CANADA

- *Canada's commitment to energy efficiency through its policies will help the economy to keep its overall energy demand moderate in the long term.*
- *Canada will remain the world's largest oil sands producers, one of the largest shale gas producers, and a major energy exporting economy.*
- *Annual CO_2 emissions from fuel combustion are projected to increase by 20% over the outlook period. This can be attributed to Canada's projected strong growth in the resources sector fuelling economic growth and activity.*

ECONOMY

Canada's land area is the second largest in the world, after Russia. The economy is located in the northern part of North America, and has a widely varied climate, from temperate in the south to sub-arctic and arctic in the north. Canada's geography and climate contribute to its high energy consumption (about four times the APEC average) (APERC, 2009). The economy's high energy use is due in part to the demand for the transportation fuels required to travel its vast distances, and the space and water heating needed to cope with its cold weather.

Canada is made up of a Federal Government, 10 provincial governments and three territories. Roughly 90% of the land in Canada is Crown land (land held for the monarchy). The majority of this land is owned by the relevant provincial government. Under the Canadian Constitution, the provinces have ownership over the natural resources that lie within their provincial boundaries. Provincial governments manage the pace of energy resource development within their jurisdiction. Federal jurisdiction applies to territories north of 60 degrees, aboriginal and offshore frontier areas. Offshore areas are jointly managed by federal/provincial authorities. The federal government also regulates interprovincial and international energy trade.

Canada was demonstrating solid economic growth before the onset of the global recession in 2008 and its continuation into 2009. Between 1990 and 2009, GDP increased at an average of 2.4% per year. Although there was negative growth in Canada's economy in 2009, GDP is expected to recover, and to grow at an average of 2.4% per year over the outlook period.

The affluence of this economy translates into a high standard of living. Canada's car ownership rate is high for the APEC region. In 2009, there were nearly 21 million registered vehicles on the road—96% of these vehicles were up to 4.5 tonnes (light vehicles) (Statistics Canada, 2010a). Given the urban sprawl and the well constructed road network, automobiles are the dominant means of intercity passenger travel. Compared to other industrialized economies, the public transport system is less extensive and its market share is primarily limited to the larger cities. However, compared to its neighbour the United States (US), Canada's public transport is better funded and of a higher quality.

Canada is an advanced industrialized economy with a substantial services sector. Unlike many other developed economies, Canada's economy has a large natural resources producing component. This includes oil and natural gas, minerals and metals mining, forestry, and agricultural sectors. The mining and oil and gas extraction industries alone accounted for about 4.5% of GDP in 2010 (Statistics Canada, 2012).

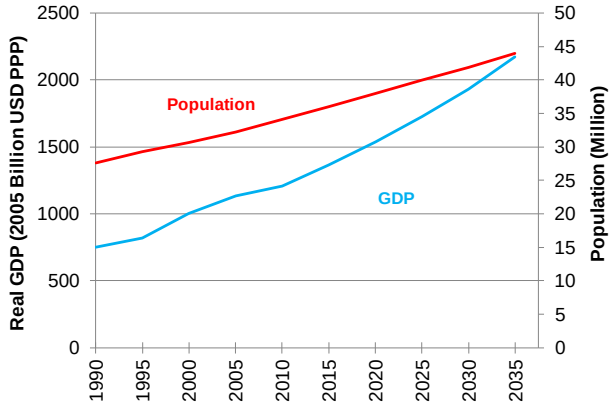
Canada is moving toward a knowledge-based economy: the service industry employs three-quarters of the workforce and generated 72% of GDP in 2010. Manufacturing makes up 13% of GDP—this includes major industries producing transport equipment, food, chemicals, fabricated metal products, and machinery. Canada's economy is closely tied in with the US economy: in 2010, the US accounted for 73% of Canada's exports and 63% of its imports (Statistics Canada, 2012).

There is an extensive freight rail network across the southern part of Canada. Given Canada's large size, long distance trucking is quite common. Along with this, Canada has many sea ports along its Pacific Ocean and Atlantic Ocean coastlines.

In 2009, Canada had a population of 33.7 million, with the majority of the population living in urban areas. Given Canada's climate, most of the population lives in the southern region, avoiding the sparsely populated northern region that suffers from very cold temperatures. The population is estimated to reach 44.3 million by 2035, growing at an average of 1% per year. The median age of the Canadian population has been increasing over the last

three decades: at 1 July 2010 the median age was 39.7 years. In the long term, this could have labour force implications (Statistics Canada, 2011, p. 352).

Figure CDA1: GDP and Population



Sources: Global Insight (2012) and APERC Analysis (2012)

ENERGY RESOURCES AND INFRASTRUCTURE

Canada is richly endowed with natural resources: oil, natural gas, coal, and uranium in its western provinces and huge hydropower resources in Quebec, British Columbia, Newfoundland, Ontario, and Manitoba. It also has offshore oil and gas reserves near Nova Scotia and Newfoundland. Installed electricity generation capacity was 130.5 gigawatts (GW) in 2010 (Statistics Canada, 2010b). Canada is the world's fifth-largest energy producer (behind the United States, Russia, China and Saudi Arabia). It is a major energy exporter, being the most important source for US energy imports (EIA, 2009).

Canada is the world's third largest hydroelectricity producer, after China and Brazil. Even though it is greatly used, there is still undeveloped hydropower potential available, more than double the current capacity, across all provinces and territories (technically, the potential for an additional 163 000 MW). There is roughly 25 000 MW of additional capacity in various planning stages (Irving, 2010).

Canada is endowed with huge oil potential. At 173 billion barrels, Canada's proven oil reserves are the third largest in the world, after Saudi Arabia and Venezuela. The oil sands account for 98% of Canada's oil reserves. 'Proven oil reserves' are the estimated remaining volume of oil that is economic to recover with current technology. This figure is known through drilling, testing and production.

As of 2011, Canada's remaining technically recoverable oil sands and conventional oil resources were estimated by the National Energy Board (NEB) at 343 billion barrels. The oil sands account for 90% of these oil resources. 'Technically recoverable oil' is the volume of oil that can be produced, and recovered from the subsurface, if costs are not considered a limiting factor.

There is much potential to add to Canada's proven oil reserves. Presently, non-conventional established oil reserves are only reported for Alberta. However, assessments are still underway to estimate the size of the oil sands bitumen resources in Saskatchewan. In future, Canada's proven oil reserves could grow as some of Saskatchewan's oil sands resources become recognised as proven oil reserves. Furthermore, the Grosmont carbonate formation is estimated to account for 21% of the oil sands resources in-place in Alberta but thus far has not been assigned any value as either a proven oil reserve, or even a technically recoverable resource.

The application of horizontal drilling and multi-stage hydraulic fracturing has given new life to previously low-producing or unproductive conventional oil reservoirs. The development of tight oil resources (also called shale oil) has already reversed the decline of conventional oil production in Canada and the United States. Since tight light oil extraction technology is still in its early stages of development in Canada, the ultimate impact on the resource potential is unclear. However, the successful development of Canada's tight oil resources could lead to a significant increase in the size of conventional oil reserves.

Canada is seeking to expand its oil pipeline infrastructure to enable it to export its growing oil production. In December 2011, the National Energy Board approved the Bakken Pipeline project. The pipeline will extend from Saskatchewan to Manitoba, connecting to the Enbridge Pipelines Inc. mainline system and will serve as a continuous, long-term source of light crude oil supply to the central Canadian and US mid-west markets. This will maintain the long-term competitiveness of refineries in those regions (APERC, 2012). In addition, Enbridge's Northern Gateway pipeline, a 525 000 barrel per day (26 Mtoe/year) project, is currently undergoing regulatory review and Kinder Morgan plans to twin its existing TransMountain pipeline, via a 450 000 barrel per day (22 Mtoe/year) expansion. It intends to seek regulatory approval in 2014 and anticipates the expanded pipeline system could be in service by 2017. These pipelines will enable Canada to expand oil exports to the Asia Pacific region (NRCan, 2012a).

Globally, Canada is the third largest producer of natural gas (behind Russia and the US) and fourth largest exporter (behind Russia, Norway and Qatar). Canadian natural gas production is expected to rise over the outlook period, driven by growth in unconventional natural gas production (NRCan, 2012a).

Most of the economy's conventional gas resources are located in western Canada. The Canadian Society for Unconventional Resources (CSUR) estimates Canada's marketable natural gas resources (conventional and unconventional gas resources) at 19.9 to 36.8 trillion cubic meters (131 000 to 242 000 Mtoe). These natural gas resources represent hundreds of years of supply. Unconventional natural gas (e.g. shale and tight gas) represents the largest component of Canada's natural gas resources, and most of these resources are located within the Western Canadian Sedimentary Basin. However, there are significant natural gas resources located in eastern Canada within the Utica and Maritime Basins (NRCan, 2012a).

Currently in the North American market, natural gas prices are depressed, largely due to excess supply. The US, like Canada, is rich in shale gas resources and while the US is looking at developing these resources, it is also looking at developing LNG (liquefied natural gas) export terminals, rather than import terminals. Nevertheless, the US (EIA, 2012) projects that Canada will remain a major exporter of natural gas into the US market up to the end of the reference period in 2035.

Canada, too, is looking at building LNG export terminals with proposed sites on the west coast. The development of these terminals will provide Canada with a larger market for its gas—other Asia Pacific economies such as Japan and Korea. There are several LNG terminals proposed for British Columbia:

- Douglas Channel LNG, a partnership between BC LNG Export Co-operative and Douglas Channel Energy Partnership, to liquefy 7.1 million cubic metres/day (2.3 Mtoe/year) of natural gas. The first phase to liquefy 3.5 million cubic metres/day (1.15 Mtoe/year) could be in-service in late 2013 or early 2014;
- Kitimat LNG, a partnership between Apache, EnCana and EOG Resources, to liquefy 36.8 million cubic metres/day (12.1 Mtoe/year) of natural gas, expected to be in-service in 2017;
- LNG Canada, a partnership between Shell, Mitsubishi Corp, Korea Gas Corp. and PetroChina Company Limited, to liquefy 96.3 million cubic metres/day (31.6 Mtoe/year) of natural gas, the first phase of which (48.1 million cubic metres/day or 15.8 Mtoe/year) is expected to be in-service in 2019;
- Two other LNG terminals are proposed for the Port of Prince Rupert in British Columbia, led by Petronas of Malaysia and the British Gas Group.

In oil sands operations in Alberta, natural gas is used to generate electricity and steam. Steam is used for in situ oil production and in the production of hydrogen to upgrade bitumen into synthetic crude oil blends. Gas consumption by the oil sands industry in 2011 was estimated to be approximately 10% of Canada's total natural gas production (NEB, 2011a).

As noted earlier, growing natural gas requirements in North America have prompted a major push in the construction of LNG export facilities on Canada's west coast. On Canada's east coast, the Canaport LNG terminal in Saint John, New Brunswick, began operating in June 2009 and is currently Canada's only operating LNG import facility. However, the focus is now on export terminals given Canada's considerable unconventional gas supply potential, especially in the form of shale gas and tight gas (NRCan, 2011b). Due to the shale gas supply revolution and low North American natural gas prices relative to world markets, almost all import proposals are on hold.

Most of Canada's coal reserves are located in western Canada. The consumption of domestic coal and thermal coal imports are expected to decline in the outlook period, largely due to the phasing out of coal fired power generation by 2015 in Ontario. However, coal production is expected to increase as a result of multiple projects coming online in western Canada, increasing the exportable amount of coal (NEB, 2011b).

Canada continues to be a leading producer of uranium, with nearly one-fifth of world production (9145 tonnes of uranium metal) in 2011. Canada's low-cost high-quality uranium resources are the third largest in the world, after those of Australia and Kazakhstan. As of January 1, 2012 Canada's total recoverable low-cost uranium resources were estimated at 466 300 tonnes of uranium metal. Recent exploration activity is expected to further increase these figures (NRCan, 2012a).

Hydropower dominated electricity generation in 2010 (59%), followed by coal (13%) and nuclear energy (15%). Nuclear generated power is most prominent in the province of Ontario, where it accounted for 54% of electricity generation in 2010.

Ontario has initiated plans to construct two new nuclear plants (1000 MW each). A clear timeline for their completion has not yet been announced. The Point-Lepreau Station in New Brunswick is expected to be back online in 2012. The Government of Quebec recently announced it will not continue with the refurbishment of the Gentilly-2 reactor and instead intends to close the nuclear generating station by the end of 2012 (NRCan, 2012a).

Canada is a net exporter of electricity. Given the increase in the production of clean and renewable energies, there is potential for significant extra electricity to be available for export. The US is the recipient of Canada's electricity exports. In 2011, Canada's electricity exports to the US totalled CAD 2.03 billion (NEB, 2011).

ENERGY POLICIES

The Canadian Government has a number of policies that promote energy efficiency and cleaner technologies, boost renewable energy supplies and aim to reduce greenhouse gas (GHG) emissions. Since 2006, the Government of Canada has invested more than CAD 10 billion to reduce greenhouse gas emissions and build a more sustainable environment through investments in green infrastructure, energy efficiency, clean energy technologies and the production of cleaner fuels. As part of the Copenhagen Accord, Canada pledged to set a goal to reduce emissions by 17% from 2005 levels by 2020; this was endorsed again through the Cancun Agreement and is in line with US goals.

The Energy Efficiency Act, which took effect in 1992, has been amended to expand its scope and increase its effectiveness (NRCan, 2009a). This includes provisions aimed at reducing standby power consumption, which is currently 10% of household electricity use in Canada. Provincial governments are also major contributors to energy efficiency in their respective provinces through the establishment of energy efficient building codes, equipment standards, etc.

Canada's energy policy, including for resource development, is market-based and incorporates a mix of domestic and foreign owned companies. As per the Canadian Constitution, the regulation of mining activities on publicly owned mineral leases falls under provincial or territorial government jurisdiction. Therefore, there is separate mining rights legislation for each of the 13 Canadian jurisdictions except Nunavut (the northern and eastern portions of the former Northwest Territories). Off-shore mineral rights are usually owned by the Canadian Federal Government (NRCan, 2011b).

Since the signing of Western Accord and the Agreement on Natural Gas Markets and Prices, in 1985, oil and natural gas prices in Canada have been deregulated. The agreements opened up the oil and gas markets to greater competition by permitting more exports, allowing users to buy directly from producers and unbundling production and marketing from transportation services. Oil and gas pipeline networks continue to be regulated as natural monopolies (NRCan 2009b; NEB 1996).

In most provinces, the electricity industry is highly integrated with the bulk of generation, transmission and distribution services provided by one or two dominant utilities. Although some of these utilities are privately owned, many are Crown corporations owned by the provincial governments. Independent power producers also exist, but rarely in direct competition with a Crown corporation. Exceptions include the provinces of Alberta, which has moved to full wholesale and retail competition, and Ontario, which has established a hybrid system with competitive and regulated elements. Retail electricity prices vary across the provinces, in terms of both their level and the mechanism by which they are set. Within the power sector, Canada has an accelerated capital cost allowance (CCA) program which gives a tax benefit for clean energy generation, allowing 50% CCA for projects that use renewable energy equipment or use fossil fuels efficiently, including co-generation (NEB, 2011). In addition, the federal government has invested CAD 1.5 billion to increase Canada's energy supplies from renewable sources, including solar, tidal, hydro, wind, biomass and geothermal through the ecoENERGY Renewable Initiative.

One policy measure that has proved successful in promoting energy efficiency and creating energy savings is the ecoENERGY Retrofit initiative. The program provided incentives for energy efficiency improvements in low-rise residential housing and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The ecoENERGY Retrofit–Small and Medium Organizations component of the initiative ran from April 2007 to March 2011. This CAD 40 million program provided financial incentives to implement energy retrofit projects in buildings with up to 20 000 square metres of floor space and industrial facilities with fewer than 500 employees. Financial incentives stimulated almost 1300 energy retrofit projects. The ecoENERGY Retrofit–Homes component of the initiative was also launched in April 2007. The four year, CAD 745 million program provided federal grants to property owners for improving the energy efficiency of their homes. In

2011, an additional one-year investment of CAD 400 million was made, which allowed as many as 250 000 homeowners to participate in the programme. In total, ecoENERGY Retrofit–Homes helped over 640 000 Canadians increase the energy efficiency of their homes. Homeowners reduced their energy consumption by an average of 20% for ongoing savings of more than CAD 400 million a year (NRCan, 2012b).

In the transport sector, energy consumption growth rates have decreased in recent times. This could be attributable to federal, provincial and territorial programs that promote alternative fuel supply. These include funding programs that encourage investment in the biofuels industry as well as separate renewable fuel blending mandates. For instance, since 2010, Canada has had a 5% renewable fuel mandate. This mandate was expanded in July 2011 to include a 2% renewable fuel content requirement for diesel fuel and heating oil. Several provincial governments have set their own renewable fuel standards, some of which mandate a higher renewable fuel content, and some of which were implemented before the federal mandatory blending requirements (CRFA, 2010). Due to growing domestic supply, natural gas is also being promoted as a transportation fuel, particularly for medium and heavy duty vehicles in the freight sector.

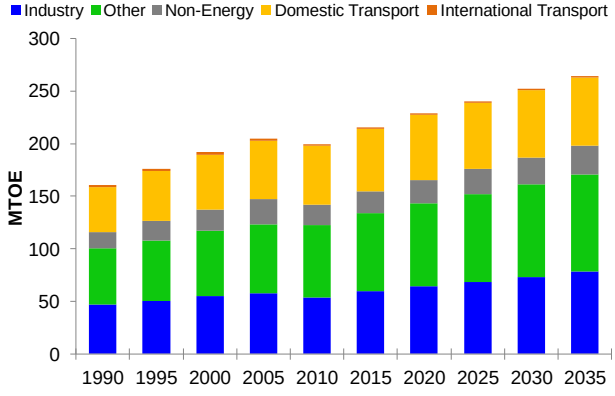
In addition to the above, in October 2011, light-duty vehicle greenhouse gas emission regulations came into force for model years 2011 to 2016, establishing a common Canada–US emissions standard for new vehicles.

BUSINESS-AS-USUAL OUTLOOK

FINAL ENERGY DEMAND

Business-as-usual (BAU) final energy demand is expected to grow on average 1.1% per year over the outlook period.

Figure CDA2: BAU Final Energy Demand

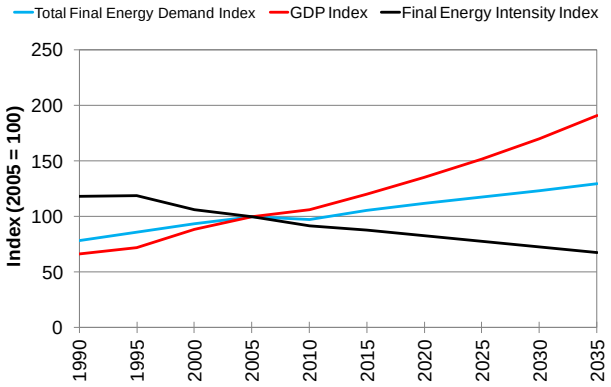


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

A majority of this increase can be attributed to increases in energy consumption across all sectors, especially in the industry and 'other' (residential, commercial and agricultural) sectors.

Despite this small increase in final energy demand, final energy intensity (Figure CDA3) is expected to decline by 32% between 2005 and 2035.

Figure CDA3: BAU Final Energy Intensity



Source: APERC Analysis (2012)

Industry

Energy demand in the industry sector is projected to grow at an average annual rate of 1.5% between 2010 and 2035. Much of the energy demand will come from energy intensive industries such as iron and steel, aluminium, cement, chemicals and fertilisers, pulp and paper manufacturing, and oil and gas extraction.

Transport

On average over the outlook period, Canada's total transport energy demand (including international transport) is projected to grow by an average of 0.6% per year. This is a much smaller growth rate than between 1990 and 2009, when energy demand for transport averaged 1.3% a year.

To comply with the Federal Government's greenhouse gas emission policies (such as the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations) it is likely fuel economy will improve over the projection period. In April 2012, the Government of Canada released proposed on-road heavy-duty vehicle greenhouse gas emissions regulations for model years 2014 and beyond. Proposed regulations for new passenger cars and light trucks for the 2017 to 2025 model years are also under development. These regulations combined with the renewable fuel content mandate (discussed above) and an interest in natural gas vehicles for medium to heavy fleet trucks in the western

provinces may bring about change in the types of energy sources demanded within the outlook period.

Conventional gasoline and diesel vehicles will account for most of the light vehicle fleet in the projection period, accounting for 84% of the fleet by 2035, with conventional hybrid gasoline and diesel vehicles accounting for another 5%. The dominant fuel source over the projection period and in 2035 for all domestic transport will be oil.

Other

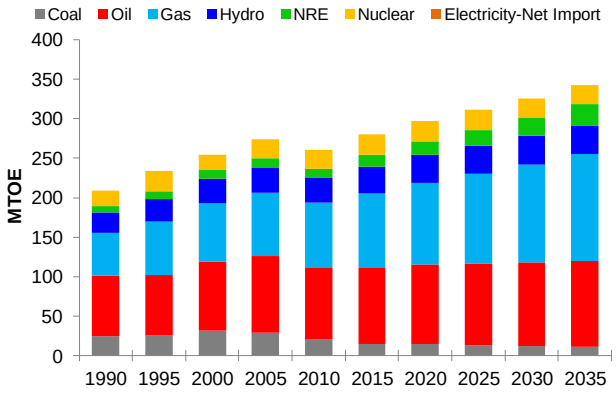
Canada has many policies promoting energy efficiency within the residential and commercial sectors (such as the ecoENERGY Retrofit programs).

However, these efforts will be offset by factors such as the growing population. Energy demand in the 'other' sector, which includes residential, commercial, and agricultural demand, is expected to grow on average 1.2% per year over the outlook period. Given Canada's cold climate, much of the residential and commercial energy use is linked to space and water heating in homes and commercial buildings. Electricity is expected to dominate the fuel mix in this sector throughout the projection period, accounting for 41% of the 'other' sector's energy consumption in 2035, followed closely by gas at 38%.

PRIMARY ENERGY SUPPLY

Canada's primary energy supply between 2010 and 2035 is projected to grow at an average annual rate of 1.1%, in line with the growth in energy demand. Primary energy intensity is projected to decline 34% between 2005 and 2035.

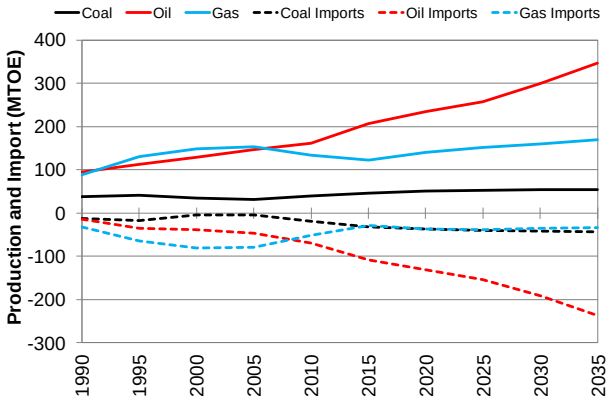
Figure CDA4: BAU Primary Energy Supply



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

The primary supply of oil is projected to increase by 19% between 2010 and 2035, while gas production is projected to increase 27%. Conventional oil and gas production is expected to decline, while increases in production from unconventional resources (especially oil sands, tight oil, and shale gas) are expected to more than compensate (NEB, 2011a).

Figure CDA5: BAU Energy Production and Net Imports

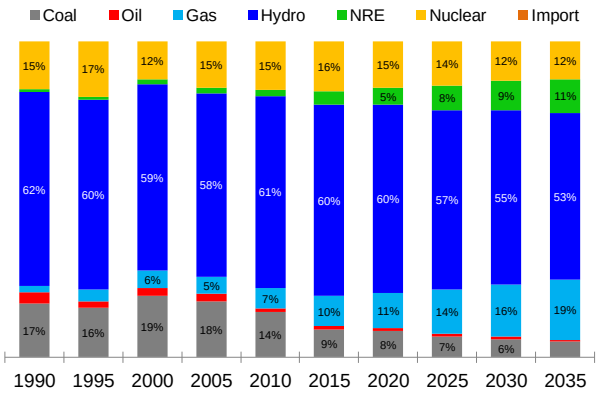


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

ELECTRICITY

Hydropower will remain Canada's dominant source of electricity generation throughout the outlook period. After hydropower, gas is expected to be the largest contributor. In 2035, gas will account for 19% of the generation mix, an increase in share of 12% from 2010. This increase will be driven by higher gas production, and a significant reduction of coal use in electricity generation. The reduction in coal use is partly in response to combined efforts by the federal and provincial governments to reduce reliance on coal-fired electricity generation, especially Ontario's coal phase-out policy and the recently released federal regulations for reducing greenhouse gas emissions from the coal-fired electricity sector.

Figure CDA6: BAU Electricity Generation Mix



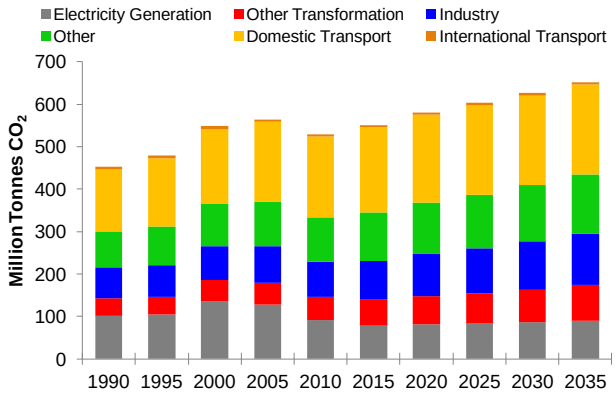
Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

CO_2 EMISSIONS

Over the outlook period Canada's total CO_2 emissions from fuel combustion are projected to increase by 23% from 2010 to 2035, to reach

652.2 million tonnes. By fuel, most of the increase in emissions can be attributable to gas, closely followed by oil. By sector, emissions from electricity generation are projected to decline as a result of reductions in coal-fired generation, while emissions in other sectors will continue to grow.

Figure CDA7: BAU CO_2 Emissions by Sector



Source: APERC Analysis (2012)

Table CDA1 shows that the growth in emissions that would have otherwise resulted from Canada's GDP growth are partly offset by reductions in the energy intensity of GDP and reductions in the CO_2 intensity of energy. Reductions in the energy intensity of GDP include improved energy efficiency and shifts to less energy-intensive industry. Reductions in the CO_2 intensity of energy include reductions in coal generation and increases in renewable energy generation.

Table CDA1: Analysis of Reasons for Change in BAU CO_2 Emissions from Fuel Combustion

(Average Annual Percent Change)

	1990-2005	2005-2010	2005-2030	2005-2035	2010-2035
Change in CO_2 Intensity of Energy	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
Change in Energy Intensity of GDP	-1.0%	-2.2%	-1.4%	-1.4%	-1.2%
Change in GDP	2.8%	1.2%	2.2%	2.2%	2.4%
Total Change	1.5%	-1.3%	0.4%	0.5%	0.8%

Source: APERC Analysis (2012)

CHALLENGES AND IMPLICATIONS OF BAU

Under business-as-usual, Canada's opportunities as an energy exporting economy appear assured. The global demand for oil from secure sources and for natural gas, which has much lower CO_2 emissions than coal, is likely to grow over the Outlook period. Canada has abundant resources of both unconventional oil and unconventional gas, and should be in a good position to help meet this demand. It is, however, important to recognize that there is growing public concern over the environmental risks of unconventional oil and unconventional gas development. These concerns will need to be addressed through enlightened regulation if oil and gas development is to win the public confidence it will need for Canada to achieve its potential.

ALTERNATIVE SCENARIOS

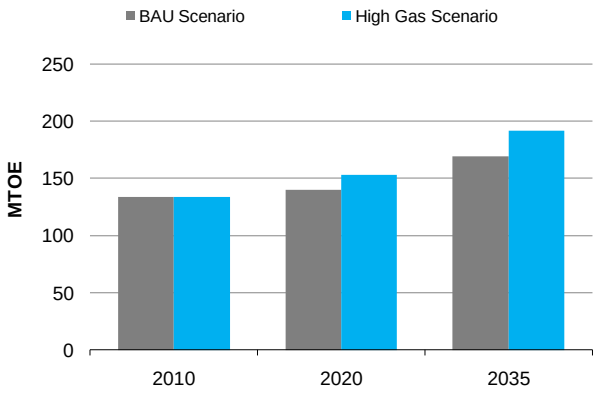
In order to address the energy security, economic development, and environmental sustainability challenges posed by the business-as-usual (BAU) outcomes, three sets of alternative scenarios were developed for most APEC economies.

HIGH GAS SCENARIO

To understand the impacts that higher gas production might have on the energy sector, an alternative 'High Gas Scenario' was developed. The assumptions behind this scenario are discussed in more detail in Volume 1, Chapter 12. The scenario was built around estimates of gas production that might be available at BAU scenario prices or below if constraints on gas production and trade could be reduced.

The High Gas Scenario production for Canada assumed a production increase of 13.2% by 2035 compared to BAU, as shown in Figure CDA8. This assumption is based on Canada's prospective unconventional and conventional gas reserves. As noted above, even under the BAU scenario gas production is expected to increase significantly over the outlook period. Under the alternative scenario, it is assumed that opposition to some gas development projects can be overcome through more intensive engagement with stakeholders, and that the sometimes cumbersome and lengthy approvals processes will be streamlined to allow more gas projects to move ahead quickly.

Figure CDA8: High Gas Scenario – Gas Production



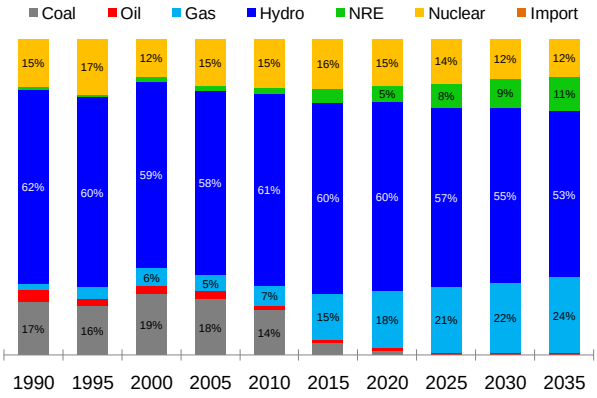
Source: APERC Analysis (2012)

Additional gas consumption in each economy in the High Gas Scenario will depend not only on the economy's own additional gas production, but also

on the gas market situation in the APEC region. While some of Canada's additional natural gas will be consumed domestically, it is likely that much will be exported. While currently there are no operational LNG export terminals in Canada, project proposals are under consideration and are assumed to come to fruition under the High Gas Scenario. There should be significant demand for natural gas in Asian economies such as China, Japan, and Korea.

The additional gas in the High Gas Scenario was assumed to replace coal in electricity generation. Figure CDA9 shows the High Gas Scenario Electricity Generation Mix.

Figure CDA9: High Gas Scenario – Electricity Generation Mix

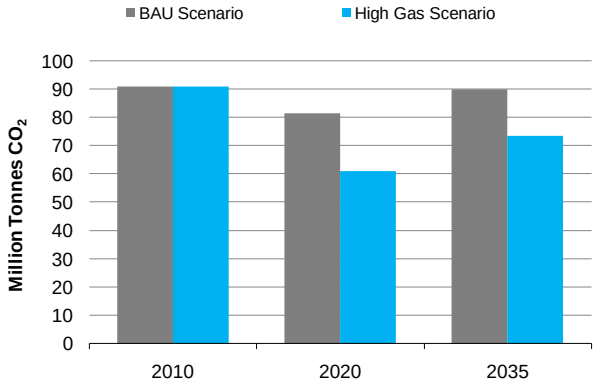


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

This graph may be compared with the BAU scenario graph shown in Figure CDA6 above. The gas share is 5% higher in 2035 compared to the BAU case, because coal has a 5% market share in the BAU case, the increased gas production thus displaces coal in power generation.

Since gas has roughly half the CO_2 emissions of coal per unit of electricity generated, this had the impact of reducing CO_2 emissions in electricity generation by a significant 24% in 2035. The reduction in emissions is comparatively large in percentage terms because the majority of Canada's electricity generation is from hydro and has no emissions. Figure CDA10 shows this CO_2 reduction.

Figure CDA10: High Gas Scenario – CO_2 Emissions from Electricity Generation



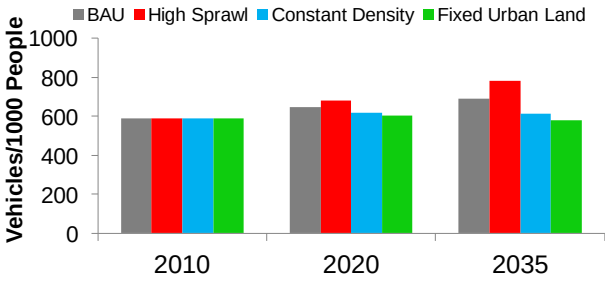
Source: APERC Analysis (2012)

ALTERNATIVE URBAN DEVELOPMENT SCENARIOS

To understand the impacts of future urban development on the energy sector, three alternative urban development scenarios were developed: 'High Sprawl', 'Constant Density', and 'Fixed Urban Land'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure CDA11 shows the change in vehicle ownership under BAU and the three alternative urban development scenarios. It can be seen that better urban planning is likely to prove beneficial in Canada since under a High Sprawl scenario, vehicle ownership is projected to increase by 13% in 2035 compared to the BAU scenario, whereas under the Constant Density and Fixed Urban Land scenarios vehicle ownership declines 11% and 16%, respectively, compared to the BAU scenario.

Figure CDA11: Urban Development Scenarios – Vehicle Ownership

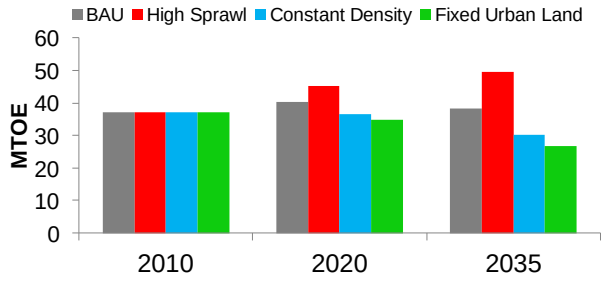


Source: APERC Analysis (2012)

Figure CDA12 shows the change in light vehicle oil consumption under BAU and the three alternative urban development scenarios. Similar, but larger, effects than those seen in figure CDA11 can be seen in figure CDA12, since urban planning affects not only vehicle ownership, but also the distances driven.

Oil consumption is projected to increase 29% in 2035 under a High Sprawl scenario compared to the BAU scenario, whereas oil consumption is projected to decline 21% and 31% under the two other scenarios.

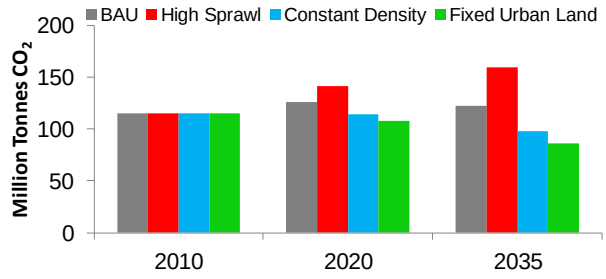
Figure CDA12: Urban Development Scenarios – Light Vehicle Oil Consumption



Source: APERC Analysis (2012)

Figure CDA13 shows the change in light vehicle CO_2 emissions under BAU and the three alternative urban development scenarios. The impact of urban planning on CO_2 emissions is the same in percentage terms as the impact of urban planning on oil consumption, since there is no significant change in the mix of fuels used under any of these scenarios.

Figure CDA13: Urban Development Scenarios – Light Vehicle Tank-to-Wheel CO_2 Emissions



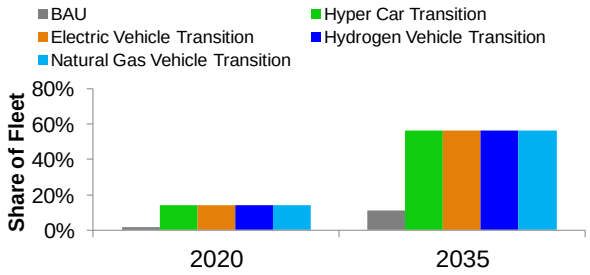
Source: APERC Analysis (2012)

VIRTUAL CLEAN CAR RACE

To understand the impacts of vehicle technology on the energy sector, four alternative vehicle scenarios were developed: 'Hyper Car Transition' (ultra-light conventionally-powered vehicles), 'Electric Vehicle Transition', 'Hydrogen Vehicle Transition', and 'Natural Gas Vehicle Transition'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure CDA14 shows the evolution of the vehicle fleet under BAU and the four 'Virtual Clean Car Race' scenarios. By 2035 the share of the alternative vehicles in the fleet reaches around 57% compared to about 11% in the BAU scenario. The share of conventional vehicles in the fleet is thus only about 43%, compared to about 89% in the BAU scenario.

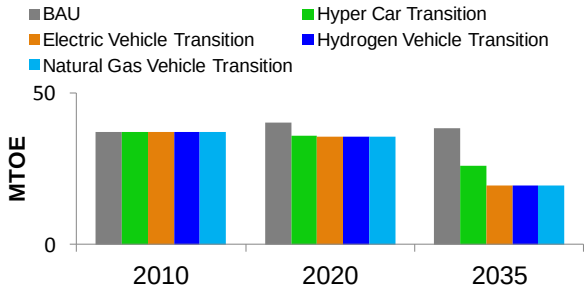
Figure CDA14: Virtual Clean Car Race – Share of Alternative Vehicles in the Light Vehicle Fleet



Source: APERC Analysis (2012)

Figure CDA15 shows the change in light vehicle oil consumption under BAU and the four alternative vehicle scenarios. Oil consumption drops by 50% in the Electric Vehicle Transition, Hydrogen Vehicle Transition, and Natural Gas Vehicle Transition scenarios compared to BAU by 2035. The drop is large as these alternative vehicles use no oil. Oil demand in the Hyper Car Transition scenario is also significantly reduced compared to BAU: down 34% by 2035—even though these highly-efficient vehicles still use oil.

Figure CDA15: Virtual Clean Car Race – Light Vehicle Oil Consumption



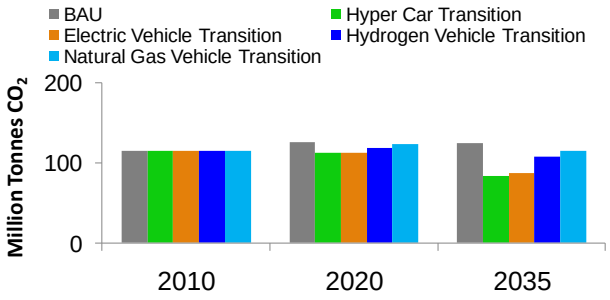
Source: APERC Analysis (2012)

Figure CDA16 shows the change in light vehicle CO_2 emissions under BAU and the four alternative vehicle scenarios. To allow for consistent comparisons, for the Electric Vehicle Transition and Hydrogen Vehicle Transition scenarios, the change in CO_2 emissions is defined as the change in emissions from electricity and hydrogen generation. The emissions impacts of each scenario may differ significantly from their impact on oil consumption, since each alternative vehicle type uses a different fuel with a different level of emissions per unit of energy.

In Canada, the Hyper Car Transition scenario is the winner in terms of CO_2 emission reduction, with an emission reduction of 33% compared to BAU in

2035. The Electric Vehicle Transition scenario does almost as well, reducing emissions 30% compared to BAU in 2035, reflecting the fact that, in Canada, relatively low-emission natural gas is assumed to be the marginal source of electricity generation. A Hydrogen Vehicle Transition scenario would reduce emissions by 13% compared to BAU in 2035, while the Natural Gas Vehicle Transition scenario would reduce emissions by 7% compared to BAU in 2035.

Figure CDA16: Virtual Clean Car Race – Light Vehicle CO_2 Emissions



Source: APERC Analysis (2012)

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