From wind to horsepower to steam power and internal combustion engines—How we get around has evolved our world.

A LONG ROAD AHEAD

Toward a lower-carbon transportation future

THE CHANGING FACE OF RETAIL
What’s your destination?

No matter where you’re shipping goods or shuttling families, transportation fuels are vital to keep Canada mobile and globally competitive.

At the Canadian Fuels Association, we represent the industry that produces, distributes and markets petroleum products in Canada—trusted, proven products that account for 95 percent of the transportation fuels Canadians rely on every day.

The fuels sector contributes more than $5 billion to Canada’s GDP each year and employs over 100,000 Canadians at 15 refineries, 70 fuel distribution terminals and approximately 12,000 retail and commercial sites across the country.

We’re here for Canadians, wherever you’re headed. We’ll take you there.
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Governments at all levels are increasingly focused on the issue of climate change. The 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), scheduled for Paris in the first half of December 2015, may be a defining moment in charting the road forward.

An aggressive target

The Intergovernmental Panel on Climate Change has determined that keeping the global temperature increase to within two degrees Celsius will require GHG emission reductions of 80 percent below 1990 levels by 2050. A new Canadian report explores that challenge in detail. The Conference Board of Canada’s A Long, Hard Road: Drastically Reducing GHG Emissions in Canada’s Road Transportation Sector by 2050 takes into account the most promising initiatives and technologies. It finds that an 80 percent reduction target for Canada is unrealistic. Converting all passenger transportation to zero emission modes would still leave Canada well short of this goal. Even a 50 percent reduction target will be costly and require not only a significant reduction in transportation activity, but also a break in the traditional connections between economic growth, our standard of living and transportation demand.

The Conference Board report highlights the difficulty for policy-makers: transportation is a significant component of emissions in Canada and around the world. Transportation is also vital for a strong economy and decent quality of life. How can we achieve meaningful emissions reductions without compromising our ability to travel and constraining our economy?

Targets are essential. But they must be realistic and set in conjunction with clear, practical plans on how to achieve them. An aggressive aspirational target in the absence of such strategy is a formula for failure. Kyoto is a good example.

Driving towards a sustainable transportation system that balances Canadians’ environmental, economic and social aspirations.
Progress is being made

Rather than dwell on unachievable targets, we feel it is helpful to focus on the environmental progress that’s being made (Breathing Easier, page 32) and the many ways we can make a difference now (eco-driving techniques, page 26). The carbon footprint of transportation will get smaller in coming years, but short of some new and as yet unknown technological breakthrough, incremental technology developments will deliver some of the most beneficial contributions (Fuelled by Innovation, page 22). While the fuel mix will diversify in the decades ahead, petroleum will remain the dominant transportation fuel for the foreseeable future.

Beyond this, demand-side management is the key challenge and opportunity. Canadians and governments must make smart decisions about where we live and work, how we get around, and how much we are prepared to pay for our transportation options (see Get Smart, page 12). The goal is to grow a sustainable transportation system that balances Canadians’ environmental, economic and social aspirations.

We believe combined efforts to achieve this sustainable outcome must be founded on three key actions:

- Explore, define and evaluate emission reduction pathways in collaboration with stakeholders before targets are set.
- Recognize Canada’s productivity and competitiveness as core considerations in the development and implementation of a national GHG reduction strategy.
- Ensure that sound science and cost-benefit analyses drive decision-making and are transparently shared with citizens.

Our industry fuels mobility. We are committed to working constructively together with governments and other stakeholders to achieve a sustainable, lower-carbon transportation future for Canada.

Perspectives is an important part of our contribution. This annual publication gathers clear and balanced insights from academics, researchers, independent journalists and industry experts to provide Canadians with the knowledge they need to make informed decisions about our transportation fuels future. Perspectives carries on the Canadian Fuels Association’s active role in the public discourse on Canada’s transportation fuels.

Our members are not responsible for setting targets. But, as Canadians, we are all responsible for helping governments set realistic ones and exploring the ways we can work successfully toward them.
From wind to horsepower to steam power and internal combustion engines—How we get around has evolved our world.

Pierre Desrochers is an associate professor of geography at the University of Toronto. He writes and researches extensively about energy policy.
Two centuries ago, renewable technologies such as human and animal power, windmills and watermills helped feed and drive economies for the world’s 1 billion human inhabitants. Those power sources were, of course, the best available.

At that time, humans had a one in three probability of being malnourished, average incomes of around a dollar a day and a life expectancy of around 30 years. Life was short, even for most of the relatively well off. Put another way, people’s average standard of living in wealthier nations in the early 1800s was similar to the poorest rural inhabitants of today’s least developed economies.
Humans began to develop coal, crude oil and natural gas-powered technologies. With the introduction of the internal combustion engine, fuelled by hydrocarbons from petroleum, the commute to prosperity and personal independence was underway. These innovations played a crucial role in changing some very grim statistics.

In 2015, human life has improved beyond recognition in most of the world, especially in developed countries. We are born, go through our daily existence and die surrounded by petroleum-derived products, and petroleum continues to be the most reliable liquid energy known to mankind. It has brought us greater wealth by enabling swift and affordable transportation, by bringing us consumer goods that improve our lives, by fuelling the delivery of foods and other necessities from around the world—the list goes on. Our resulting greater wealth has helped society build better infrastructure, technologies and supply chains of all kinds that constitute our best possible insurance against starvation and other potentially fatal challenges.

The fact is, petroleum-derived products have changed our lives, mostly for the better. And that reality isn’t going to change any time soon.

Has our transformational relationship with petroleum-based fuels arrived with some risk? Certainly. Greenhouse gas emissions are a serious concern in many quarters of society and there is no doubt that we must move forward with measures to protect the environment from further harm. But the associated rewards of having modernized society through the use of petroleum-based products far outweigh the hazards by most people’s reckoning.

Consider a world without petroleum-based products. Life as we know it would be brought at a near standstill, as roughly two thirds of these products are used as fuels to power land, water and air transportation. Cars and, to a lesser extent, buses, trains and aircraft give us unprecedented individual mobility, not to mention the associated benefits such as access to employment, more varied recreational options—in general, greater prosperity and personal independence.
Equally important, the large-scale, reliable and affordable long distance transportation of goods—be it by petroleum powered trucks, railroads and container ships—has also delivered a wide range of benefits.

Consider:
- improved nutrition with the concentration of food production in the areas best suited to grow it, making food more plentiful, diverse and affordable
- the eradication of famines by moving surpluses from regions with good harvests to those that have experienced mediocre ones
- large-scale urbanization and the wealth creation that can occur only when a large number of people move away from the countryside and into cities

Can you imagine a world in which we would be comfortable getting along without these conveniences and necessities? Nether can I.

So, what do we do?

**Many options, but no magic solution**

There is much wishful thinking in society about a "revolution" in transportation energy that would see widespread adoption of electric cars, for instance, or hydrogen fuel cells on the road in high numbers. It’s an alluring fantasy indeed.

But I prefer to focus my attention on the realities: No viable alternative exists at present to the high energy density, affordability, relatively clean combustion, relative safety, greater ease of extraction, handling, transport and storage of raw product than petroleum-derived fuels. Alternative power sources such as wind turbines, solar panels and geothermal systems that produce electricity are showing some promising applications. And many talented individuals and organizations are working toward incremental solutions that will, eventually, broaden the mix of fuels available and the technologies to utilize them.

But where the rubber hits the road in today’s day and age, electricity has been shown not to be of much practical use— at least not until a radically new battery design comes along that can reliably and sustainably power trucks, aircraft or container ships. Most locomotives continue to be powered by diesel because battery technology is not yet a realistic option for trains that travel beyond the geographical confines of large urban

In 2015, human life has improved beyond recognition in most of the world, especially in developed countries.
Consider this comparison. Two hundred years ago, 1 billion people lived in the world. Today, our global population is 7 billion. In developed countries over that period, the average wage has soared from $3 to more than $120 per day (adjusted for inflation). For the first time in history, even lower income families have access to sufficient food.

**1815**  **200 YEARS**  **2015**

**GLOBAL POPULATION**

1 billion  
7 billion

**DAILY WAGES**

$3/day  
$120/day

Part of the challenge is the limited power and range of electric vehicles, the charging period they require, their performance in cold weather (relatively poor) and security concerns, especially in collisions. Another significant challenge is the time and investment Canada will need to build a robust production and delivery infrastructure for electrically powered vehicles. The fact is, you have to fill up somewhere, and you can’t always be close to home. Realistically, Canada will need a national network of fuelling stations for electric cars (likely decades in the making) before Canadians will adopt these vehicles in high numbers.
One bright spot for alternative fuels is the recent abundance and affordability of natural gas, which, in its liquid form, could be a worthy option in some niches. But natural gas is not as energy dense as petroleum fuels. And, again, Canada faces a challenge with the delivery infrastructure for natural gas. Realistically, natural gas is well suited to vehicles that have large storage capacity and that can return regularly to fuelling stations. This makes it a viable alternative for city buses, which is encouraging.

The future will see incremental innovation

Most observers agree that over the next 25 years or more, petroleum-based fuels will provide 85 percent of global transportation needs. That’s the reality and we need to move forward as constructively as possible within it.

As for biodiesel and ethanol, even Canada does not have sufficient agricultural capacity to produce more than a tiny fraction of the fuel our modern economies would require without gasoline and diesel.

Most observers agree that over the next 25 years or more, petroleum-based fuels will provide 85 percent of global transportation needs. That’s the reality and we need to move forward as constructively as possible within it.

Without a doubt, climate change is a major concern and focus for Canadians, and fossil fuels contribute to the GHG production that has exacerbated climate change.

But we’re getting better.

The Canadian transportation fuel industry had made great strides in reducing its GHG production at refineries (page 32). More efficient fuel consumption by Canadians, better driving behaviors (page 26) and smart urban planning are all part of the short-term solution to reducing Canada’s GHG production (page 12).

Petroleum-based fuels are far from perfect. And they clearly will not last forever. But they have been a remarkable blessing to humanity, and the way humans use them continues to improve with every passing year. Together, Canadians can make a difference in reducing transportation’s environmental footprint by fully understanding the complexities and options within our situation, by accepting the realities of our continuing dependence on petroleum-based fuels, and by sharing in the real, actionable opportunities for becoming more environmentally aware and responsible within a society that will continue to be petroleum-based for many years to come.

canadianfuels.ca
The creative individuals who sit on the Canadian Fuels Association’s National Environment Committee find innovative ways to protect communities, workplaces and the environment. Together with federal, provincial and municipal governments and other groups, the committee focuses on keeping the lines of communication open so it can help drive informed policy decisions.

We profiled three outstanding members of the committee. These women—two engineers and one policy advisor—bring the importance of the environment to life for the sector.

Robyn McMullen
Engineer, Irving Oil
page 11

Jill Donnelly
Engineer, Chevron
page 21

Helen Bennett
Policy advisor, Shell
page 27
“Communities and governments are asking the industry to take increasingly more responsibility to eliminate environmental problems.”

Robyn McMullen has been working steadily for the past few years to support the Saint John Irving Oil refinery’s relationship with governments and communities. She has seen positive change in her varied career and is confident that her efforts are making a difference.

“Im seeing that communities and governments are asking the industry to take increasingly more responsibility to eliminate environmental problems,” says McMullen. “It’s a positive step that Irving Oil supports wholeheartedly.”

McMullen is a native of New Brunswick who worked for seven years in Alberta as a process engineer with Suncor Energy. She specialized in areas such as hydro-desulfurization (a process that removes sulfur and other impurities from crude and petroleum feedstocks) and hydrogen production. McMullen returned to Saint John in 2002 to work with Irving Oil, again as a process engineer, where she worked in sulfur recovery and hydrocracking processes. Following her second maternity leave, she was looking for a change.

McMullen moved to the environmental group because she believed she could add value to conversations taking place about issues such as environmental regulations, permits and compliance. Today, McMullen is Manager of Environment and Community Relations for the Saint John refinery.

“I had the technical experience to understand our processes and felt I could do a good job of communicating that to government.” McMullen says environmental regulations as they apply to refinery operations are deeply complex and negotiations require the expertise of a technical person who is also an adept communicator. “I think I enhance the technical discussion.”
We’ve got a lot of ground to cover in Canada—almost 10 million square kilometres. Getting smart about how we get around means getting smart about how we plan and how we innovate for Canada’s energy transportation system.

Smart energy communities are an important piece of the emissions-reduction and energy-conservation puzzle.

Brent Gilmour is the Executive Director of QUEST, a non-profit organization that conducts research, engagement and advocacy to advance smart energy communities in Canada.

Tonja Leach is QUEST’s Director of Communications and National Affairs.
The reality for Canadians is that transportation for personal mobility and the movement of goods is an essential component of our everyday lives, and a direct contributor to our economic well-being. Vehicles account for 30 percent of Canada’s energy use and 24 percent of greenhouse gas (GHG) emissions, 50 percent of which are from personal vehicle use.

Meanwhile, more than three-quarters of Canadians live near or within an urban centre and it is expected that by 2020 the number will likely increase to 85 percent or more. This adds up to communities being responsible for 60 percent of the country’s energy use and more than half of all GHG emissions.

So how do we become more energy efficient, reduce our emissions, cut costs, improve reliability and stimulate economic growth—and still go about our everyday lives? It starts by investing in smart energy communities.

Efficient, reliable and affordable

Smart energy communities improve energy efficiency, enhance reliability and cut costs and GHG emissions in three ways.

First, smart energy communities integrate conventional energy networks, better coordinating sources such as natural gas, electricity and transportation fuel networks to match people’s energy needs with the most efficient energy source. For example, in Ontario, the City of Hamilton collaborated with Union Gas to capture biogas from a local waste treatment facility and clean it to produce renewable natural gas, or RNG. This allowed the city to begin to use the RNG along with compressed natural gas to operate the city’s municipal fleet.

Second, smart energy communities harness local energy opportunities. The Southeast False Creek neighbourhood in downtown Vancouver is an example. It recovers heat from the city’s wastewater and uses it to supply up to 70 percent of the space and water heating needs of local residents and businesses.

Third, smart energy communities integrate energy and land use, recognizing that poor land use decisions can equal a whole lot of energy waste. For example, all buildings in Toronto’s Regent Park neighbourhood are being connected to a district energy system that will produce high-efficiency heating and cooling for residential and commercial tenants with the potential to generate electricity from cleaner sources such as cogeneration, solar and geo-exchange.

Changing land-use patterns has the potential to significantly reduce transportation emissions and influence transportation options. An important finding of a 2010 study prepared for QUEST was that the best long-term opportunity to influence energy use and GHG emissions starts with decisions made early on about land use and transportation. These decisions can reduce the amount of energy used in a community by 15 to 30 percent, largely by reducing the number of trips that people take daily.

As the outer areas of cities continue to grow—at present, they are growing 160 percent faster than city centres—the efficient use of land becomes even more important, as it minimizes the number of trips taken and ensures a range of mobility options. For instance, people who live outside of a city centre are three times more likely to get into a vehicle and drive to their destination, which is highly problematic for conserving energy related to transportation.

Smart energy communities can lessen this problem by delivering mobility efficiently through public transit, especially via fixed-route systems, such as subways and light rail. Light-rail transit exists in Metro Vancouver, Edmonton, Calgary, Montreal and many communities in the Greater Toronto and Hamilton Area. It is currently under development in a number of Ontario communities, including Ottawa, Mississauga, Hamilton, Brampton and York Region. Fixed-route systems establish transit corridors that bring people to the city’s core for work and other activities, making it easier for people to leave their cars at home and use public transit instead.

More than three-quarters of Canadians live near or within an urban centre and it is expected that by 2020 the number will increase to 85 percent or more.
contributing to the development of “walkable” communities.

But to substantially reduce emissions associated with transportation, we will need to do much more. We also need to continue to innovate when it comes to fuel resources and fuel conservation.

Pathways to innovation

Advancing a smart energy community requires constant innovation. Across Canada, there are important innovations happening in the energy sector that are making the production, distribution and use of energy cleaner, more efficient, more affordable and more reliable, especially for transportation.

For instance, there has been a growth of alternative transportation fuels, including biofuels (ethanol, biodiesel and renewable diesel), natural gas in its compressed and liquefied form, and electricity for a range of electric vehicle applications. As result, communities are exploring how to harness local energy resources and the electricity grid for transportation.

In BC, the City of Surrey is developing an organic biofuels facility, which will turn organic waste into renewable natural gas for use in its municipal vehicle fleets. And the community of Niagara-on-the-Lake in Ontario is running pilot projects to optimize the local electric grid infrastructure for electric vehicles.

Another important area of innovation is fuel conservation. Right now, the internal combustion engine vehicle is only about 25 percent efficient, with most of the energy lost as heat. However, it is expected that within the next decade, through a focus on innovation, vehicles will be 50 percent more efficient than they were in 2008, which will contribute to more efficient use of current fuel resources. Optimizing the efficiency of conventional vehicles is important for reducing GHG emissions and energy use, and will make smart energy communities even more effective.

Each community is unique, with its own set of energy challenges and opportunities. The potential solutions for high-density communities will be different than those that are resource-based, and will vary in scale and form based on local conditions and characteristics. The design and layout of a community significantly influences its energy profile, defining everything from home heating options to transportation choices.
It may seem intuitive that Canada could gain more benefit from its crude oil resources by refining them in Canada and exporting refined products. But this theory fails to account for the structure of global markets, constraints in infrastructure and geography, and trends in global demand for refined products.

The structure of global markets

Any company considering investing $10 to $15 billion dollars in export refineries must take into account significant Asian growth that has been matched by rapid building and even over-building of refining capacity in China, India and the Middle East. Even there, refinery utilization has fallen.

Refinery utilization rates

Constraints in infrastructure

Furthermore, the world is cutting back on refinery construction projects and closing existing capacity.

Since 2008, 4.5 million barrels per day (b/d) of OECD refining capacity has been shut down.

Source: IEA, June 2014 Medium Term Market Report: Market Analysis and Forecasts to 2019

Continued on page 17
The Goldilocks principle states that reasonable argument falls within certain margins rather than occupying extremes. Consider the argument over how much refining is right for Canada. One extreme holds that we should refine all Canadian crude in Canada; the other that we should refine no crude in Canada. The former suggests markets for refined products are unlimited and there is more value in refining crude than selling it as a critical Canadian commodity. The latter proposes reliance on imported transportation fuels, exposing Canada to supply insecurity and foregoing the associated economic and social benefits of refining.

The reasonable position is the middle ground, where market forces dictate the wisdom of selling and refining crude.

Refining is a complex business and an integral component of Canada’s oil and gas value chain. The industry provides jobs for nearly 18,000 workers and contributed over $5 billion to GDP in 2014. The industry operates 15 refineries in seven provinces for a total capacity of nearly two million barrels per day—enough to meet Canadian demand and ensure we are a net exporter of products.

It is an industry that has been shaped by the market, if sometimes harshly. Since 1970, 20 refineries have closed; others have increased efficiency and expanded their capacity to remain competitive and satisfy Canada’s current demand. Production and demand in Canada are in positive balance, with Canada a modest net exporter of refined products.

The outlook for demand is flat, which explains why, to date, investors are skeptical of new refinery proposals such as BC-based Kitimat Clean and Pacific Future Energy. Kitimat Clean is projected to cost $21 billion—with requests for government loan guarantees in the vicinity of $10 billion.

How will local declining demand impact the business case? Where are the markets?

Canada’s export refiners must compete on a continental and global stage to survive and thrive. We currently export refined products where geography—specifically tidewater locations—makes us competitive. For example, the northeastern U.S. is a strong and reliable export market served by refineries in Newfoundland and New Brunswick.

In effect, we have struck a market-based balance between selling and refining crude. According to the Goldilocks principle, we likely have got it just right.
Revisions to capacity expansion plans since 2013 Medium-term Oil Market Report

![Bar chart showing revisions to capacity expansion plans since 2013.]

Even in non-OECD countries, refinery expansion and construction is being scaled back in the face of over-building.

Source: IEA, June 2014 Medium Term Market Report: Market Analysis and Forecasts to 2019

SHELTERED BUT NOT IMMUNE

The U.S. has been the exception to refinery construction cutbacks. Why? Cheap natural gas for fuel, the U.S. ban on crude exports that keeps feedstocks cheap, and easy access to Latin American and other export markets for refined products from the Gulf Coast. But this experience is regional. Over on the U.S. east coast, there has been 800,000 b/d in refinery closures in last 10 years.

Canadian refiners are similarly affected, as evidenced by recent refinery closures in Montreal and Dartmouth. While refinery expansions have occurred, no new refineries have been built in Canada since the 1980s (a new 50,000 b/d bitumen refinery is now under construction in Alberta; see next page).

TRENDS IN GLOBAL PRODUCTS DEMAND AND SUPPLY

To complicate matters, North American products consumption is declining as a result of vehicle fuel efficiency standards, ethanol/biofuels mandates, a more urbanized population and the growth of online shopping. This situation exists in all OECD countries. The sole markets where demand for refined products is growing are non-OECD countries. As a result, North America is oversupplied with refined products, and the glut is growing—and will continue to grow at least through 2019.

North America is oversupplied with refined products, and the glut is growing—and will continue to grow at least through 2019.

GLOBAL MARKET COMPETITION FOR CANADIAN REFINING INVESTMENT

What prevents Canada from competing globally in refined products markets as the U.S. Gulf Coast refiners have? The answer is that Canada is constrained by geography. We are located further from Latin American or Asian markets where refined product demand is growing.

And today there is no way to cost-effectively move crude to a coast, refine it and compete with a Chinese or Indian refiner running Russian or Middle Eastern crude that arrived at a lower cost.

Canadian crude availability is located offshore in Newfoundland and land-locked in the West—away from high-demand areas. We can’t move closer to clearing markets where the wholesale commodity price is determined.

CONSTRAINED BY CONFIGURATION

Not all refineries are alike. East coast Canadian refineries were built to run light crude. American Bakken and Eagle Ford feedstocks are good options, but most domestic Canadian crude production is heavy. Therefore, these refineries are not well placed to monetize Canadian domestic crude resources.

Currently, east coast refineries are refining less than 50 percent of the east coast offshore Canadian grades. And locking into one feedstock source threatens the profitability of refiners. Building a refinery solely to monetize one type of crude is perilous, as the light/heavy spread can change, and margins can contract or even disappear.

Mandating processing in Canada would almost inevitably raise prices for Canadian consumers. In the end, the best way to achieve optimal natural resource utilization and fair prices for consumers is to allow markets to function rationally, allowing market forces to allocate supply where it is needed. The constraints of inflexible infrastructure and the geographical challenges of stranded supply pools and scattered demand centers no doubt complicate the efficiencies that markets could bring. But intervention along the supply chain will only stop the flow and distort prices in ways we simply cannot predict.
The first new refinery built in Canada in more than 30 years will bear little resemblance to its predecessors. There'll be no pile of coke to be trucked away. No longer waste, that 10 percent to 15 percent at the bottom of the barrel will be converted into a valuable resource. CO₂ is also valuable; it is captured and sold for enhanced oil recovery (EOR) to generate refinery revenue and GHG emission offset credits.

In fact, there will be relatively few refinery emissions even though the feedstock is bitumen from Alberta’s oil sands. Water usage will be minimized through air cooling, advanced treatment and recycling. The facility will also use considerably less natural gas because gasification of the low valued bottoms provides most of its hydrogen.

This refinery will take advantage of existing pipeline feedstock supply at a lower cost, then convert and distribute its primary product—diesel—into markets across North America: all with an improved low-carbon footprint. Diesel is the one bright spot in otherwise declining North American demand for transportation fuels.

While debates continue over building new crude and bitumen pipelines, this innovative, world-class refinery is well under construction in Sturgeon County, just north of Edmonton, and will be operational in 2017.

The Sturgeon Refinery is being built by the North West Redwater Partnership (NWR), which brings together NW Refining Inc. and Canadian Natural Resources Limited.

“Our vision is to build a refinery with the world’s best environmental performance and solve two big problems facing Alberta’s energy industry,” says NW Refining President Ian MacGregor. “First, achieve market access by converting Alberta’s bitumen resources to light products that can either be sold in western Canada or to the world market through existing marine terminals already handling diesel. Second, reduce the high CO₂ content of bitumen-derived energy products to meet the aspirations of regional and national governments in Canada, U.S. and Europe.”

NWR presents fresh thinking about how to build new refineries that meet the global need for low-carbon fuels while exceeding today’s environmental standards.

“This is the world’s first refinery built from the start to capture CO₂ and use it for feedstock,” Ian MacGregor explains, adding that carbon is going to dominate the agenda for the next century.” We live
in an increasingly carbon-constrained world, where government imposed carbon pricing mechanisms are likely to drive up the cost of carbon,” he predicts. “It’s already happening in Alberta”.

NWR didn’t have to develop new science to make the refinery exceed currently accepted environmental standards. Instead, the partnership selected the best available technologies and configured them in a unique and innovative way. The result is a system that complements refinery components such as hydrocrackers with gasifiers and then connects the entire system to an EOR complex.

NWR estimates Phase 1 of the refinery will capture over 3,600 tonnes of CO$_2$ per day for delivery into the Alberta Carbon Trunk Line (ACTL) and then injection into depleted reservoirs in central Alberta to produce incremental light oil. The CO$_2$ is left behind and considered to be safely and indefinitely sequestered, just as the oil and gas in the fields were sequestered for millions of years before they were drilled. When all three phases of the refinery are in operation, this sequestration will be the CO$_2$ equivalent of taking approximately one million cars off the road.

“Our technology approach should have a big impact on reducing CO$_2$ compliance cost and that pays for a lot of capital,” MacGregor states.

The $8.5 billion Sturgeon Refinery first phase will process 79,000 barrels per day of diluted bitumen and produce ultra-low sulphur diesel and other value-added products including diluent, naphtha and low-sulphur vacuum gas oil. The refinery’s design and operating licence allow for two more identical phases of expansion.

“This really is a forward-looking refinery in its technology and environmental design,” adds Ian MacGregor. “What we’re building today will deliver environmental and economic benefits well into the next century.”

Terry Kemp is one of the founding developers of the Sturgeon Refinery project and NW Refining Inc. He has more than 35 years of energy development experience and is currently focused on reducing carbon intensity and the carbon offsets of energy systems.
"As part of the new Building Canada Plan, the renewed federal Gas Tax Fund provides predictable, long-term, stable funding for Canadian municipalities to help them build and revitalize their local public infrastructure while creating jobs and long term prosperity."

― Infrastructure Canada

Since 2005, governments in Canada have collected more than $185 billion in revenue from taxes on petroleum fuels, including more than $21.5 billion in 2014. The federal government also launched the Gas Tax Fund (GTF) in 2005, and a portion of petroleum tax revenues—approximately $13 billion—have flowed through it so far. Another $10.4 billion will be allocated by 2018–2019, part of nearly $22 billion by 2025.

Many of these projects are helping to improve the environment and build sustainable communities across Canada.

### WHERE DOES THAT MONEY GO?

Municipalities of all sizes have come to count on the GTF as a long-term and predictable source of vital infrastructure funding for:

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<th>JURISDICTION</th>
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### PUBLIC TRANSIT

### SHORTLINE RAIL

### HIGHWAY AND BRIDGE UPGRADES

### PROJECTS IN TOURISM, SPORT AND RECREATION
ALWAYS MOVING FORWARD

Jill Donnelly’s commitment to innovation at Chevron

Jill Donnelly knows a thing or two about progress. A career engineer, she has spent 25 years at Chevron’s Burnaby refinery working in a number of positions—from operations to laboratory supervisor to Health, Environment and Safety Manager. She loves the variety.

Donnelly’s most recent positions (she is now Manager of Special Projects in Safety) have focused on the refinery’s environmental activities as well as issues of worker safety. She has seen close up Chevron’s progressive culture toward reducing emissions and keeping workers safe. Donnelly says that experience has helped her appreciate how much she and her employer have in common.

“My personal commitment comes easily because my personal values line up with my company’s values.”

Donnelly’s work is closely tied to the community where the refinery is located. She sits on a community advisory panel for the refinery, discussing environmental issues such as emissions. For example, Chevron adjusts its operations in response to live readings from MetroVancouver’s ambient air monitoring stations. If climatic conditions such as temperature inversions occur, which can trap air contaminants, Chevron adjusts its operations to reduce emissions. Regulators that sit on the community advisory panel have made presentations about how over the years, