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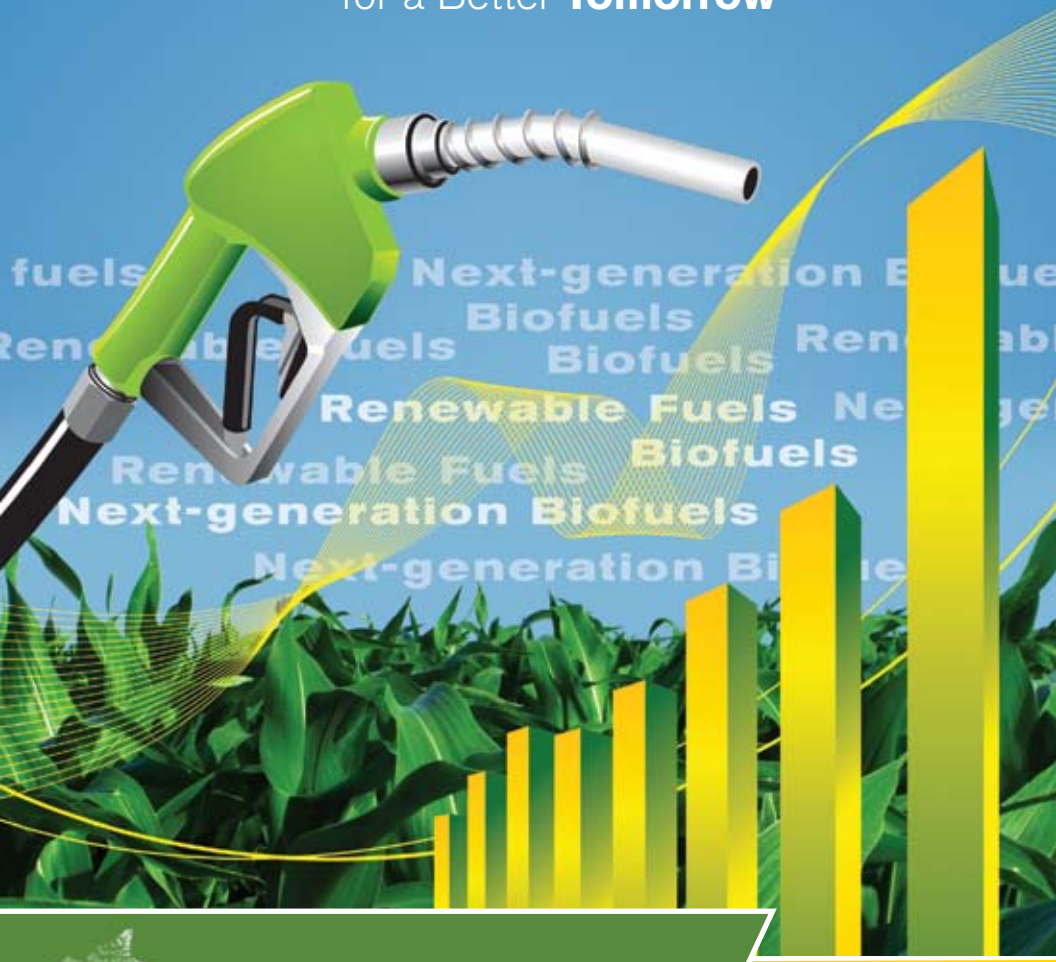
Alternative Fuels in Canada

Making Choices **Today** for a Better **Tomorrow**



Canada

INTRODUCTION

Road transportation is the largest single source of greenhouse gas (GHG) emissions worldwide and a major contributor to smog and other air quality problems that affect the health of millions of Canadians every day. Alternative transportation fuels that can reduce the environmental impact of vehicles are a key component of Canada's efforts to address climate change and ensure a healthy environment for future generations.

Alternative fuels are derived from both renewable and non-renewable sources, and include ethanol, biodiesel, natural gas, propane, electricity and hydrogen. Renewable fuels, such as ethanol and biodiesel, can be made from feedstocks that are available in Canada. Natural gas and propane are non-renewable fuels, but are cleaner burning than gasoline. Electricity in batteries and hydrogen in fuel cells are potential new alternative transportation fuel technologies that are showing promise for the future. Electricity and hydrogen can be produced from either renewable or non-renewable sources. Alternative fuels can:

- offer significant environmental benefits compared to conventional transportation fuels, including reduced GHG emissions over their life cycle (i.e. all stages of production and use);
- diversify Canada's energy supply;
- offer opportunities for investment, economic growth and job creation in areas of the economy, such as rural and agricultural communities.

