Adapting Canadian Work and Workplaces to Respond to Climate Change

Energy Working Group

ACW Baseline Report: Energy

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Executive summary

Climate change is one of the most important issues Canada is facing. While greenhouse gas (GHG) emissions do arise from natural processes, the current rapid concentration of these gases in our atmosphere is primarily being driven by human activity. Changes to the climate affect all aspects of the natural environment and have the potential to affect the Canadian economy, infrastructure, energy supply and demand, manufacturing, and services. As a consequence, it is critical that Canada move to curb these emissions.

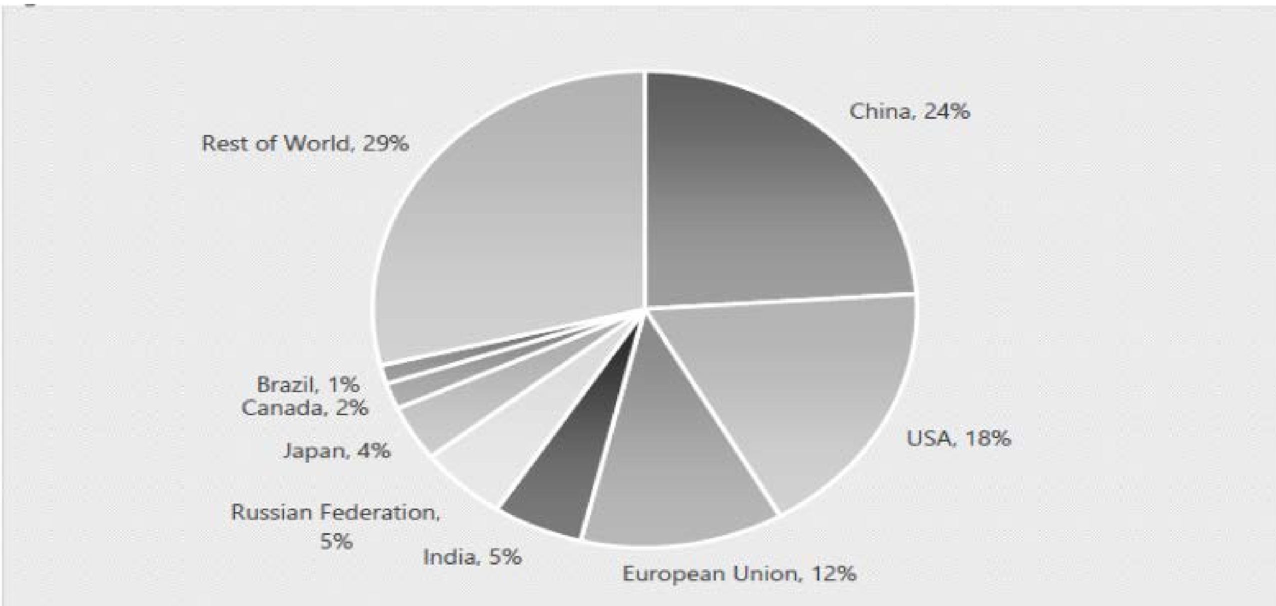
As a signatory of the United Nations Framework Convention on Climate Change (UNFCCC), Canada signed onto the Copenhagen Accord (December 2009) thereby committing to reduce its GHG emissions to 17% below 2005 levels by 2020. The commitment represents a significant challenge for an expanding economy that is expected to be 31% larger in 2020 than it was in 2005 (Environment Canada 2014). In order to follow through on this commitment the Government of Canada is taking a sector-by-sector approach to GHG regulation and reduction.

Canada's GHG emissions are largely related to the production and use of energy across the country. A review of all energy-related emissions is provided in the pages that follow, along with projections of future energy use. It is shown that oil and gas, transport, and buildings are the sectors most responsible for our increased emission profile. Growth in industrial and transport energy use will demand significantly more fossil fuel unless policy interventions push us towards 'greener' scenarios; using projections from the Trottier Energy Futures Project (TEFP 2016), two such scenarios are explored, one focused on sustainable urban development, and the other on a future where new electricity generation from nuclear sources is constrained. In both of these scenarios, the amount of electricity used in every sector increases dramatically. This suggests that a critical issue of the future will be designing new electricity generation in order to benefit both society and the workers who are engaged in the projects.

Four critical research topics are identified at the end of this report, focused on issues of industry and manufacturing, transport, buildings, and electricity generation. It is expected that these topics will be explored at the ACW Workshop in November, 2015, and a series of targeted research projects will be developed from these topics.

Canada in the global context

Figure 1. Distribution of world carbon dioxide emissions from fuel combustion, 2013



Source: IEA 2015

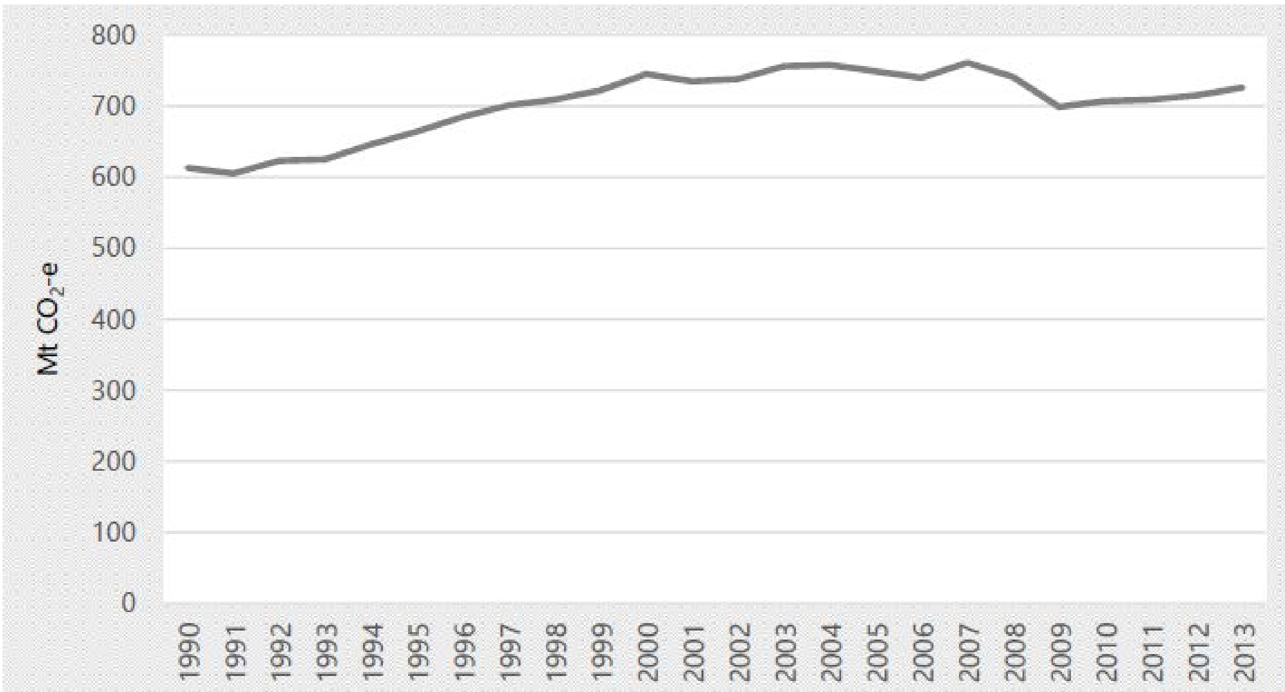
The International Energy Agency (IEA) reports on carbon dioxide equivalent (CO2-e) emissions from fossil fuel combustion. In 2013, Canada's CO2-e emissions were 726 Mt, amounting to approximately 2% of the global CO2 emissions that year. China led the world in CO2 emissions contributing 24% (7259 Mt CO2-e) of global emissions, followed by the USA (5369 Mt CO2-e or 18%) and the member states of the European Union (3660 Mt CO2-e or 12%) (IEA 2015). Over a third of CO2-e emissions worldwide come from the USA and China. It is worth noting that Canada emitted approximately 20.7 t CO2-e/capita/year in 2013, compared to 17 t CO2-e /capita in the USA and 5.3 t CO2-e /capita in China.

The primary source of anthropogenic CO2 emissions is fossil fuel combustion for energy production; this accounted 89% of total anthropogenic CO2 emissions in 2011 (IEA 2015). Though CO2 is the most prevalent GHG emitted, there are a cocktail of other gases that contribute to GHG emissions. Inventory estimates from the International Panel on Climate Change (IPCC) on GHG emission from anthropogenic sources include CO2, methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF6), and nitrogen trifluoride (NF3). In 2011 Canada's emissions were 79% CO2, 12% N2O, and 7% CH4; these three gases account for 98% of the emission produced (Environment Canada 2014).

Implications: As a signatory to the Copenhagen Accord of 2009, Canada committed to a 17% reduction in CO2-e emissions, under 2005 levels, by 2020 (Pew Center 2010). As 2005 emissions were 749 Mt CO2-e, this translates to a commitment to reduce emissions by 127 Mt, taking us to about 622 Mt of CO2-e emissions by 2020. Achieving this goal would require reductions of approximately 15 Mt CO2-e per year from 2013 to 2020, which is equivalent to almost 0.5 t/capita/year. While a small player in terms of total global emissions, Canada is one of the worst offenders in terms of per capita emissions, and achieving our climate goals will require every Canadian to find ways to make significant reductions on an annual basis.

Historic trends in Canada's GHG emissions

Figure 2. National GHG emissions for Canada, 1990 to 2013



Source: Environment Canada 2014

Canada's total GHG emissions for 2013 were 726 Mt CO2-e, which is 18% higher than 1990 levels of 613 Mt CO2-e. Between 1990 and 2005 there was a steady increase in GHG emissions followed by fluctuations and a steep decline in 2009 (see Figure 2), which was largely caused by the global financial crisis. Canada reached peak emissions to date in 2007 at 761 Mt CO2-e. In order for Canada to keep its commitment to the Copenhagen Accord there will need to be a significant reduction in GHG emission over the remaining years to reach 622 Mt CO2-e by 2020.

In the period since 1990, Canada has attempted to address GHG emissions via a number of different plans and strategies enacted by the Federal government. Notable among these include Canada's Green Plan (1990), the National Action Program on Climate Change (1995), our commitments to the Kyoto Protocol (1997), the Action Plan (2000), the Climate Change Plan for Canada (2003), and Project Green (2005). Three of these plans (Kyoto, the Climate Change Plan for Canada, and Project Green) were designed to achieve the international Kyoto Protocol target of 6% below 1990 levels over the 2008-2012 period. As our emissions in 1990 were 613 Mt CO2-e, the goal would have been 576 Mt (Canada 2010).

Implications: The relative lack of success in dealing with national emissions may be in part attributed to the lack of engagement with Canadians on the best ways to deal with the problem. A top-down, target approach without practical measures that can be implemented by provinces, municipalities, employers and citizens is essentially doomed to failure. Future plans for climate action must include discussion with these stakeholders, in the form of real engagement, in order to manage issues around lack of data, low levels of public involvement, and cause-and-effect issues (see Cloutier et al. 2015).

Sectoral analysis of Canada's GHG emissions

Table 1. GHG emissions by economic sector (Mt CO2-e/year) excluding LULUCF

	1990	**2000**	**2005**	**2011**	**2012**
Transportation	128	155	168	170	165
Oil and Gas	101	150	162	163	173
Electricity	94	129	121	90	86
Buildings	70	82	84	84	80
Emission Intensive and Trade Exposed	93	85	87	78	78
Agriculture	54	66	68	68	69
Waste and Other	50	51	49	49	47
National Total	**591**	**718**	**737**	**702**	**699**

Source: Environment Canada 2014

The Government of Canada has decided to follow a sector-by-sector approach to regulate GHG emissions. The National Inventory Reports (NIR) delivered to the UN Framework Convention on Climate Change, Canadian Environmental Sustainability Indicators, and Environment Canada all document Canada's emissions by economic sector or origin (Environment Canada 2014). The most recent report from Environment Canada uses data from 1990 to 2013 to determine historical trends and produce future predictions. Emissions growth over the given timeframe can be attributed primarily to fossil fuel and transportation sectors, which account for the majority of GHG emissions. Electricity also played a large part in the steady increase from 1990 to 2005 but has since decreased significantly, largely due to the decision of Ontario to phase out coal-fired generation. A notable decline occurred in 2009 where Canada's economy endured a recession. Data shown in Table 1 above highlights the challenge that transportation (165 Mt in 2012) and oil and gas (173 Mt in 2012) pose for an emission reduction strategy. It is worth noting that emissions intensive, trade-exposed industries (including cement production and metals) and waste-related emissions have declined since 1990, due to improved technologies. Buildings and agriculture have contributed to a slight increase in overall emissions (Environment Canada 2014).

Implications: The data highlights the challenge that the oil and gas sector and transportation hold for Canada. Growth in these emissions has been consistent over a 22-year period, with oil and gas rising by 71% in that period and transportation rising by 56%. Electricity emissions, on the other hand, peaked and have now dropped below rates seen in 1990, reflecting the actions of different provinces to manage those emissions. Many climate policies have focused on electricity generation as this is a sector typically controlled by the provinces, with a small collection of very large emitting plants that can be managed relatively easily through policy. Other sectors, including buildings and agriculture, have more modest growth in emissions that are likely more reflective of population pressure than increasing emission intensity. The increase in agricultural emissions, for example, was 15 Mt (28% growth) between 1990 and 2012 and mainly consists of methane and nitrous oxide emission from livestock and crops.

Projected emissions trends by sector

Table 2. Change in GHG emissions by economic sector (Mt CO_2 e/year)

	2005	**2012**	**2020**	**% Change, 2005-20**
Transportation	168	165	176	5%
Oil and Gas	162	173	200	23%
Electricity	121	86	82	-32%
Buildings	84	80	95	13%
Emission Intensive and Trade Exposed Industries	87	78	90	3%
Agriculture	68	69	69	1%
Waste and Other	49	47	50	2%
Expected LULUCF Contribution	n/a	n/a	-28	n/a
National Total	**737**	**699**	**734**	**-0.4%**

Projected emissions trends are based on the Environment Canada report “Canada’s Emissions Trends”, October 2014. To date there has not be a national level report completed that includes data beyond that collected in 2012. Main drivers of GHG emissions in Canada will continue to be economic growth, population growth, and the mix of energy supply. Thus GHG emissions projections rely heavily on the ability to correctly predict changes in these areas and derive assumptions from them.

The emissions scenarios presented in “Canada’s Emissions Trends” rely on a key set of assumptions. Economic projections are based on data from Finance Canada’s Private Sector Survey and Economic and Fiscal Implication of an Aging Population reports. The mix of energy supply was based on the National Energy Board’s projections. Key assumptions and variables incorporated in the model included oil sands production, hydroelectricity capacity expansion, and nuclear refurbishment or additions. Existing government policy is incorporated in order to predict changes in consumer and business behaviour in response to these policies. Technological change, on the other hand, is not modeled beyond existing trends as it is very difficult to anticipate disruptive technology impacts.

Implications: Based on this modelling exercise, it is anticipated that the national GHG emissions for 2020 will be 734 Mt, down 15 Mt from the 2005 baseline year for the Copenhagen Accord, but still 112 Mt higher than our target. The scenario actually predicts a rise in GHG emissions from 2012, when Canada's economy was still mired in recession and emissions hit a low point of 699 Mt CO2-e. It is anticipated that Canadian GHG emissions per capita will experience a small drop, from 20.4 T CO2e to 20 T CO2e (Environment Canada 2014). This is a sign of improved policies, technologies, and overall efficiencies in most economic sectors, but is not nearly enough to meet our current target under the Copenhagen Accord.

The model predicts that the key sectors where growth in emissions may be expected are oil and gas (increased to 200 Mt by 2020, or 23% over 2005 levels), transportation (increase to 176 Mt by 2020, or 5% over 2005), and buildings (increase to 95 Mt by 2020, or 13% over 2005). Less worrisome are emissions from emission intensive industries (3% growth), agriculture (1% growth), and waste (2% growth). Electricity is anticipated to contribute to emission reductions with a 32% drop in emissions, down to 82 Mt from 121 Mt in 2005. Overall, it can be seen that the key areas for climate action are industrial emissions (mostly related to oil and gas), transportation, and buildings.

Trends in transport emissions

Table 3. Transportation sector emissions (Mt CO2e)

	2005	**2011**	**202**	**% Change, 2005-20**
Passenger Transport	96	96	90	-6%
Cars, Trucks, and Motorcycles	*87*	*88*	*81*	*-6%*
Bus, Rail, and Domestic Aviation	*9*	*8*	*9*	*0%*
Freight Transport	57	61	70	23%
Heavy-Duty Trucks, Rail	*49*	*54*	*61*	*24%*
Domestic Aviation, and Marine	*8*	*7*	*9*	*13%*
Other: Recreational, Commercial, Residential	14	13	15	7%
Total*	**168**	**170**	**176**	**5%**

Source: Environment Canada 2014

*Numbers may not add up due to rounding.

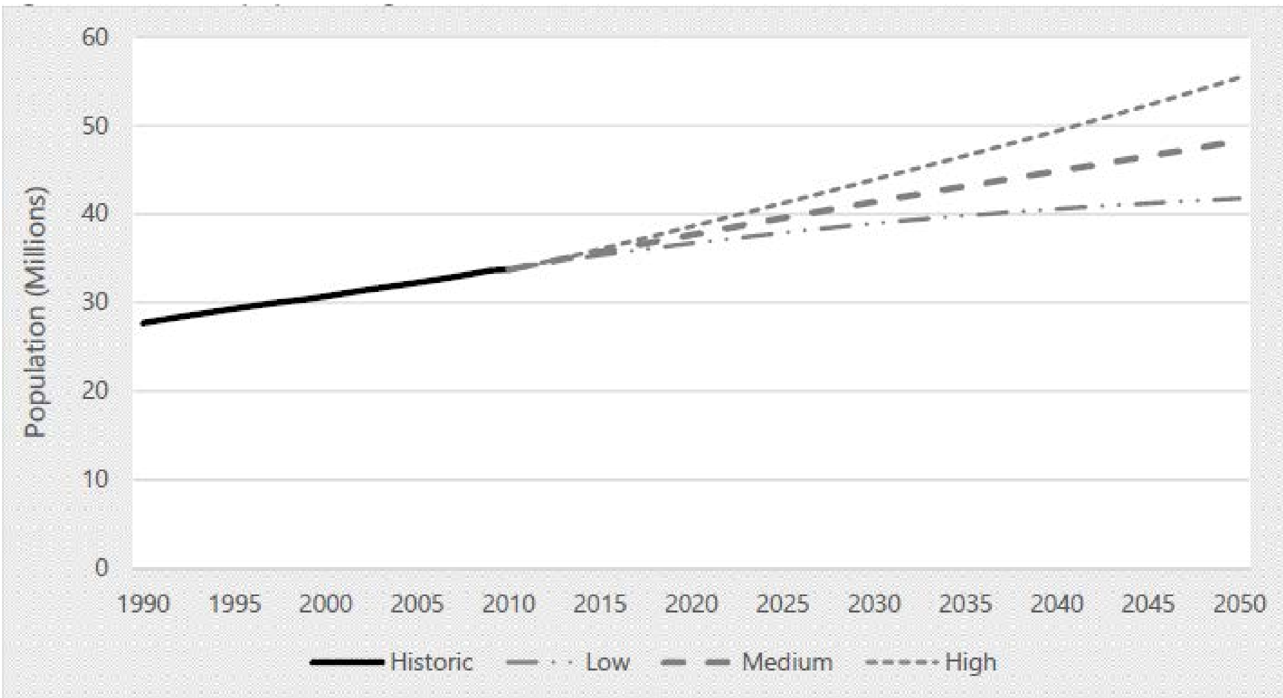
As noted previously, between 1990 and 2005 emission from the transportation sector grew from 128 Mt to 168 Mt of CO2-e (31% growth), which is faster than population growth over the same period (about 28%, as described in the next section), suggesting increasing intensity of use on a per capita basis as well as real emission growth. Growth in transport emissions over this period may be linked to economic growth, relatively low oil prices, and a shift from cars to light-duty trucks. Since 2005, transportation emissions risen to about 170 Mt CO2-e (2011) and are anticipated to rise to 176 Mt CO2-e by 2020, suggesting 5% growth over 15 years. This is likely to be lower than the rate of population growth, which will likely be about 18% over the same 15 year period, which may be attributed to increasing regulation on fuel efficiency, cleaner fuel options, and renewable content fuel requirements.

