

DRIVING TO 2050

THE ROLE OF TRANSPORTATION FUELS
IN CANADA'S LOW-CARBON FUTURE



Canadian Fuels
ASSOCIATION

We see remarkable change ahead.

We see a future where Canadians achieve significant transportation GHG emission reductions without compromising the ability to move people and goods. We see a future where Canada is a leader in the development of clean transportation-energy choices. A future where those choices include reliable, affordable low-carbon liquid fuels.

Contents

The challenge we face	1
An integrated approach to reducing transportation GHG emissions	3
The future is now	7
Driving to success.	12



The challenge we face

When Canadians look to the future and the possibilities that lie ahead, they see a country defined by its strong and resilient economy, its leadership in a low-carbon world and the ability to supply its own energy needs.

Canada's refining industry shares our country's bold aspirations and will do its part to help build a prosperous low-carbon future while continuing to enable the transportation infrastructure that Canadians have come to rely on. Our challenge has been made more difficult and the future less certain due to the COVID-19 pandemic, but we will remain committed to continued leadership in tomorrow's low-carbon economy.

A nation on the move

Transportation is essential to Canadians' way of life and a healthy economy. Meeting the transportation needs of more than 37 million people across nearly ten million square kilometres is no small task, especially taking into account vast regional differences in climate, geography, infrastructure and energy needs.

The people of our industry fuel the trucks, trains, ships and aircraft that move the vital goods that Canadians rely on every day – within and beyond our borders. Transportation fuels ensure that Canada can succeed in a global marketplace.

Achieving significant emission reductions is a daunting challenge for a country as large and diverse as Canada. Traditionally, nearly half (45%) of Canada's emissions have come from sources needed to generate heat, electricity and industrial power. Transportation was the second largest source at 25%. The future is uncertain, but our industry is committed to the Pan-Canadian Framework on Clean Growth and Climate Change. We are up to the task of delivering emissions reductions while supporting a healthy economy and providing secure and reliable solutions to Canada's energy needs.

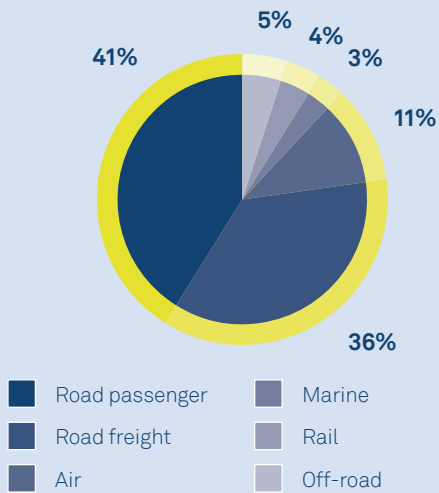
A time for transformation

Members of the Canadian Fuels Association believe that achieving our national emissions-reduction targets and meeting Canada's commitments under the Paris Agreement will require a profound change – nothing short of a transformation in our transportation energy system.

The early stages of this transformation are already underway. Canadians are beginning to make different transportation fuel choices. We are questioning the way we use those fuels while looking for ways to make them cleaner and more efficient.

Road transportation accounts for more than 75% of total transportation emissions.

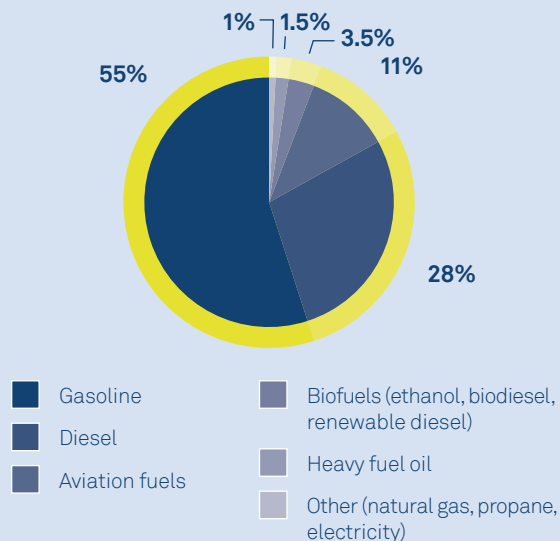
Transportation emissions by mode, 2017



Totals may not add up due to rounding.
Source: Natural Resources Canada

Petroleum fuels power more than 95% of transportation.

Energy use in the transportation sector, 2017



Source: Natural Resources Canada

We're ready

Energy transformation will mean big changes for Canada's transportation fuels industry. We have a major role to play. We are ready to support Canada's post-pandemic recovery and beyond by:

- **Reducing GHG emissions at the lowest possible cost to society** – because we need to balance our emissions reductions with maintaining a healthy economy
- **Leveraging and adapting existing infrastructure and expertise** – to enable us to respond faster and with greater agility.
- **Enhancing domestic energy security** – so that Canada can act independently and harness our domestic capability.

We have met Canadians' evolving transportation-fuel needs and expectations for more than a century. Now, we are focused on finding solutions to reduce transportation GHG emissions and using Canadian resources to support our country in creating a low-carbon economy.

We see opportunities to develop new technologies and processes, and to adapt the existing fuel-production and distribution infrastructure. We're seizing these opportunities now with refinery co-generation initiatives, for example, that generate most of the energy needed on-site (see page 9). And using carbon capture and storage (CCS), we are reducing CO₂ emissions by millions of tonnes (see page 10).

We see the benefits of collaborating in more strategic and innovative ways with vehicle manufacturers, technology developers and providers, and other energy sectors. These collaborations are already delivering results in the pursuit of new biomass-based fuel formulations (see page 9).

We also see the need to diversify our transportation-energy products, distribute more types of fuel and satisfy a broader range of business and consumer needs – all while reducing emissions. One of the best examples of this is the deployment of electric fast-charger facilities and hydrogen refuelling sites at traditional filling stations (see page 11). ➔



AN INTEGRATED APPROACH TO REDUCING TRANSPORTATION GHG EMISSIONS

The complexity of the climate change challenge means that there will be no single fix. We must be ready to pursue a range of solutions, specifically:

Provide more
low-carbon
fuel choices

Improve
vehicle
efficiency

Rethink
mobility

Build
a stable policy
environment

The benefit of an integrated approach is to fuse the ingenuity of industry, governments and academia to develop solutions as diverse as Canadians' energy needs.

1 Provide more low-carbon fuel choices

Canada's future will demand a variety of fuels and vehicle types that is as diverse as the transportation modes we use and the geography we face. Our members see immense potential for fuel choices in three broad categories: low-carbon liquids, electric and gaseous. As Canada moves into this diversified fuel future, each option should have the opportunity to build its strength, relevance and value in a competitive market.

LOW-CARBON LIQUIDS

Is there a future for liquid fuels? Absolutely. Canadians have relied on liquid transportation fuels for nearly 125 years. These fuels deliver safety, dependability, convenience and affordability in all transportation modes. Gasoline, diesel and aviation fuel are available 24/7 through a sophisticated nation-wide system – the result of billions of dollars of investment and decades of innovation. These fuels will remain vital to meet Canada's transportation energy needs as alternatives mature. In the meantime, the environmental performance of liquid fuels will continue to improve.

CFA members aim to reduce GHG emissions without sacrificing fuel performance. Cleaner fuel means lower carbon intensity – through biofuel blending, for example. Agricultural crops such as corn and canola are used to produce liquid biofuels today. Eventually, biomass fuels will come from agricultural, forestry and urban solid waste, as well as algae and other products, all of which will be co-processed with petroleum feedstocks. In the early stages of development, these advanced products are referred to as "drop-in" biofuels, because they could power today's vehicles and be stored and distributed in existing infrastructure. Biomass-based liquid fuels are ideal for emission reduction in aviation and heavy road freight, where high energy density is essential, and electrification impractical.

Synthetic fuels – also known as e-fuels or "power to liquids" (PtL) – are another area of innovation. They are created using captured CO₂ and green or blue hydrogen produced from renewable electricity. As drop-in hydrocarbons, synthetic fuels are compatible with existing fleets and liquid fuel infrastructure and offer strong potential to fuel aviation and heavy road-freight modes where high energy density is critical.

ELECTRICITY

Electrification offers GHG emissions reduction potential mainly in light-duty vehicles (LDVs). The shift to electric vehicles (EVs) is already underway, but the pace has been relatively slow. As a result, EVs account for only a small market share. However, a significant acceleration of this technology is likely to occur as costs come down, battery performance improves, and the fast-recharging infrastructure expands, especially in urban and suburban settings.

Hydrogen fuel-cell electric power is a promising alternative for heavy freight vehicles because it is not limited by the range, recharging-time and energy-density restrictions of battery electric power. Advancement of fuel cell technology – and greater market adoption – is currently constrained by limited hydrogen production, as well as the absence of hydrogen distribution and refuelling infrastructure.

GASEOUS FUELS

Natural gas and propane already power fleet vehicles such as taxis, local delivery and heavy freight trucks. These vehicles produce up to 25% less GHG emissions than gasoline or diesel equivalents.

Historically, gaseous-fuelled vehicles have held a minor market share. Widespread adoption has been hindered by high vehicle-acquisition costs and limited refuelling infrastructure. As impediments fall away, the transformation opportunities for gaseous fuels will likely remain in commercial and government fleets.

2 Improve vehicle fuel efficiency

This is another action that is key to an integrated approach to reducing GHG emissions. Recent advances in vehicle fuel efficiency have already led to reductions. Those gains are due primarily to upgrades in internal combustion engines (ICEs). Experts see significant potential to further optimize the fuel and emissions efficiencies of ICE-powered vehicles. In fact, widely adopted ICE technology improvements could provide the greatest short-term reductions in fuel consumption and GHG emissions.

3 Rethink mobility

The pandemic has shown us that we may not need to travel as much as we think. When we do, we can use less energy and reduce emissions by choosing lower fuel- and emissions-intensive transportation modes and systems. In cities, this means offering more choices: public transit, ride-sharing, cycling, walking. Urban densification is critical to situate more Canadians in proximity to the services they need.

Shifting modes between cities means upgrading rail infrastructure and investing in new high-speed rail corridors to reduce reliance on road and air travel. It means restructuring freight logistics systems to move goods by less energy intensive modes.

4 Build a stable policy environment

Government action is the final element in an integrated approach to reducing transportation GHG emissions. Canadian Fuels members support a strong regulatory system of environmental protection that is coherent and consistent to enable complex industries and supply chains to meet Canadians' needs and expectations. Policy instruments need to respect technology-neutral solutions and not create unnecessary regulatory hurdles. Smart public policy creates a stable regulatory environment that drives private sector investment and helps accelerate change.

What will the future of transportation fuels look like?

For any future fuel option to succeed, it must meet basic minimum requirements related to scale, ease of substitution, reliability, commercial readiness, sustainability and affordability. These demands make it difficult to forecast the future fuel mix. The uncertainty can be summarized in two basic questions:

How fast and how far will technologies develop?

Breakthroughs and setbacks are inevitable with any new technology. This is one of the main reasons we must avoid picking winners, remain "technology neutral" and keep our range of potential fuel and vehicle solutions open. We may need to make nimble shifts as the technological landscape changes. Events such as the COVID-19 pandemic could stall emerging technologies and highlight the value of leveraging and adapting our current, reliable fuel infrastructure.

What choices will consumers make?

Consumers have immense influence over the future of transportation fuels. In a competitive market, Canadians will pay close attention and make decisions based on their assessment of technologies that best meet their needs. →

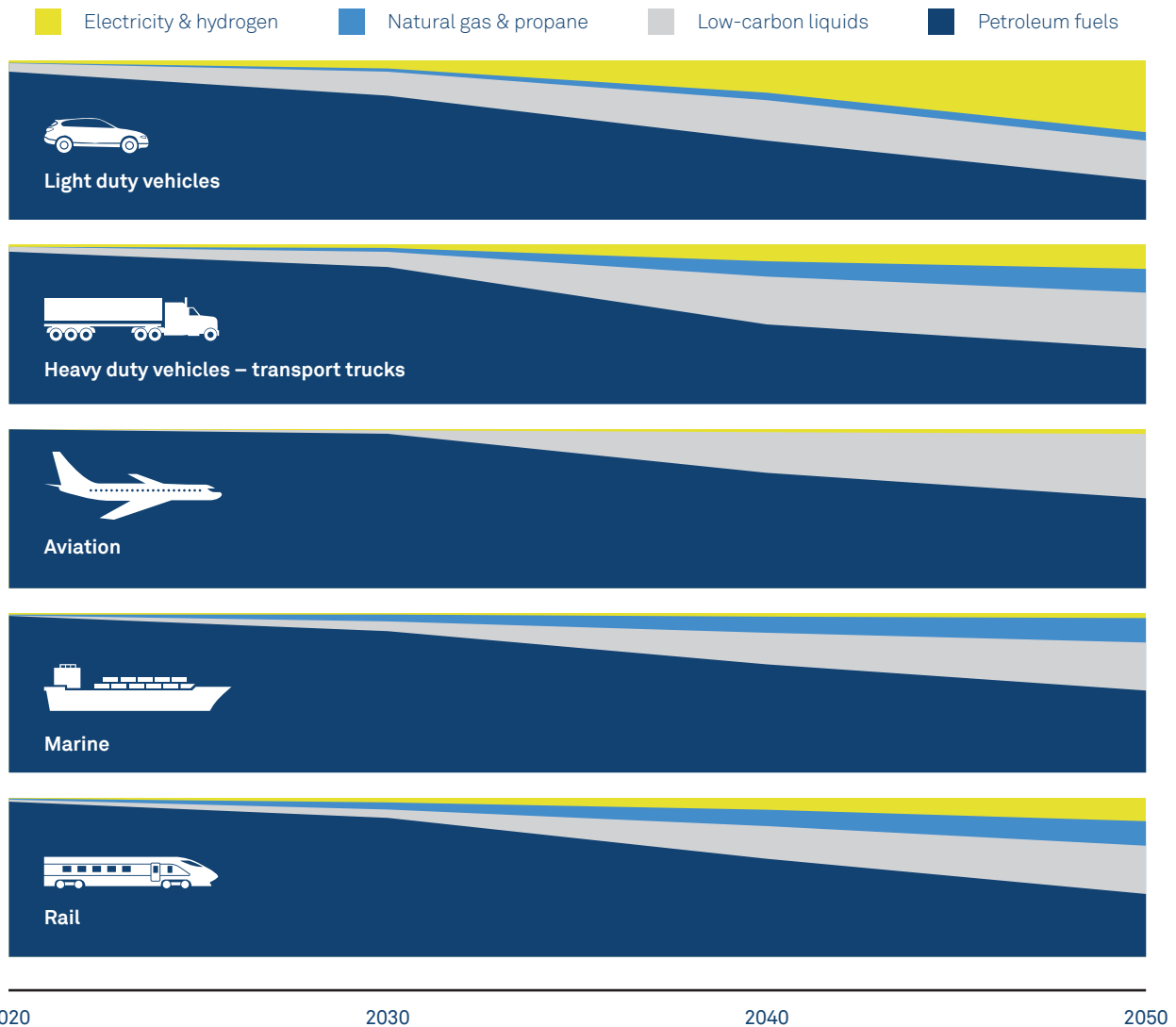




A glimpse ahead

The way we fuel transportation in 2050 will be different than the way we do it today. Transformation is inevitable, and our members will be part of the process and ultimate solution. The future will require a diverse mix of fuels and vehicles. There will be no 'one size fits all' fuel solution. Vaclav Smil, Distinguished Professor Emeritus in the Faculty of Environment at the University of Manitoba adds another proviso: "...the unfolding energy transition towards decarbonization will inevitably follow the progress of all previous large-scale primary energy shifts. In other words it will be a gradual, prolonged affair."¹

Here is one vision of a *potential* future that finds promise in all fuel options and acknowledges the need for different solutions in various modes.



Light duty vehicles

A significant shift to electricity is likely for light duty vehicles (LDVs) in urban and suburban settings. Transformation opportunities for gaseous fuels are mainly in commercial and government LDV fleets.

Heavy duty vehicles – transport trucks

Hydrogen fuel cells offer promise as an electrification option for long distance heavy freight transport; natural gas, especially in liquefied form (LNG), also offers promise. But liquid fuels continue to dominate.

Aviation

Biomass-based and synthetic liquid fuels are ideal emissions-reduction solutions in aviation and heavy freight, where high energy density is essential. Electricity could be a path forward for lighter aircraft on short-haul routes.

Marine

Natural gas, low-carbon liquids and petroleum are the main fuels of choice. Hydrogen fuel cells are the only practical electrification option.

Rail

Rail becomes one of the most balanced modes by fuel option, being well suited to all four future-fuel options.

¹ Smil, V. 2019. What we need to know about the pace of decarbonization. *Substantia*. <http://vaclavsmil.com/wp-content/uploads/2020/01/Substantia.pdf>



The future is now

As we journey into an uncertain future, our industry's scientific, engineering and business expertise will continue to advance Canadian innovation, create new jobs and power Canada to greater prosperity.

A tradition of innovation

Innovation has defined the refining industry's progress for more than 125 years.

When the auto industry advanced power-train technology early in the 20th century, we kept pace with the fuels automobiles needed to run smoothly and effectively. For half a century we have worked collaboratively with governments and industry to improve the environmental performance of vehicles and fuels. Perhaps the most remarkable success has been the deep reductions in vehicle emissions of sulphur oxides, nitrogen oxides and volatile organic compounds. Since 2005 alone, we have invested more than \$5 billion to reduce sulphur content by more than 90% in gasoline and 97% in diesel fuel.

New ideas. New methods. New products.

Canada's refining industry is now applying its experience and ingenuity to develop "made in Canada" climate-change solutions. Innovations in carbon-intensity reduction include production **process improvements, biomass-based fuels, carbon capture and storage (CCS), synthetic fuels, and expanding the existing distribution and retail infrastructure** to diversify product offerings and create more choice for consumers. These innovations will unfold in a phased approach to transform operations and increase the refining sector's role in the low-carbon economy.

PHASE
1

FOUNDATION

Seize immediate opportunities to increase operational energy efficiency.

Process improvements, biomass-based fuels, CCS, expanding existing distribution and retail infrastructure

PHASE
2

TRANSFORMATION

Progressively increase number of low-emission components and range of low-carbon feedstocks.

Process improvements, biomass-based fuels, CCS

PHASE
3

REALIZATION

Become a production and distribution hub for low-emission energy products and raw materials.

Process improvements, biomass-based fuels, CCS, synthetic fuels

Adapted from Figure 2, pg. 30, *CONCAWE Review*, Volume 29, Number 1, June 2020.
<https://www.concawe.eu/publications/concawe-reviews/>

PROCESS IMPROVEMENTS

PHASES **1** **2** **3**

Process improvements along the whole production and distribution value chain will continue to drive down the carbon intensity of fuels. New resource-extraction techniques, improved energy management, process optimization, reduced flaring, switching to low-carbon energy sources and co-generation are prime examples of work now underway to reduce energy consumption and emissions.

Co-generation captures process heat to generate electricity or produce steam. The process could enable a production facility to produce enough energy to meet on-site demand. Larger co-generation initiatives can produce excess electricity for connection into provincial grids.

Imperial's co-generation facility at its Edmonton refinery captures gas that is a by-product of operations to produce 80% of the electricity the refinery needs. Waste heat from the process will be used to produce enough steam to meet half the refinery's needs.



BIOMASS-BASED FUELS

PHASES **1** **2** **3**

We are continuing to leverage innovation and work with vehicle manufacturers to give consumers additional lower-carbon fuel choices that can be safely used in existing vehicles. A key objective is to supply lower-carbon liquid fuels that are cost and emissions competitive with alternatives. We see significant opportunities to leverage the superior energy density of liquids and the continuing improvements in ICE vehicle technology to deliver the affordable emissions reductions solutions Canadians want.

Canada's refiners were some of the earliest investors in ethanol production. Now, they operate some of Canada's largest ethanol production facilities. **Valero Energy's** Canadian operations are leveraging the parent company's significant US ethanol and renewable diesel production capacity. **Federated Co-operatives Ltd.** is the most recent Canadian refiner to invest in its own ethanol production facility. Industry investments include extensive terminal and retail conversions to enable more biofuel blending across Canada.

Other investments focus on dedicated bio-refineries and advanced biofuels that expand the feedstock mix and deliver greater emissions reductions. Canada is in a unique position to be a leader in the production of these drop-in biofuels. For example, **Suncor** is investing in the production of cellulosic ethanol from municipal solid waste.



Co-processing of biomass feedstocks like bio oils with petroleum feedstocks is a promising way to produce low-carbon drop-in transportation fuels. Current innovation efforts are examining multiple feedstocks and processing methods. **Parkland** is a Canadian leader in this approach at its Burnaby, British Columbia refinery; their co-processed fuels are approximately 85 percent less carbon intensive than conventional fuels. Tidewater is also in the early stages of developing a co-processing facility at its refinery in Prince George, British Columbia. Co-processing has the potential to become a significant way to decarbonize liquid fuels and lower the carbon content in each of a refinery's products

CARBON CAPTURE AND STORAGE (CCS)

PHASES **1** **2** **3**

CCS is essential to global energy transformation. The technology captures, liquifies and injects CO₂ underground for safe and permanent storage. Canada is a world leader in CCS, which is already helping to reduce the carbon intensity of liquid fuels.



In Fort Saskatchewan, Alberta, the **Shell**-operated Quest CCS project has captured and safely stored five million tonnes of CO₂ – the most of any onshore facility in the world. Five million tonnes of CO₂ is equal to the annual emissions from about 1.25 million cars.



The **North West Redwater Partnership's** Sturgeon refinery north of Edmonton is Canada's newest refinery and the first such facility in the world to integrate CCS into its original design, enabling the development of cleaner, high-value products.

EXPANDING THE REFUELLING INFRASTRUCTURE

PHASES **1** **2** **3**



Credit: Shell International Ltd.

Canadians want transportation energy options. The lack of a refuelling infrastructure for alternative fuels such as electricity has been an obstacle to greater choice. Liquid-fuel distributors are diversifying their product offerings to include propane, electricity, hydrogen and natural gas.

An early adopter of EV technology in Atlantic Canada, **Irving Oil** hosts fast-charger stations at many of its locations. **Suncor** has deployed a first of its kind electric network enabling customers to re-charge electric vehicles at Petro-Canada branded high-speed charging stations along the full length of the Trans-Canada highway.

And we're moving beyond electricity. In a first for Canada, **Shell** has opened two retail hydrogen-refuelling stations in Vancouver and plans to further expand the network. **Federated Co-operatives Ltd.** has expanded its E85 offering at retail sites in British Columbia.

SYNTHETIC FUELS

PHASE **3**

The production of synthetic fuels at scale is a longer-term undertaking with significant technical and commercial challenges to be overcome. These fuels could include "green" hydrogen, which is created using emissions-free electricity.

Suncor is an early investor in process-technology intellectual property for the conversion of CO₂ to liquid fuels. The technology has the potential to support multiple Canadian plants in the future. →

Driving to success

Remarkable changes lie ahead. And Canada's opportunity is to be at the environmental and economic forefront.



We all share a responsibility to take timely action and focus on shared aspirations for a healthy environment and a safe, prosperous future. We have the responsibility to work together across industrial sectors, jurisdictional boundaries and political lines.

Collaboration is critical as we strive to balance Canada's economic and environmental goals. That's why Canadian Fuels has taken a leading role in the Clean Resources Innovation Network (CRIN). CRIN is a group of progressive oil and gas industry professionals, innovators, financiers, policy-makers, academics and students committed to clean hydrocarbon energy and a strong Canadian economy. Canadian Fuels members lead the CRIN Cleaner Fuels theme group focussed on developing lower-emissions fuels.

Our partnerships extend beyond Canada to include international colleagues directly or through organizations like IPIECA – the global oil and gas industry association for advancing environmental and social performance.



Our commitment to Canadians

As Canada's transportation fuels providers, our commitment is to continue to make significant contributions to a strong and resilient economy as well as meaningful reductions in greenhouse gas emissions. Through collaboration, we will deliver emissions reductions without compromising our ability to move people and goods across Canada and beyond. Together, we will build a future where Canada is a leader in the development of clean transportation energy choices – a future where those choices include reliable, cost effective and low-carbon liquid fuels. →



We represent Canada's transportation fuels industry.

Our sector contributes over \$10 billion to Canada's GDP each year and employs more than 117,000 Canadians at 15 oil refineries, 78 fuel distribution terminals and 12,000 retail and commercial sites. The association helps its members meet government environmental policy objectives and the expectations of Canadians without compromising our country's access to a secure, reliable and competitively priced fuel supply.

We are recognized internationally as a trusted source of industry information and technical expertise, and have worked collaboratively and productively with governments and other sectors for decades.



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