reduction, then elimination, of coal-fired electricity, as well as the increased capacity of renewable resources, four refurbishments at Bruce Power, and the ongoing contribution of nuclear as Ontario's baseload supplier of electricity has resulted in a steady decline in GHG emissions from the electricity sector in Ontario since 2008.

The loss of nuclear capacity with the scheduled closure of Ontario Power Generation's Pickering facility after 2024 is anticipated to result in a significant increase in annual GHG emissions to the Ontario environment, even under an optimal scenario in which renewable resources such as wind, solar and hydro increase their contribution to meet energy demand beyond the forecasted increase in production, rather than shifting greater dependency on natural gas facilities.

Fig. 14 **Carbon intensity (g CO_2/kWh) for various jurisdictions globally**



Lessons for Canada from other jurisdictions

In Figure 14, we see carbon intensity for various jurisdictions globally. Focusing on the example of France – a country with a low-carbon electricity sector – just 79 grams of CO_2/kWh is emitted at plants. A main contributor to this low figure, is due to the fact that France's supply mix relies heavily on nuclear power. In fact their carbon productivity of 0.15kg CO_2/$ is one of the best globally.[23]

In 2016, Canada's electricity generation was 66 per cent renewable and 80.6 per cent non-emitting in operation.[24] However, in 2015, Canada still emitted 722 megatons of carbon dioxide equivalent (Mt CO eq). Of these emissions, 10.9 per cent came from electricity generation.[25]

Since 2005, generation has trended away from coal and towards increased generation from natural gas and wind, which although favourable to coal, may present other challenges due to their intermittent nature. Nuclear, currently located exclusively in Ontario and New Brunswick, supplied an average of nearly 15 per cent of Canada's electricity from 2005 to '16, and was the second largest source of total generation.[26]

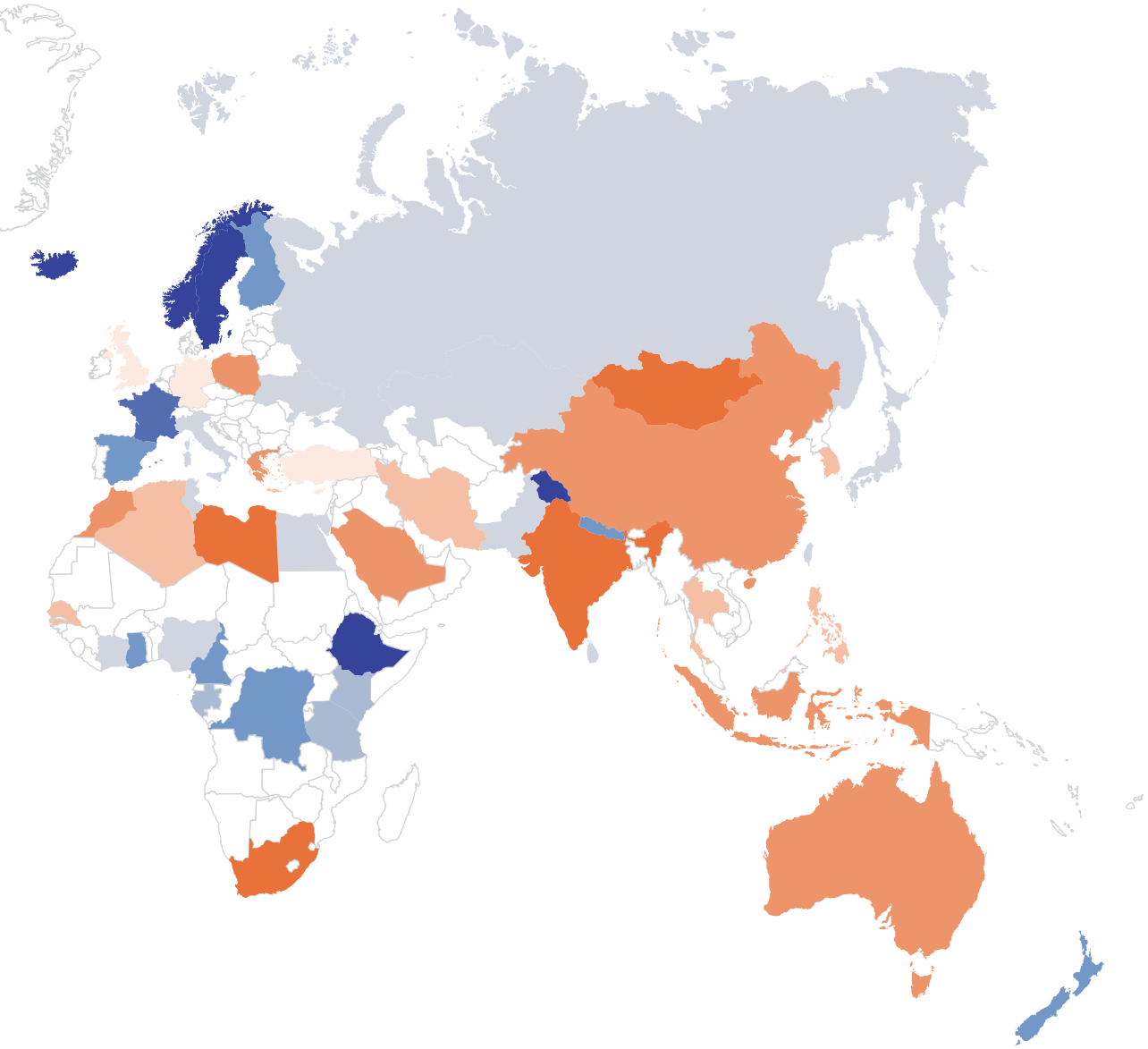


Fig. 15 **Canadian generation by fuel type**

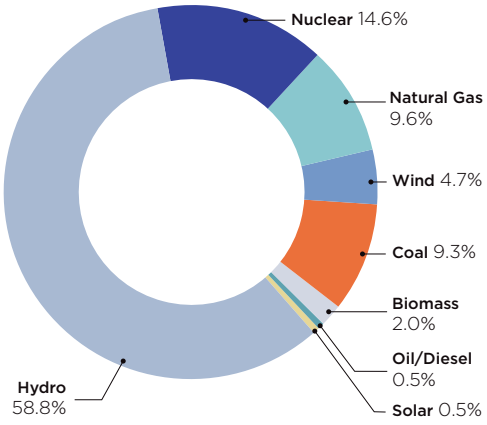
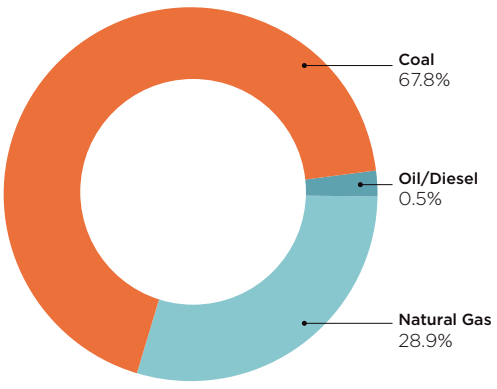


Fig. 16 **Electricity sector GHG emissions by fuel type (2016)**



GERMANY

In 2017, Germany generated 37 per cent of its electricity from non-carbon sources. Since the early-2000s, Germany has made massive investments in altering its grid by removing nuclear power in favour of large scale renewables. In pursuing the *Energiewende* (German for Energy Transition), Germany will have invested $580 billion in renewable energy and storage by 2025.[27]

Despite these investments, Germany's current grid CIPK is roughly 500 grams (average over a year). During the same time, the household price of electricity tripled between 1999 and 2015. Yet CO_2 emissions and CIPK are not much different today than in 2000 as seen in Figure 17. According to a recent Environmental Progress Analysis, California and Germany could have mostly or completely decarbonized their electricity sectors had their investments in renewables been diverted to new nuclear.

CALIFORNIA

Figure 18 shows California's 2015 grid electricity CIPK (prior to San Onofre's exit), compared with Germany and Ontario. As you can see, California's CIPK is similar to Ontario's at the height of coal, yet Ontario demonstrated leadership in reducing GHG emissions, demonstrating a model for the rest of Canada and other countries.

Fig. 17 **Germany vs Ontario CIPK 1996-2015**

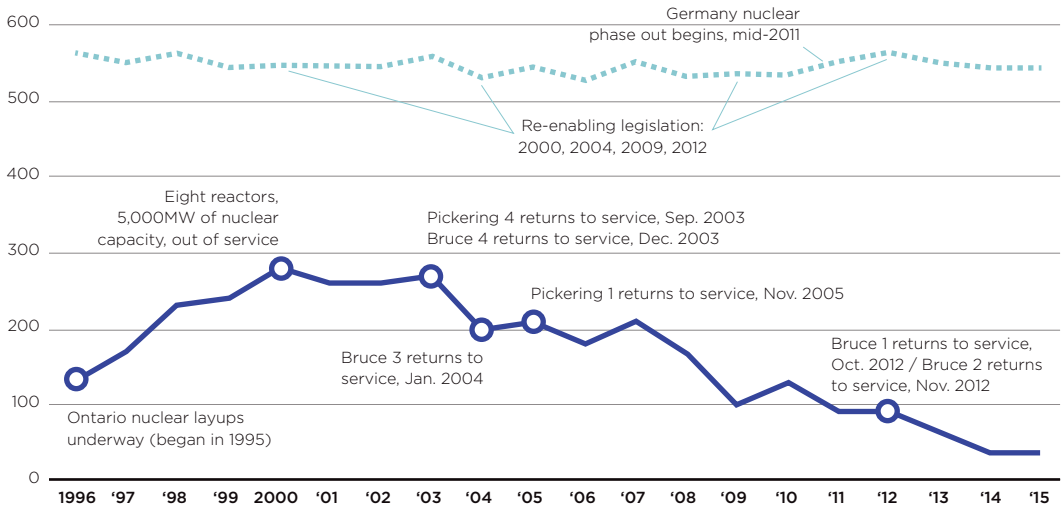
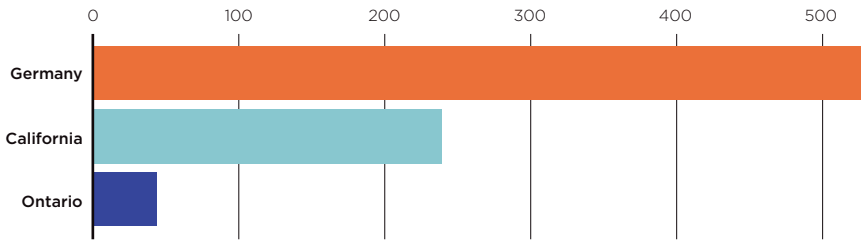


Fig. 18 **Emission intensity Ontario vs California vs Germany**



Conclusion

Energy policy, which provides commitment to the continued use of low-carbon energy options such as nuclear, is a key factor to ensuring the air we breathe remains clean.

Clean air also does not need to come at the expense of the economy and jobs. In October 2016, Bruce Power, in collaboration with respected business, economic development, trades, and union leaders, released an Economic Impact Study on the positive role the Bruce Power site plays in the province. By securing the future of the Bruce Power site, the annual economic impact of extending the life of the facility to 2064 will create and sustain 22,000 direct and indirect jobs annually, and $4 billion in annual provincial economic benefit through the direct and indirect spending in operational equipment, supplies, materials and labour income.

Over the next 20 years, as Bruce Power renews its fleet through its Major Component Replacement Project, as outlined in Ontario's Long-Term Energy Plan, additional economic benefits of 5,000 direct and indirect jobs will occur annually, while about $1 billion will be invested in the province's economy through equipment, supplies and materials. There is no other single, well-established project, facility or infrastructure program in Ontario that will have such a significant economic impact.

Global energy demands can be met with a combination of nuclear and renewables, which would sharply decrease GHG emissions, improve air quality, boost quality of life, and benefit economies — just as Ontario has shown. The Province of Ontario has taken a bold leadership position by phasing out coal-generated electricity. Ontario recognized the health burden coal-generated electricity places on its present and future residents.

It is critical for other provinces and jurisdictions to follow Ontario's lead.

REFERENCES

1. Government of Canada. Ministry of Natural Resources. Energy and Greenhouse Gas Emissions (GHGs). 2017. https://www.nrcan.gc.ca/energy/facts/energy-ghgs/20063

2. Government of Canada. Ministry of Natural Resources. Energy and Greenhouse Gas Emissions (GHGs). 2017. https://www.nrcan.gc.ca/energy/facts/energy-ghgs/20063

3. Pembina Institute. A Costly Diagnosis: Subsidizing Coal Power with Albertans Health. 2013. http://www.pembina.org/pub/2424

4. International Energy Agency. Global Energy and C02 Status Report 2017. 2018. https://www.iea.org/publications/freepublications/publication/GECO2017.pdf

5. Ibid.

6. Ibid.

7. Government of Canada. Ministry of the Environment. Pan-Canadian Framework on Clean Growth and Climate Change. 2016. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

8. Government of Canada. Ministry of the Environment. Estimated Impacts of the Federal Carbon Pollution Pricing System. 2017. https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/pricing-carbon-pollution/estimated-impacts-federal-system.html

9. World Health Organization. 2016. Director-General keynote address at the Human Rights Council panel discussion on climate change and the right to health.

10. Asthma Canada. Asthma Facts and Statistics. 2018. https://www.asthma.ca/wp-content/uploads/2017/06/Asthma-Facts-and-Stats.pdf

11. Government of Canada. Ministry of Environment and Natural Resources. Economic Analysis of the Pan-Canadian Framework. 2017. https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/economic-analysis.html

12. Pembina Institute. A Costly Diagnosis: Subsidizing Coal Power with Albertans Health. 2013. http://www.pembina.org/pub/2424

13. Government of Canada. Ministry of Environment and Natural Resources. Economic Analysis of the Pan-Canadian Framework. 2017. https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/economic-analysis.html

14. Rhonda J. Rosychuk et al. Asthma Presentations by Children to Emergency Departments in a Canadian Province: A Population-Based Study. Pediatric Pulmonology. 2010. https://onlinelibrary.wiley.com/doi/abs/10.1002/ppul.21281

15. Toronto Public Health. Path to Healthier Air: Toronto Air Pollution Burden of Illness Update. Technical Report.. https://www.toronto.ca/wp.../11/9190-tph-Air-Pollution-Burden-of-Illness-2014.pdf

16. Government of Canada. Ministry of the Environment. Estimated Impacts of the Federal Carbon Pollution Pricing System. 2017. https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/pricing-carbon-pollution/estimated-impacts-federal-system.html

17. Pembina Institute. A Costly Diagnosis: Subsidizing Coal Power with Albertans Health. 2013. http://www.pembina.org/pub/2424

18. International Energy Agency (IEA). 2015. Energy and Climate Change.

19. DSS Management Consultants Inc. for Ontario Ministry of Energy. Cost Benefit Analysis: replacing Ontario's coal-fired electricity generation. 2005. http://www.ontla.on.ca/library/repository/mon/10000/252195.pdf

20. Government of Alberta. Climate Leadership Plan: Implementation Plan 2018-19. https://www.alberta.ca/climate-leadership-plan.aspx

21. National Energy Board. Canada's Renewable Power Landscape 2017 – Energy Markey Analysis. 2017. https://www.neb-one.gc.ca/nrg/sttstc/lctrct/rprt/2017cndrnwblpwr/index-eng.html

22. international Energy Agency. Global Energy and C02 Status Report 2017. 2018. https://www.iea.org/publications/freepublications/publication/GECO2017.pdf

23. Clean Technica. Electricity and Carbon Intensity. 2014. https://cleantechnica.com/2014/04/15/greenest-source-power-french-response-low-carbon-strategy/

24. National Energy Board. Canada's Renewable Power Landscape 2017 – Energy Markey Analysis. 2017. https://www.neb-one.gc.ca/nrg/sttstc/lctrct/rprt/2017cndrnwblpwr/index-eng.html

25. Ibid.

26. Ibid.

27. Environmental Progress. With Nuclear Instead of Renewables California and Germany would already have 100% Clean Electricity. 2018. http://environmentalprogress.org/big-news/2018/9/11/california-and-germany-decarbonization-with-alternative-energy-investments

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