Federal renewable fuel regulations, announced in December 2006, will require 5% renewable content based on the gasoline pool by 2010 and 2% renewable content in the diesel and heating-oil pool by 2012, upon successful demonstration of renewable diesel fuel (which includes biodiesel) use under the range of Canadian conditions. Some provinces have also set mandates and targets for renewable content in their gasoline and diesel pools.

To support the development of a robust national market for renewable fuels, the ecoENERGY for Biofuels Initiative, announced in July 2007, will invest up to $1.5 billion over nine years to boost Canada's production of biofuels. Biofuels include all fuels derived from biomass (e.g. plant and materials). For more information, visit **www.ecoaction.gc.ca/biofuels**.

The Government of Canada is also supporting the research and development of fuels and technologies that produce even fewer GHG emissions, and is also working with industry and Canadians to make our vehicles and buildings more energy efficient.

The fuel choices you make today can have an important impact on GHG emissions in the years ahead. Some of the alternative fuels discussed in this booklet are already widely available in Canada; others are still in development and offer significant future potential.

For more information on life-cycle GHG emissions, or any of these fuels and technologies, visit Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) web site at **www.alternativefuels.gc.ca**.

ETHANOL

Ethanol is a liquid alcohol made up of oxygen, hydrogen and carbon, and can be obtained from the fermentation of sugar. Sugar is extracted from certain plants (e.g. sugar cane), or it can be obtained by converting starch contained in cereal grain, or by converting cellulosic material (for example, agricultural biomass and forest biomass). Most of the ethanol currently produced in Canada is made from corn and wheat.

Ethanol reduces GHG emissions because the biomass used to make ethanol absorbs carbon dioxide as it grows. Although both the production and combustion of ethanol produce emissions, the net effect can be a large reduction in GHG emissions, compared with fossil fuels. For example, the life-cycle GHG emissions from corn-based ethanol can be around 40% lower under typical Canadian conditions, compared with gasoline, on a life-cycle basis.

As well as offering the potential for environmental benefits when compared to conventional fuels, ethanol production contributes to regional economic growth. It also diversifies rural economies by creating new markets for Canadian agriculture and forestry producers.

Ethanol can be blended with gasoline in any proportion up to 85% ethanol and 15% gasoline. It is normally sold as blends of either E10 (between 5 to 10% ethanol by volume) or E85 (85% ethanol by volume).

E10

All gasoline vehicles manufactured since the 1980s can use fuel blends containing up to 10% ethanol (check your vehicle manual to verify which fuels are recommended and the warranty requirements). The use of E10 can increase fuel consumption by about 2% compared with pure gasoline. This is because ethanol contains less energy content per litre than gasoline.

Under typical Canadian conditions, E10, using ethanol made from corn or wheat, can produce about 4% fewer GHG emissions, compared to pure gasoline.

Low-level ethanol blends are available in various parts of the country. To locate an ethanol refuelling station, either look for the ethanol pump at your local retailer, or visit **www.alternativefuels.gc.ca**. Click on "Find a refuelling station" to locate web links to alternative fuel distributors in your area.

All gasoline sold in Ontario, Saskatchewan and Manitoba must contain a minimum average ethanol content of 5%, 7.5% and 8.5% respectively.

E85

Because ethanol contains less energy content per litre than gasoline, the use of E85 can increase fuel consumption by about 30%, compared to pure gasoline.

Under typical Canadian conditions, E85, using ethanol made from corn or wheat, can produce about 35% fewer GHG emissions, compared to pure gasoline.

Several automakers are manufacturing flexible-fuel vehicles that can run on E85. Some of these vehicles are sold in Canada; to obtain a list of models, visit the *Fuel Consumption Guide* at **www.vehicles.gc.ca**.

E85 is typically used by some organizations that have large vehicle fleets and dedicated refuelling facilities, including the Government of Canada. However, its availability to the public is very limited.

For more information, visit **www.alternativefuels.gc.ca**.

BIODIESEL

Biodiesel is a non-toxic, biodegradable fuel made from vegetable oil, waste cooking oil, animal fat or fish oil. Biodiesel is usually manufactured through a process called transesterification in which methanol and sodium hydroxide are mixed with the oil, producing the biodiesel and glycerine (used in soap making) as a by-product. It can be used in any diesel engine built after 1994.

Under typical Canadian conditions, biodiesel can reduce life-cycle GHG emissions by around 60% to nearly 100% compared to petroleum diesel, depending on the feedstock used. Biodiesel also reduces emissions of some air pollutants, compared to petroleum diesel. The production of biodiesel can divert waste from landfill sites and increase markets for agricultural products.

Engines powered by biodiesel blends perform virtually the same as those with petroleum diesel, delivering similar torque and horsepower. Using biodiesel blends may improve engine performance, may reduce engine wear and may extend engine life.

Biodiesel can be blended with petroleum diesel in any proportion, and contains slightly less energy by volume than petroleum diesel. It is normally sold as a blend anywhere from B2 (2% biodiesel by volume) to B20 (20% biodiesel by volume). Check your vehicle manual to verify which fuels are recommended and the warranty requirements.

Special care needs to be taken to avoid fuel gelling in very cold weather. Fuel additives, engine block heaters or fuel filter heaters can be used, and storing fuel and vehicles inside can help to avoid this problem. Biodiesel's mild solvent effect may "clean out" sediments from fuel tanks and storage systems. Fuel filters may need to be replaced several times within the first few months after introducing biodiesel into a fuelling tank.

Some North American vehicle engine manufacturers approve the use of low-level biodiesel blends (up to 5% biodiesel) in their engines.

Heating fuel

Biodiesel can also be used as a heating fuel in oil furnaces and boilers. Although there is limited experience with the use of biodiesel as a heating fuel, no significant adverse effects from using biodiesel in low-level blends in furnaces and boilers have been reported from initial trials. It is supplied as a heating fuel in a few locations, but it is not yet widely available across Canada.

The Government of Canada continues to test biodiesel use as a transportation and heating fuel under real world conditions. This testing advances our knowledge and information for improved handling of this fuel under the range of Canadian conditions, particularly in extreme cold weather.

For more information on this fuel, visit **www.alternativefuels.gc.ca.**

NATURAL GAS

Natural gas can burn more cleanly than gasoline or diesel fuel. It produces fewer toxic pollutants and can also reduce life-cycle GHG emissions by around 20%, compared with pure gasoline. Although prices fluctuate, it is usually less expensive than gasoline as a transportation fuel, on an energy content adjusted basis, in part because there is no federal excise tax or provincial/territorial road tax on natural gas as a vehicle fuel.

Factory-built natural gas light-duty vehicles are not offered for sale in Canada. However, conventional gasoline vehicles can be converted to natural gas. Factory-installed natural gas engines are available in certain medium- and heavy-duty vehicles, such as municipal waste-collection trucks and urban and city transit buses.

Natural gas refuelling for vehicles is available at select retail outlets in Alberta, British Columbia, Ontario and Saskatchewan. On-site vehicle refuelling appliances are also available for installation at your place of business or home.

For more information on certified conversions, refuelling, or other related topics, visit the Canadian Natural Gas Vehicle Alliance's Web site at **www.cngva.org**.

PROPANE

Propane is a lower-carbon, gaseous fossil fuel that is pressurized and stored as a liquid when used in vehicles. Most of Canada's propane is a co-product of natural gas production. But it can also be produced from the refining of crude oil.

Like natural gas, propane can burn more cleanly than gasoline or diesel fuel. It can also reduce life-cycle GHG emissions by around 20% compared with pure gasoline. And it produces less pollution. For example, because propane has a low sulphur content, it does not produce significant amounts of sulphur oxides, which can contribute to acid rain and smog.

Propane has less energy content by volume than gasoline does (it takes about 1.4 litres of propane to travel the same distance as one litre of gasoline).

Although prices fluctuate, propane is typically less expensive than gasoline on an energy content adjusted basis.

Currently only one automaker in the North American market offers a factory-built model that can run on propane. By using a certified conversion kit, conventional gasoline vehicles can be converted to run on propane (or on both propane and gasoline). For more information on conversions, consult your local propane supplier or visit **www.propanegas.ca**.

To locate service stations in your area or for more information, visit **www.alternativefuels.gc.ca**.

ELECTRICITY

Electricity is the most widely available energy source in Canada today. It is currently being used in three types of vehicles: hybrid electric, plug-in hybrid electric and battery-electric.

Hybrid-electric vehicles

Hybrid-electric vehicles (HEVs) have both an internal combustion engine and a battery-powered electric motor – a combination that gives motorists the extended driving range and rapid refuelling capabilities of a conventional vehicle – and many of the energy and environmental benefits of an electric vehicle.

HEVs use less gasoline than conventional vehicles, typically reducing fuel consumption and GHG emissions by between 30 – 50%. HEVs do not need to be plugged in for recharging; harnessing the energy from coasting, braking and the gasoline engine recharges the batteries.

Virtually all major automakers in the North American market offer hybrid models. As the market expands, the difference in cost between HEVs and conventional vehicles is declining.

Plug-in electric vehicles

Plug-in hybrid electric vehicles (PHEVs) are the same as HEVs except that they can be plugged into an electrical outlet in order to recharge the battery. Their batteries are usually more powerful. All this combined means that they can travel short distances without using the gasoline engine at all – just the electric motor. This reduces their fuel consumption when compared with HEVs. PHEVs are still under development, but may be introduced into showrooms within the next five years.

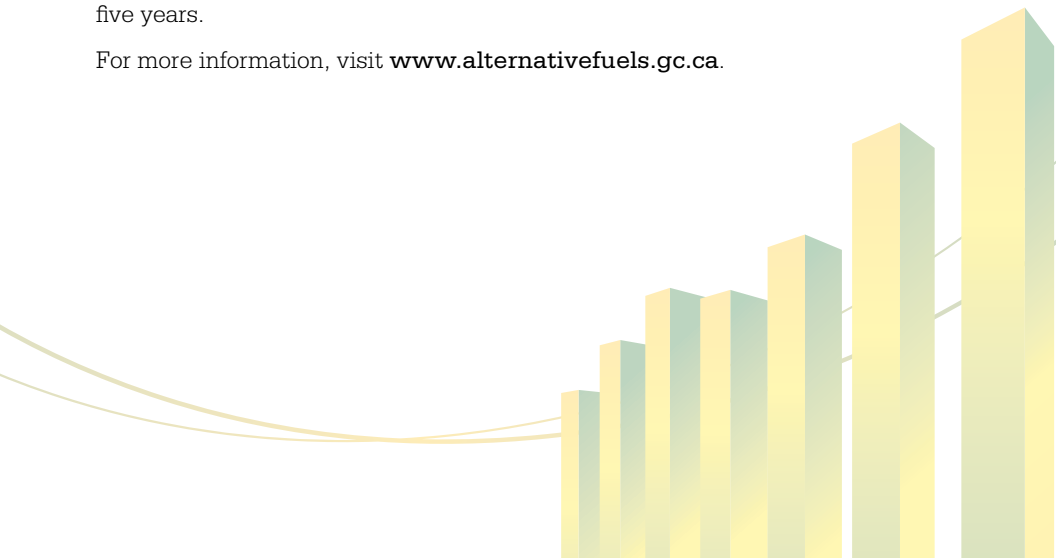
Battery-electric vehicles

Battery-electric vehicles (BEVs) are powered only by electric motors which draw power from on-board storage batteries. BEVs produce no pollution from the tailpipe or through fuel evaporation, which means they could have great potential to reduce GHG emissions and smog-forming pollutants. Depending on the source of electricity used to recharge the batteries, the vehicles can also have zero or very low life-cycle GHG emissions. Because they use electric motors to power them, BEVs are quieter and offer greater acceleration at lower speeds than conventional vehicles.

The travel range of BEVs depends on their battery type. Conventional lead-acid batteries can store enough energy to travel only 50 to 100 kilometres. But more advanced batteries, such as nickel-metal hydride and lithium ion, store enough to travel 150 kilometres or more. Most BEVs are being designed to recharge from a standard household electrical outlet.

BEVs are not common in Canada, but their viability is improving with the development of batteries that are smaller and lighter, can be recharged more quickly and store more power than today's batteries. BEVs are already available as low-speed special application and neighbourhood delivery vehicles, and their uses are increasing. Although a limited number of electric cars and longer distance delivery vehicles are currently available, some automakers suggest they will have battery-electric cars in their showrooms within the next five years.

For more information, visit **www.alternativefuels.gc.ca**.



HYDROGEN AND FUEL CELLS

Fuel cells generate electricity by electrochemically combining hydrogen with oxygen from the air. Fuel cells are similar in principle to batteries. The main difference is that batteries store electrical energy, while fuel cells generate electricity continuously as long as hydrogen is supplied.

Hydrogen can be used as a transportation fuel by burning it in an internal combustion engine, either alone or mixed with natural gas (a hydrogen/natural gas mix is called hythane).

Hydrogen fuel has been available for a long time, and is primarily produced today by reforming natural gas. Reforming can be done at a hydrogen production plant or at a refuelling station.

Hydrogen can also be produced

- by using other fossil fuels such as methanol or gasoline in the reforming process;
- through the electrolysis of water using an electrical current supplied by a renewable source of energy, such as hydro, wind or solar;
- from electricity produced from burning fossil fuels, such as coal;
- by using nuclear energy.

Life-cycle GHG emissions of hydrogen vary, as they depend largely on how the hydrogen is produced. On a life-cycle basis, hydrogen fuel cells can produce very low GHG emissions if renewable electricity or nuclear power is used to make the hydrogen. If fossil-fuel reformation or electricity produced from burning fossil fuels is used to make the hydrogen, fuel cells will produce emissions at the point where the hydrogen is made. However,

the fuel cell itself, if operating on pure hydrogen, produces no GHG emissions or other pollutants – only electricity, heat and water. Overall, fuel cell vehicles could have the potential to reduce GHG emissions by nearly 100% compared with conventional gasoline-powered vehicles, if the hydrogen used is produced from a renewable source.

Hydrogen fuel cell vehicles are being tested, but the technology is not yet commercially available. Most automakers are working on prototypes, although there are many barriers to using fuel cells in vehicles. These barriers include the lack of a hydrogen production and distribution infrastructure, high capital costs for fuel cells and hydrogen-production technologies, and challenges related to hydrogen storage.

For more information, visit **www.alternativefuels.gc.ca**.

BIOGAS

Canada is also starting to explore the potential for using biogas (biomethane), a renewable form of natural gas, in vehicles. Like natural gas, it can burn more cleanly than gasoline or diesel fuel, and has the potential to produce even fewer toxic pollutants, and can have a higher reduction of life-cycle GHG emissions compared with pure gasoline.

The anaerobic digestion of landfill waste, agricultural residue and other biomass generates biogas, which can be upgraded to biomethane. Biomethane is considered to be one of the most climate friendly fuels, because it is produced from a GHG (methane) that would otherwise be released into the atmosphere. It can be used in natural gas vehicles with no modifications.

Biomethane is used as a transportation fuel in Europe, but it is not yet commercially available in Canada.

For more information, visit **www.alternativefuels.gc.ca**.

NEXT-GENERATION BIOFUELS

The vast majority of ethanol produced in Canada today is made from traditional agricultural feedstocks – corn and wheat. However, there are limits to the quantity of ethanol that can be produced from these sources. As demand for biofuels increases, new feedstocks for ethanol will be required. "Next-generation" or cellulosic ethanol can be made from feedstocks like wheat straw, corn stover (the corn husks and stock) and wood residues from forestry operations and pulp and paper making. Cellulosic ethanol can also be made from feedstocks grown on marginal land not currently used for crop production and from short-rotation forests, such as fast-growing willow or poplar. Manure and municipal solid waste are other potential feedstocks. Cellulosic ethanol has the potential for even greater GHG emissions reductions than conventional ethanol on a lifecycle basis.

Biodiesel is a form of renewable diesel made from traditional feedstocks such as canola oil. New methods of producing renewable diesel fuels use both traditional and non-traditional feedstocks, using a process similar to part of the petroleum refining process and could therefore be integrated into the existing refining and distribution system, creating economic efficiencies. Renewable diesel can also be made using virtually any type of biomass including wood and other cellulose-based materials. This type of renewable diesel has the potential for even greater GHG emissions reductions than traditional biodiesel on a lifecycle basis.

Canada has an abundance of cellulose-based feedstocks and is well positioned to capitalize on next-generation biofuels. In September 2007, the Government of Canada announced the $500-million NextGen Biofuels Fund™ to invest with the private sector in establishing large-scale demonstration facilities for the production of next-generation biofuels.

Sustainable Development Technology Canada manages the NextGen Biofuels Fund™. For more information, visit **www.sdtc.ca** or **www.alternativefuels.gc.ca**.

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Natural Resources Canada's Office of Energy Efficiency

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

Cat. No.: M144-180/2008 (Print)
ISBN: 978-0-662-05371-2

Cat. No.: M144-180/2008E-PDF (On-line)
ISBN: 978-0-662-47859-1