The change in transport emissions becomes more interesting when one breaks down the sector into light- duty (primarily passenger vehicles), heavy-duty (primarily trucks), and other forms of transportation. As shown in the Table above, heavy-duty trucks and rail transport emissions are anticipated to rise by 24% by 2020, adding 12 Mt CO2-e over 2005 levels. Domestic aviation and marine travel will rise by 13% (or 1 Mt) in the same period. By contrast, passenger transport is anticipated to drop by 6 Mt or 6% by 2020. This suggests that two trends are present; a shift towards lower-emission passenger vehicles (including hybrids and electric vehicles) combined with changing lifestyles and conservation which are reducing vehicle km travelled, and an intensifying trend around the shipment of goods and materials via truck and rail which are driving up emissions from that component of the sector. Commercial and recreational

Implications: A strategy to manage emissions from the transport sector should incorporate two distinct sections. The first should address passenger vehicle emissions and energy use, and should seek to strengthen the ongoing trend towards reductions. The second should address heavy duty vehicles, particularly trucks and rail travel. While Canada has introduced a focus on aerodynamics and tires to improve vehicle fuel use in transport trucks (Kodjak et al. 2015), these policies have not yet led to any measurable reduction in absolute energy use or GHG emissions. A shift towards bio-based fuels, coupled with smarter work strategies, may help to address GHG emissions in heavy-duty transport in the future (Graham et al. 2008).

Projected population growth

Figure 3. Estimated population growth to 2050



Source: Statistics Canada 2015a (Historic), 2015b (Projections)

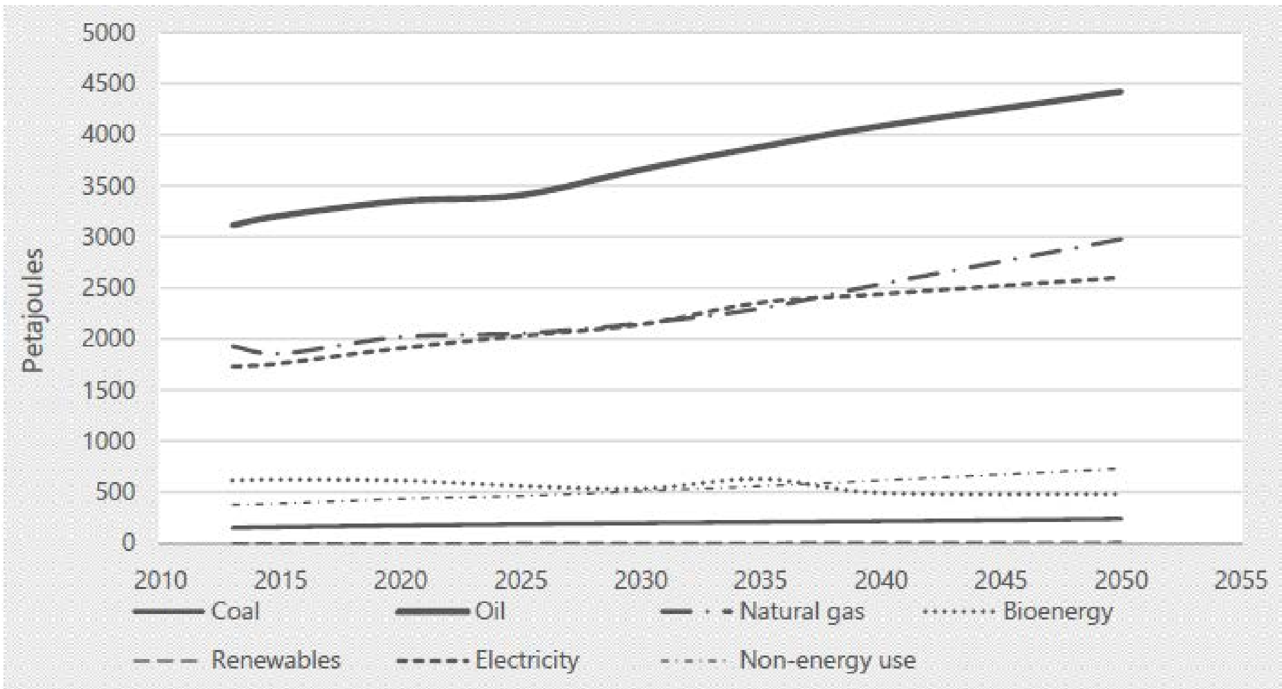
Canada currently has a population of just over 35 million people, with relatively rapid growth since 1990 of about 1.2% per year, suggesting that we are adding about 400,000 people to our population per year (Statistics Canada 2015a). It has been shown that natural increase (births within the country) now contributes about one third of our population growth, with migration providing the remainder (Statistics Canada 2015c).

Projections for our population have been provided to 2050 by Statistics Canada, suggesting that we could have a population in that year ranging from just under 42 million (following a 'low growth' scenario) to as high as 55 million (following a high growth scenario), which translates to annual growth rates of between 0.5% and 1.6%. Following the business-as-usual trend, our population would be 48 million by 2050, suggesting an annual growth rate of 1.1%.

Implications: Increased growth in population will put extra pressure on energy demand and thus GHG emissions. Adding 7 million people to our population (the difference between a medium and high- growth scenario) suggests that significantly more reduction in per capita emissions must take place to maintain a negative trend in overall emissions. It has been noted by some authors that Canada's relatively weak performance in terms of bringing down emissions to date may actually mean that there is an opportunity to reduce emissions over a short-term horizon (Hamilton and Turton 2002); however, in the face of significant population growth, such gains could be easily wiped out by overall increases in demand. Other authors, however, suggest that a strategy to manage increased population growth is a combined strategy of urban densification, which can house people at a lower energy cost (Liu et al. 2015). This suggests that a future strategy for reducing Canada's emissions must incorporate a plan to accelerate densification trends in major urban areas across the country.

Changes in baseline energy supply

Figure 4. Predicted changes in baseline energy supply



Source: TEFP 2016

Total energy supply (without counting energy products used for non-energy purposes, such as oil used for chemical production) is anticipated to rise from about 7540 petajoules (PJ) in 2013 to 10730 PJ in 2050, if all current trends continue and energy resources are developed at their current pace. This represents a 42% growth in energy supply, which is likely a little bit more growth than we can expect in our population, suggesting that overall energy supply is becoming greater on a per capita basis. The energy mix is dominated by oil (41%), natural gas (28%), and electricity from a range of sources (24%). Bioenergy and renewables play a relatively small role (<6%); coal currently sits at just over 2% of energy supply. It is worth noting that there is very little growth expected in energy supply outside of oil, natural gas, and electricity.

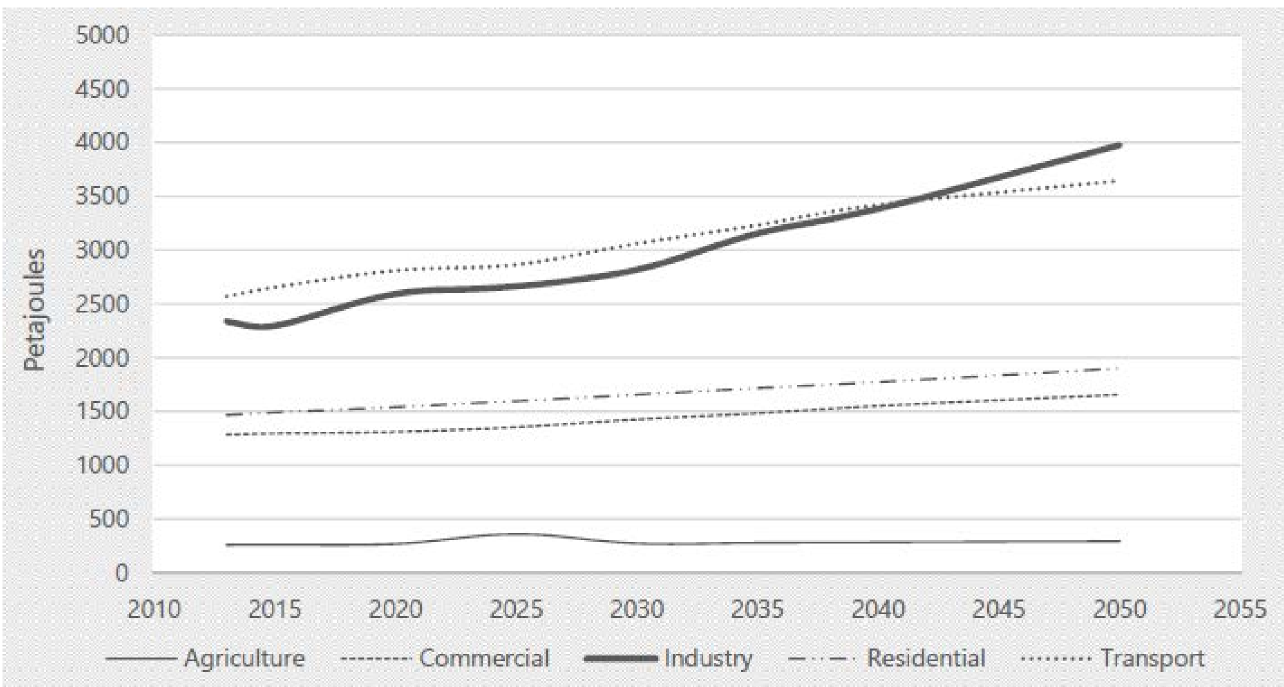
The continued development of fossil fuels is of primary concern here. This development is linked to GHG emissions which are increasingly recognized as detrimental to the climate and society's future. Canada is less reliant upon fossil energy than other nations, as the proportion of electricity in our energy supply is high and the amount of energy produced from renewable sources is higher than in most nations. Canada has some nuclear capacity (about 1000 PJ at the current time); but the remainder of our capacity is largely based on hydroelectric and some emerging renewable sources (wind and solar); legacy coal-fired generation exists in Alberta and

Saskatchewan, but one may expect that the majority of this capacity will be phased out in coming years.

Implications: The baseline trends do not support a widely energy-efficient society, as it is suggested that growth in supply will outstrip medium projections of population growth. The proportion of fossil energy used in the baseline scenario will increase without policy intervention. The overall reliance upon oil for energy will increase, although there is a slight uptick in the use of fossil sources for non-energy purposes. This strongly suggests that Canada cannot proceed based on our current policies and trends, and that intervention in terms of policy to support energy conservation (to reduce intensity) and renewables (to reduce GHG emissions and environmental footprint) will be essential.

Changes in baseline energy demand

Figure 5. Predicted changes in baseline energy demand by sector



Source: TEFP 2016

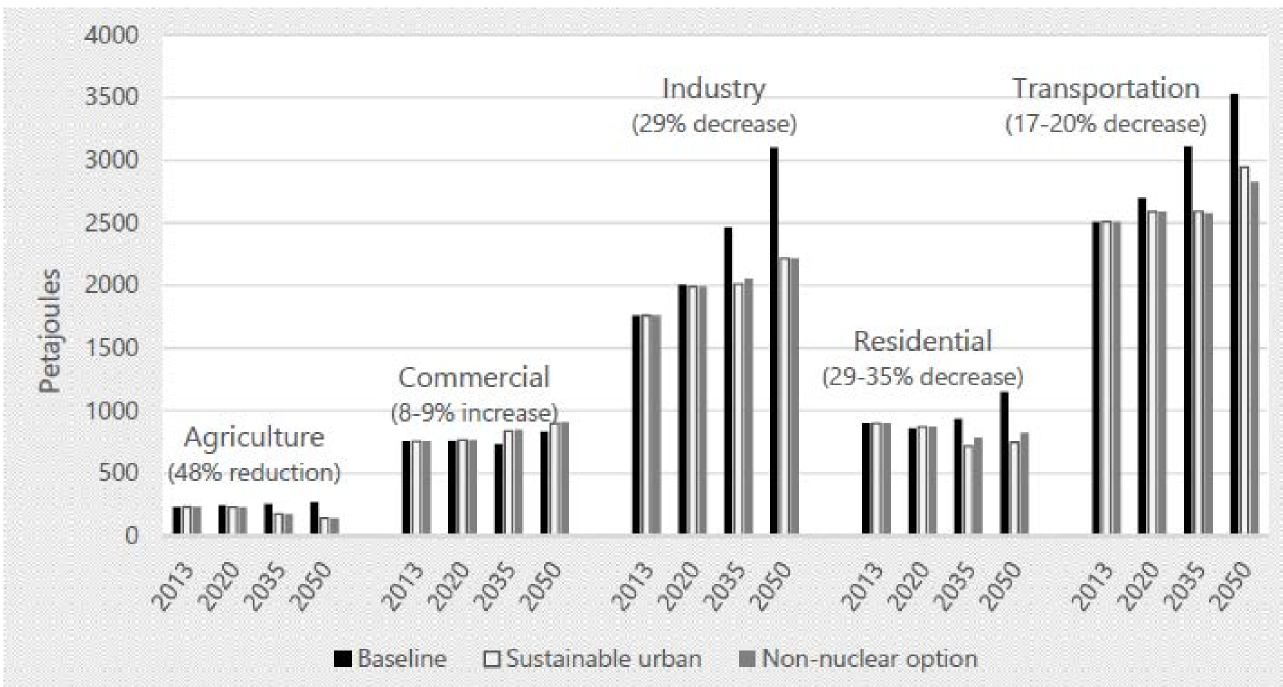
Increases in baseline energy demand across Canada is dominated by industrial energy demand, which is anticipated to rise from about 2400 PJ in 2013 to about 4000 PJ in 2050, a rise of 65%. The demand for energy for transport will also rise dramatically, from 2600 PJ in 2013 to about 3600 PJ in 2050 (about a 40% increase). Demand for residential and commercial energy is also growing quickly, each seeing about a 400 PJ rise which is equivalent to approximately 30% increase in demand. Only agriculture has no large increases predicted in baseline energy demand.

The growth in industrial energy demand and transport energy demand both exceed medium population growth estimates. Industrial energy demand growth is driven largely by oilsands operations and by potential increases in manufacturing. Transportation demand increases reflect the trend in shipping (which is driving up heavy-duty emissions) and rapid population growth. For residential and commercial energy use, the fact that demand for energy will likely lag population growth suggests a slight decline in energy intensity, but still represents a challenge in terms of being able to reduce absolute energy demand.

Implications: Canada's economy will see dramatic increases in demand for energy across all sectors in coming years. While industrial energy and energy for transport stand out as priority areas, it will be important to address residential and commercial energy demand as well. Without a comprehensive strategy, Canada's energy demand will continue to intensify relative to our population growth, and the majority of this intensification will utilize fossil fuels and lead to increased emissions.

Cross-sectional interactions - Energy (Fossil fuels)

Figure 6. Predicted growth in fossil fuel use by sector (potential % change by 2050)



Source: TEFP 2016

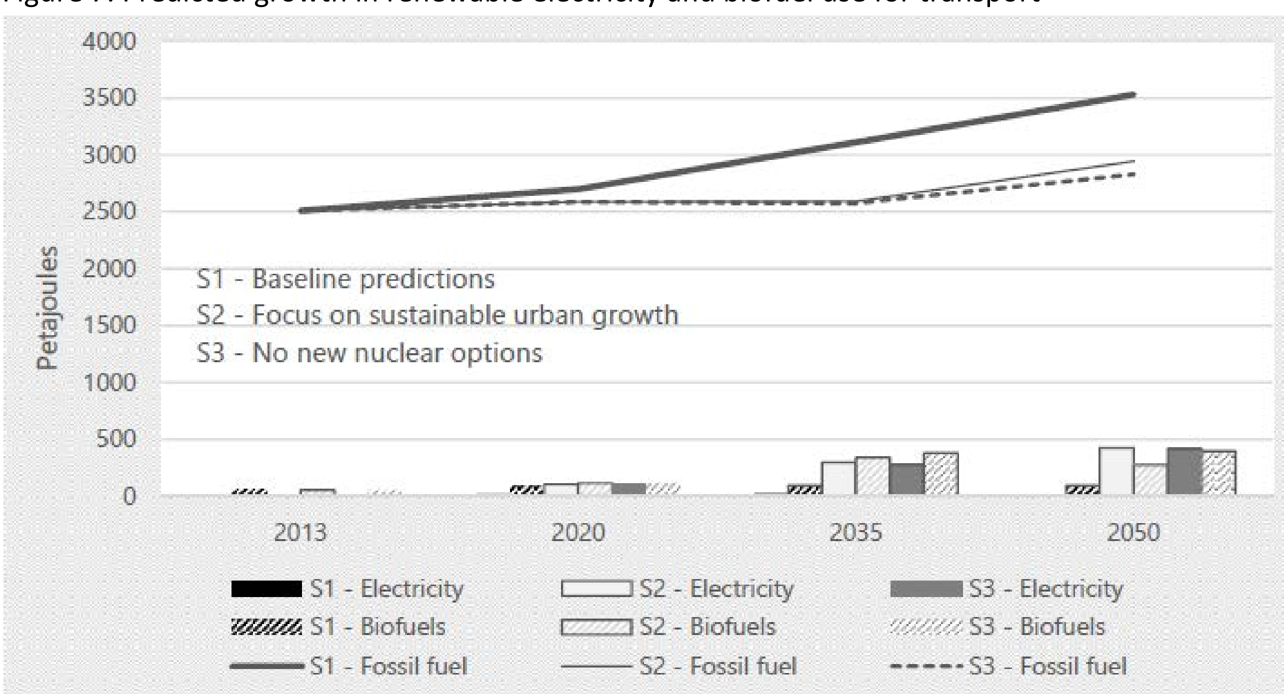
The figure above shows the potential for Canada to develop scenarios of energy development that will reduce fossil fuel consumption. Four of the five major areas identified here (all but Agriculture) are predicted to see increases in overall fossil energy use along the baseline projection. The most dramatic growth in fossil energy use is seen in industry and in transportation, as discussed previously. Two scenarios for more progressive energy development are shown: one where the focus is increasingly on sustainable urban design, and one where the principles of urban densification are kept but new nuclear power options are taken away from the electricity supply. The results of modeling these scenarios are illustrated. In most cases, the shift is facilitated by twin mechanisms of conservation (less energy use) and renewable energy (usually in the form of electricity).

It can be seen that from 2013 to 2050, shifting to a more sustainable pathway could reduce fossil fuel emissions in four out of five major sectors (all but Commercial). The greatest decreases may be seen in industry energy use (which could drop 29% below the baseline), transportation (which could drop 17-20% below the baseline), and residential energy use (which could drop 29-35% below the baseline). While already very low, the development of more sustainable pathways is likely to have a tremendous impact on the energy required for agriculture (leading to up to a 48% reduction). In most of these pathways, however, a slight uptick is expected in commercial energy use (8-9% increase); this may be due to the difficulty in decarbonizing commercial spaces.

Implications: Policy interventions and proper strategy could lead to significant reductions in the amount of energy used and the overall energy footprint associated with these sectors. The development of sustainable urban landscapes - for example, the introduction of new rapid transit options coupled with higher density and congestion charges - could reduce demand for transportation and residential energy. Better practices in industrial settings could reduce the need for energy in manufacturing and other raw material processing. The results highlight the challenges associated with energy reductions in commercial activities, but suggest that the scale of opportunity associated with other sectors is very large.

Cross-sectoral interactions - Energy (Electricity and transport)

Figure 7. Predicted growth in renewable electricity and biofuel use for transport



Source: TEFP 2016

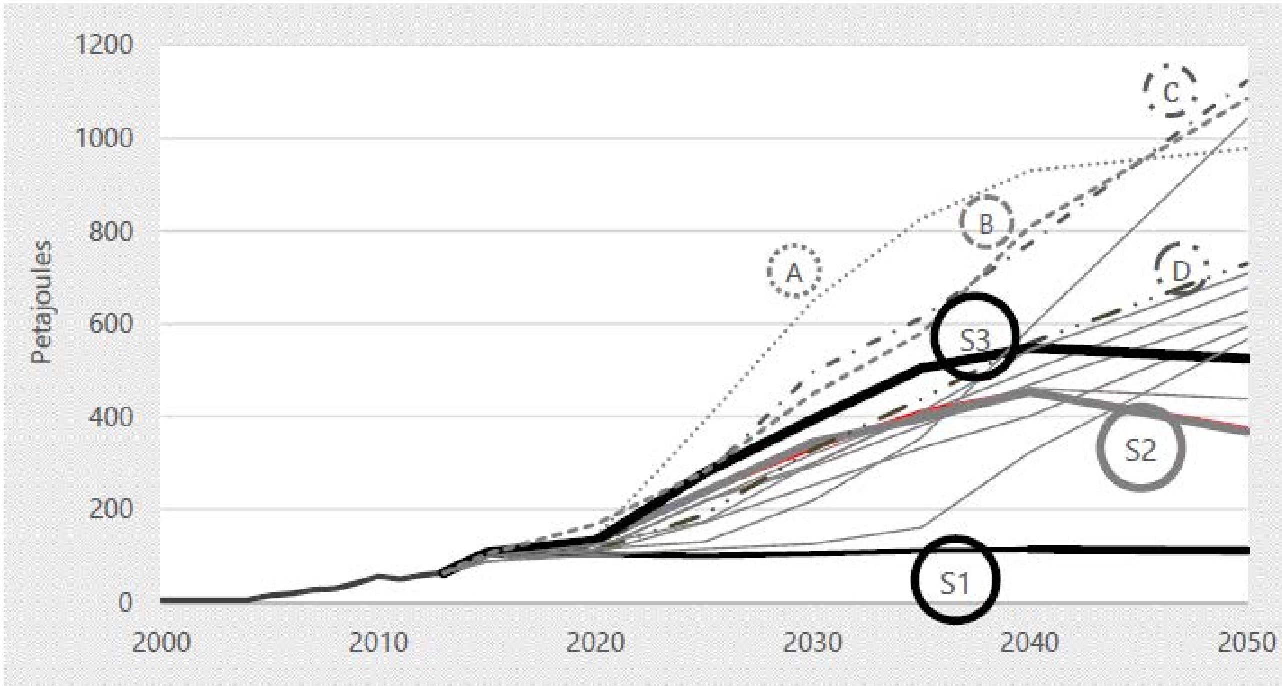
The amount of electricity and biofuel used in transport must rise in order to seriously impact the amount of fossil energy required for transport. In this figure, scenarios that focus on sustainable growth and that constrain any future nuclear options are compared to a baseline energy consumption projection to 2050. It can be seen that significant changes may be expected in the energy sector. While all scenarios still see a rise in fossil energy for transport by 2050, in the more sustainable scenarios this rise is limited to 13% over 2013 values (no nuclear options) or 17% (focus on sustainable growth). At the same time, the amount of energy used for transport taken from other sources - biofuels and electricity - increases dramatically. In a sustainable urban development scenario, the growth in electricity for transport will rise by 100-fold, compared to a 3.5-fold rise in the baseline case. In a nuclear-constrained future, the rise in electricity is almost as dramatic (98-fold). Biofuels will also rise significantly in these scenarios; compared to baseline growth of 72%, a focus on sustainable urban development will see an increase of 393%, while a future with less electricity will see biofuel use rise by 611%.

Implications: In sustainable futures, the scale of the opportunity associated with electrification and biofuel development are similar. In regards to electrification, opportunities will largely be associated with manufacturing - a retooling and expansion of auto parts manufacture is possible, as electric vehicles require different components. Additional electricity production will be required, suggesting new jobs in renewable power generation or (depending upon the scenario) nuclear plants. The complexity of the electrical grid will also increase, requiring more workers in distribution and transmission. One study, carried out in Nepal, suggests that increasing the amount of traffic carried by electrified transit from 10% to 20% could result in employment gains of 220%, as the number of people required to build and operate the expanded grid rises (Shayka and Shrestha 2011).

In regards to biofuels, the greatest opportunities are likely found in the production of biomass, as the actual vehicles are not significantly different from existing internal-combustion engine vehicles found on the road today. This is discussed in more detail on the next page.

Cross-sectoral interactions - Energy (Biofuels and transport)

Figure 8. Predicted growth in biofuel and bio-based electricity use for transport (all scenarios)



Source: TEFP 2016

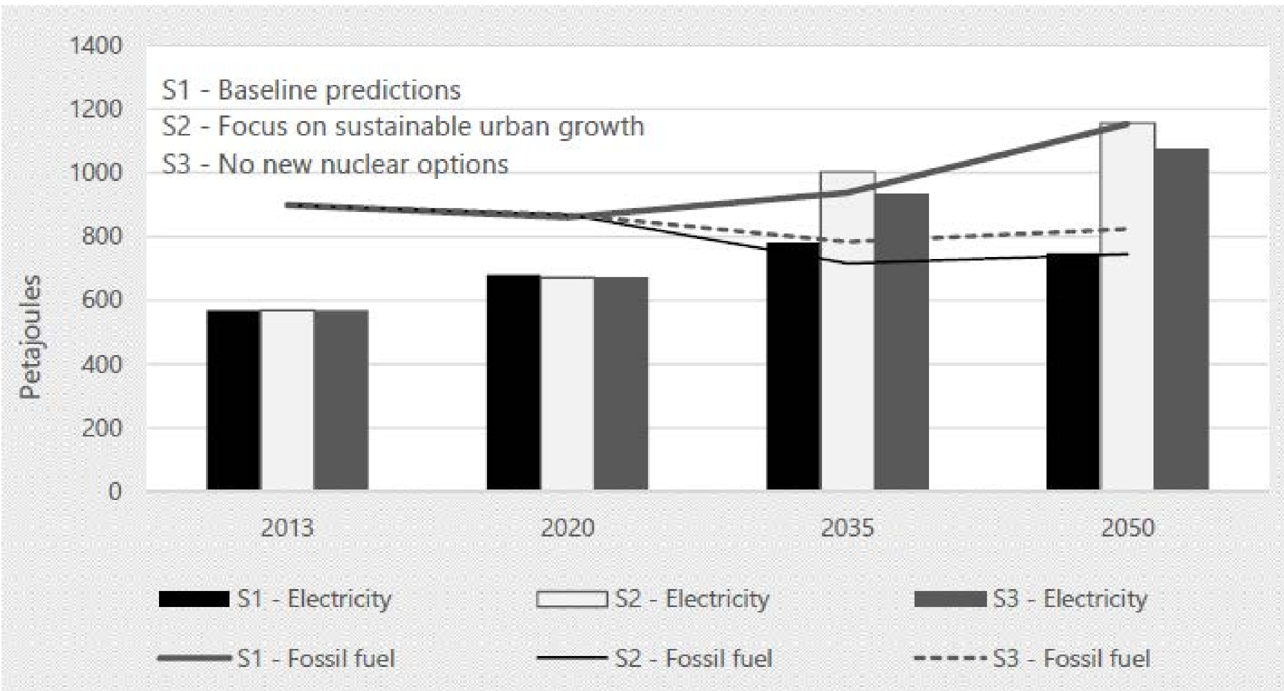
The three scenarios described earlier (S1 as a baseline, S2 as a shift to sustainable urban development, and S3 representing a future with no new nuclear capacity) are represented by the thick lines as noted on the figure. It can be seen that without policy intervention actively promoting a shift to renewable energy, the baseline would remain roughly where production sites right now, at just over 100 PJ equivalent of biofuels (primarily ethanol with some biodiesel). In the two more aggressively 'green' scenarios, biofuel production would rise by a factor of 4 or 5x. The sustainable urban future would demand less biofuel, largely because more personal mobility (light duty vehicles) would shift towards electric cars. In a future where electricity supply is somewhat constrained by the lack of new nuclear power, however, biofuels play a more significant role (TEFP 2016, Mabee 2014). Scenarios A and B represent futures heavily dependent upon emerging technologies that use cellulosic biomass as feedstock; Scenario C replaces virtually all diesel and heavy distillates with bio-based replacements, and Scenario D is a future which is dominated by bio-based electricity distributed via the grid.

Implications: The development of biofuels will create some direct employment within production facilities, although the number of jobs associated with a single plant can be relatively low (in the range of 100 jobs for 200 million litres of fuel production). Indirect jobs associated with the production, harvest, and processing of biomass (either agricultural or forest-based) could be much more significant. As an example, consider Greenfield Ethanol, the largest biofuel company in Canada, which operates three plants in Ontario, and can produce about 10 litres of ethanol per bushel of corn used as feedstock (Greenfield Ethanol 2014). In

2012, Ontario produced about 9.6 tonnes of corn per ha (Ontario Ministry of Food Agriculture and Rural Affairs 2014); the average farm size in Ontario is about 99 ha with 1.44 farmers employed (Statistics Canada 2014). Given these statistics, one can estimate that for a single plant with capacity of 200 million litres per year – such as the Greenfield facility near Prescott, just an hour away from Kingston – the equivalent of 2,000 farmers are engaged in producing feedstock for the operation on an annual basis. Thus, policies that promote biofuel use can be seen as an important driver for green employment.

Cross-sectoral interactions - Built environment (residential)

Figure 9. Predicted growth in residential energy use



Source: TEFP 2016

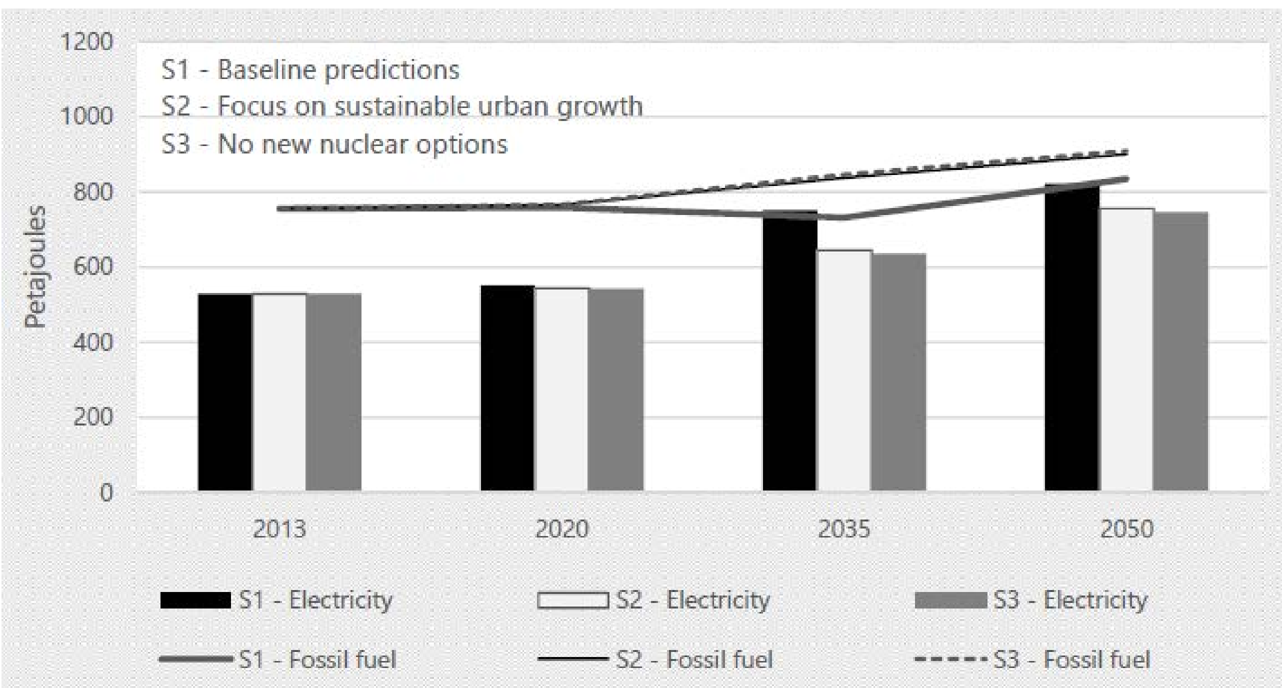
The baseline estimates for residential energy requirements suggest that fossil fuel consumption will rise by 22%, while electricity consumption in homes will increase by 24%, by 2050. As discussed in the previous section on population growth expectations, population growth between 2013 and 2015 is expected to range between 20% and 58%, with a baseline projection of about 38% growth; thus, baseline predictions on residential energy suggest that the intensity of energy use will decline over this period - the gap is met through conservation and energy efficiency. A scenario that concentrates on urban sustainability could improve upon this trend, largely by shifting fossil energy consumption to electricity sourced from renewable resources or nuclear power. Very significant reductions in total fossil energy consumption (-20%) could be achieved following this option, while electricity consumption would rise (51%). If nuclear power is excluded, fossil consumption would only decline by 9%, and electricity consumption would be slightly curtailed with growth of 47%.

Implications: A significant portion of future energy requirements are being met through conservation; based on the results of a recent European study, it is estimated that every C$85K invested in energy efficiency in residences could lead to the creation of a new job (Meijer and Visscher 2014). Other work suggests that the best job creation scenarios (including direct and indirect employment) are obtained when policies target renovation investment for existing homes (Henriques et al. 2015), rather than focusing on GDP or on employment numbers themselves. The TEFP results strongly suggest that retrofitting activities to improve energy efficiency will include shifts towards electrical-powered heating and cooling options, rather than natural gas powered furnaces, hot water heaters, or air conditioners.

New technologies such as heat pumps combined with geothermal energy sources are very likely to be an option for both single-family and multi-family dwellings, and these solutions have been shown to be highly effective in terms of reducing overall energy consumption (Ally et al. 2015). Solar panels installed in single-family and multi-family dwellings may also provide significant power. Employment opportunities are therefore likely linked to energy retrofits and new technology installation; training programs and research should support this.

Cross-sectoral interactions - Built environment (commercial)

Figure 10. Predicted growth in commercial energy use



Source: TEFP 2016

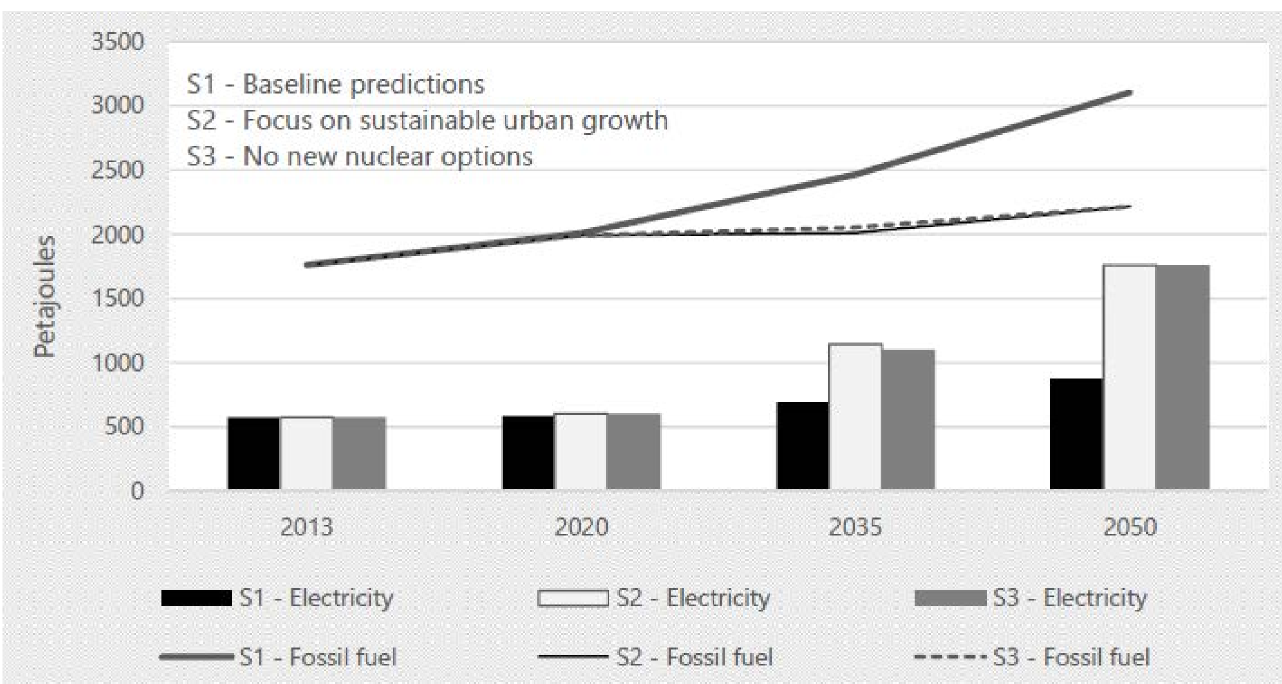
The baseline estimates for commercial energy requirements anticipate a modest rise in fossil fuel consumption (11%) by 2050, with a corresponding rise in electricity consumption (55%) over the same period. In a scenario that focuses on sustainable urban growth, the growth in fossil energy consumption would almost double compared to the baseline scenario (rising by

19-20%), while growth in electricity consumption would be less aggressive (41-43%). The absolute difference between scenarios is about 70 PJ per year. As with residential construction, commercial buildings are becoming more efficient over time when one considers that population growth is likely to be about 38% over the same period. One issue that the modeling exercise identifies, however, is that commercial real estate is likely to be less responsive to climate-positive policies and perhaps will require greater attention from decision-makers in order to promote greater energy efficiency.

Implications: Researchers have identified commercial buildings as an area where there are unique barriers to energy saving (and thus cost saving) technologies and practices. Some of these barriers include common issues such as obsolete building codes, a building sector with resistance to innovation, and a fragmented supply chain between developers, builders, and users (Peterman et al. 2014). The roles of government that could support changes in this area are the responsibility to provide a public forum and to engage with commercial partners; in both of these roles, labour can act as a key stakeholder and help guide discussion. Non-governmental approaches to improving commercial energy consumption might also be found in certification; some authors suggest that strategies for certification must be carefully assessed to address the split-incentive issue between building owners and renters (Qiu et al. 2015). Again, labour engaged in work in these buildings should be accessed to gauge their willingness to adopt such approaches. The takeaway for commercial real estate is that the barriers to adopting energy efficiency solutions are greater than in residential or pure industrial settings; extra care must be given to ensure that this sector does not fall behind.

Cross-sectoral interactions - Manufacturing

Figure 11. Predicted growth in energy use for manufacturing/industry



Source: TEFP 2016

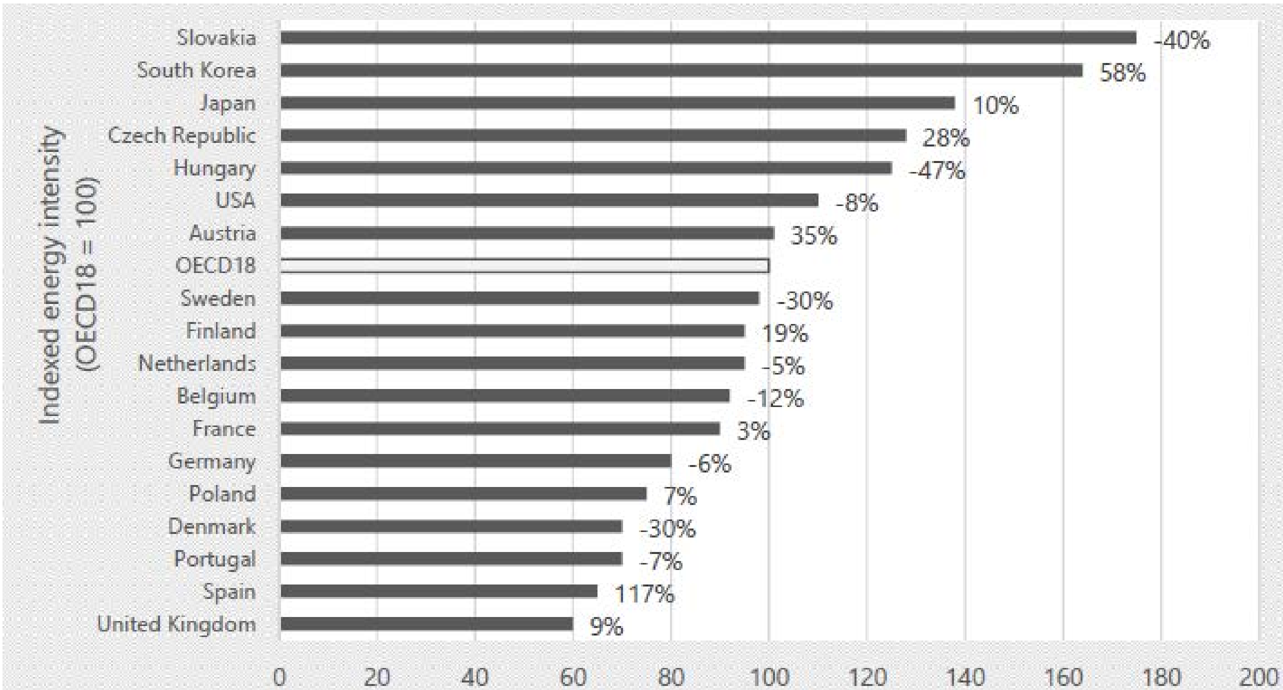
Baseline estimates for industrial energy consumption suggest that fossil energy use will increase by about 77% between 2013 and 2050, with electricity consumption rising by 51% in the same period. Pursuing greener scenarios of development - either with a focus on sustainable urban growth, or with a restriction on new nuclear development - would lead to significantly less growth in fossil energy consumption (25%), but much more electricity consumption (about 206% over 2013 levels). The lesson from the modeling exercise is clear: development of new industrial and manufacturing processes could drive significantly more fossil energy consumption, but electrification could offset much of this growth. In the more sustainable futures, fossil energy consumption would grow at a rate lower than population growth, suggesting a slow decarbonization of the manufacturing sector.

Implications: It is well known that electricity can deliver more effective energy (in terms of conversion) than most other forms of energy production; in an industrial setting, it has been shown that electricity has higher efficiency and that this efficiency is impacted by regional and climatic factors (Shui et al. 2015).

Regional barriers can include the regulatory environment. Recent work in the Netherlands has suggested that there is broad agreement between industry and government as to the barriers to achieving greater industrial energy efficiency, including lack of technologies, lack of clear information, high costs, and lack of organizational capacity (Cagno et al. 2015). A key finding is that for small- and medium-sized enterprises (SMEs), voluntary approaches to achieving energy efficiency are less effective than they are for large corporations; this is because a large company has resources to be able to implement better technologies (such as electrification) which can lower energy use, while SMEs do not have sufficient capital to be able to make these changes. The authors of the study suggest that economic incentives for lower-energy solutions be closely linked to any voluntary certification scheme (Cagno et al. 2015). Some studies indicate that energy-intensive manufacturing will see great improvements under increased regulation for energy efficiency; non-intensive manufacturing may be affected differently, and indeed may shift towards more labour-intensive options (Zhu and Ruth 2015).

Cross-sectoral interactions - Service

Figure 12. Energy intensity levels, aggregate service sectors, 2005 (indexed; OECD18=100)



Source: Mulder et al. 2014

It has been shown that a shift to the service economy has generally lowered energy intensity levels across members of the OECD (Mulder et al. 2014). Many countries that outperform the average energy intensity are also showing decreases in energy intensity, with a few notable exceptions (such as Spain, the UK, Poland, and Finland). The authors of this report suggest that there has been relatively poor energy efficiency performance across the service sectors, but point out that their results display a wide range of behaviours from country to country, suggesting that in some cases better practices have led to more effective reductions in energy intensity across the service sector (Mulder et al. 2014); best practices in these locations should be assessed, particularly in countries such as Hungary, Slovakia, the USA, and Denmark. Studies carried out in China suggest that some components of the services sector, particularly transportation, storage, mail, and telecommunications, account for much of the direct energy consumption and GHG emissions associated with services, and suggest that policies focusing on lower- emission or electric vehicles can be applied to the sector with some success (Ge and Lei 2014).

Implications: The variability in results shown in Figure 12 are an indication of how much variability is present in the broad category of services, and suggests that many different options may be available to help reduce energy intensity and emissions in these areas. Best practices should be identified that closely match the Canadian context, which would require work to select peers which have addressed a similarly- structured service sector. Lack of data on the Canadian context makes this a more challenging task. The most recent published article found by the Energy Working Group was released in 2007, and considered energy efficiency across 17 countries from 1991-2000; Canada was one of two countries (along with New Zealand) which were found to have negative trends in terms of energy-savings target ratio, which represents inefficiencies in energy utilization (Hu and Kao 2007). The results of this work suggest that the USA, which has similar geographic issues to Canada, has done a much better job of moving towards energy efficiency.

Key suggestions: International policy

- Meeting Canada's commitment to the Copenhagen Accord would require us to **lower our emissions by 15 Mt CO2-e per year** until 2020; the 2015 Paris meeting could see **higher targets**. Achieving this type of goal requires planning across all sectors to reduce emissions. It is currently anticipated that national GHG emissions for 2020 will be 734 Mt, down 15 Mt from the 2005 baseline year for the Copenhagen Accord, but still 112 Mt higher than our target.

- Canada's energy supply is growing faster than population; we **cannot meet international commitments** based on current policies and trends, and that intervention in terms of policy to support energy conservation (to reduce intensity) and renewables (to reduce GHG emissions and environmental footprint) will be essential.

- Much of Canada's anticipated increase in energy demand is related to industrial practices in the oilsands. This increase may be abated by international policies putting **prices on carbon** and driving consumer shifts towards **low carbon fuels**. A review of these types of polices, and their potential impact on the oilsands, should be carried out in order to assess the impacts that this might have on overall Canadian energy production.

- A review should be carried out to identify **best practices** in energy and cost performance around the world (see Harvey 2013). Examples of best practices related to **energy efficiency in the services sector** may be found in Denmark, Hungary, and Slovakia (Mulder et al. 2014)

- Voluntary **certification schemes** for green buildings are emerging on the international front and should be assessed for their suitability in the Canadian context.

Analyses of **emissions by sector** can inform strategies to address energy efficiency and conservation; best practices in places like China should be reviewed (Ge and Lei 2014).

Key suggestions: Domestic policy

- Meeting Canada's commitment to the Copenhagen Accord would require us to **lower our emissions by 15 Mt CO2-e per year** until 2020, which translates to approximately **0.5 t per capita per year**. This will require a redesign of our entire energy sector, with priority focus on **oil and gas** production, **transport**, and **buildings**. It is currently anticipated that the national GHG emissions for 2020 will be 734 Mt, down 15 Mt from the 2005 baseline year for the Copenhagen Accord, but still 112 Mt higher than our target.

- Because Canada has not done well in bringing down emissions related to energy consumption, there may be a **short-term opportunity** for rapid emission reduction

(Hamilton and Turton 2002); this could take the form of closing coal-fired generators (for electricity) or improving vehicle fleet standards (for transport)

- Developing a strategy to deal with emissions at the municipal, provincial, or federal level must include discussion with these stakeholders, in the form of real engagement, in order to address key challenges: these include **lack of data**, low levels of **public involvement**, and **cause-and-effect issues** (i.e. how do you reward individuals for energy savings?) (Cloutier et al. 2015).

- Canada's energy and emissions woes are compounded by a rapid **population growth** rate, currently the highest across the G7 group of nations (1.2%). Projections of future population suggest that we could reach **48 million people** by 2050, based on medium (business-as-usual) trends. This will increase the absolute demand for energy and will make reductions in energy use or emissions that much more difficult to achieve; policies must actually aim for more aggressive reductions on a per capita basis than the current population suggests.

- Policy interventions could be very effective in lowering energy demand. **Better practices** in industrial settings could reduce the need for energy in manufacturing and other raw material processing. A strategy to manage increased population growth is a combined strategy of **urban densification**, which can house people at a lower energy cost (Liu et al. 2015).

- To address energy use in the residential sector, the policy focus should target **retrofitting** for **energy efficiency**. This has been shown to have the greatest potential for job creation (Henriques et al. 2015).

- Transport emissions are not consistent across all transport uses; growth in energy use is primarily driven by **heavy-duty trucks** and **rail transport**, which will lead to a rise in emissions of **24%** by 2020; domestic **aviation** and **marine** travel will rise by **13%** (or 1 Mt). By comparison, passenger transport emissions are anticipated to drop by **6%** by 2020. Thus, the policy focus should be on reducing energy in heavy-duty transport, aviation, and marine uses.

- Even a 10% increase in **electrification** of transport could result in very large employment gains, as the number of people required to build and operate the expanded grid rises (Shayka and Shrestha 2011).

- With respect to energy use in buildings, federal policy should build on international best practices and support provincial building codes and consider **national targets** that each province could work to meet.

- Centralized government policy approaches can be seen as static; **identifying government roles** across a network (commissioner, interpreter, marketer, user) and then focusing on different roles to achieve different outcomes may be necessary (see

Peterman et al. 2014). In Canada, national goals might be set via the commissioner role; labour might interact with government in its role as an interpreter or as a marketer.

Certification schemes that support both energy conservation and better energy generation approaches should be considered for their suitability in Canada, particularly for use with commercial real estate. These schemes have been shown to be less effective with industrial energy consumption unless they are closely linked to economic incentives to actually implement lower-energy solutions (Cagno et al. 2015).

Key suggestions: Law

- Conservation strategies seem to be having an impact on **electricity consumption**. These strategies are often rooted in policy and regulation. A review of existing policies across the provinces could identify **best practices** for driving a conservation culture, and highlight strategies that are working to reduce electricity consumption across the country. These strategies could then be applied on a province-by-province basis to help accelerate the declining trend in electricity consumption.

- To address energy use in heavy-duty transport, Canada has introduced a focus on **aerodynamics** and **tires** to improve vehicle fuel use in transport trucks (Kodjak et al. 2015). These policies have not yet led to any measurable reduction in absolute energy use or GHG emissions, however; it may be that a regulation increasing the use of **bio-based fuels**, coupled with incentives for smarter work strategies, may help to address GHG emissions in heavy-duty transport in the future (Graham et al. 2008).

- To address energy use in buildings, **building codes** should be updated to reflect increasing standards of energy efficiency. Targets for energy savings or **conservation** related to heating and cooling should be considered. New technologies (**heat pumps, ground source energy**) should be facilitated to meet these goals as these technologies have been shown to provide significant energy savings (Ally et al. 2015). Overlapping and obsolete building codes should be scrapped (Peterman et al. 2014); a regular review of provincial building codes, with oversight from the federal level, could achieve this goal.

To address energy use across multiple sectors, many countries have focused on **voluntary standards**. Research suggests that **economic incentives** for **lower-energy solutions** be closely linked to any voluntary certification scheme; this is particularly true when trying to engage small- and medium-sized enterprises (Cagno et al. 2015).

Key suggestions: Work design

- Key sectors that must be addressed in a Canadian climate strategy include **oil and gas** production, **transport**, and **buildings**. Growth in these emissions has been consistent over a 22- year period, with oil and gas rising by 71% in that period and transportation rising by 56%.

- Future growth in these sectors are dominated by oil and gas (**23%** over 2005 by 2020), transportation (**5%** over 2005 by 2020), and buildings (**3%** over 2005 by 2020). Work design can impact the way that we interact with resources, the ways in which we move materials and people, and the ways in which we utilize commercial and industrial buildings.

- Current trends suggest that Canada's energy supply will see **42%** growth by 2050, outstripping gains in population (estimated to be 38%); this suggests that the current trends in energy use across all sectors is becoming more **intensive**.

- Predicted increases in energy demand are mostly positive: **65%** rise in energy use in the industrial sector; **40%** increase in energy for transport; **30%** rise in demand for residential and commercial energy.

- Electricity use is a critical sector but one in which usage is currently dropping; the intensity and overall consumption of electricity is declining across Canada. From a work design perspective, the focus should be on **maintaining the declining trend in electricity use** and encouraging the positive behaviours that have led to this decline.

- It has been shown in China that non energy-intensive manufacturing may respond to increased regulation around energy conservation/renewable energy use by shifting to a **more labour- intensive paradigm** (Zhu and Ruth 2015). It would be worthwhile to explore these types of responses in the Canadian context

- In **transport-heavy sectors** (mail and couriers, shipping, etc.) policies to promote alternative- energy vehicles and lower-impact work practices should be promoted (Ge and Lei 2014).

- A shift to **bio-based fuels** could lead to a dramatic increase in **employment** - it is estimated that approximately **10 people** in the supply chain would be employed for every **million litres** of additional production.

- In the building sector, is estimated that every **C$85K** invested in **energy efficiency** in residences could lead to the creation of **1 new job** (Meijer and Visscher 2014). Installing renewable energy technologies in existing homes is a likely strategy to increase overall energy efficiency (Ally et al. 2015); training programs and research should support skills for energy retrofits, renewable energy installations, and monitoring.

Barriers to improving energy use in commercial real estate include **obsolete building codes**, a building sector with **resistance to innovation**, and a **fragmented supply chain** between developers, builders, and users (Peterman et al. 2014). Research is required to crate links between owners and users.

Potential research topics

1. **Industry and manufacturing**: The most critical sector is that of oil and gas production. What steps can be taken to decarbonize the industrial sector? A case study approach could identify energy use across different components of an operation (extraction, processing, and transport). Survey work would provide labour-level insight into work practices that would reduce energy use or shift use towards non-emitting sources (electricity). This work can be informed by international best practices, in terms of policy and regulation, designed to facilitate these shifts. The Canadian landscape for policy and regulation also needs to be explored. The impact of current international discussions (i.e. Paris 2015) on this sector needs to be assessed, both in terms of Canadian policy response and international efforts in this area.

2. **Transport**: The critical problem related to transport is heavy-duty transport, followed by aviation and marine fuel use. What can be done to reduce the km travelled by trucks and rail by following better work practices? A survey of workers in this area can be used to identify opportunities for emission reduction. Current policies focused on aerodynamics or tires could be augmented by alternative fuels (biofuels) or multi-modal approaches (shift to rail); can we assess the potential impacts of these shifts coupled with improved work practices? This work could be informed by a review of domestic and international policy pertaining to this sector.

3. **Buildings**: A critical issue is that of building codes. A review of building codes across the country can identify gaps in approaches to energy efficiency. Considering residential, commercial, and industrial real estate as separate issues can help identify best practices to improve efficiency in each. Training of highly qualified personnel capable of delivering energy conservation or renewable energy strategies is a key component of meeting this challenge. International and domestic best practices should be identified. How would densification and urban strategies impact our overall energy demand, and how will impact the way that work is designed in the future? These issues should also be considered.

4. **Electricity**: While electricity in Canada is fairly green, and becoming greener with the phase-out of coal-fired generation, the shift to renewables and potentially nuclear power has many potential implications for workers in this area. What are the potential opportunities to ensure that workers in a highly-distributed renewable energy sector enjoy the same benefits and opportunities that workers in centralized power generation have typically had? How have other countries around the world dealt with this problem? Are there best practices that could be applied to this evolution in energy generation? This project becomes more important when one recognizes that electricity becomes a more important component in Canada's energy mix in all more sustainable futures.

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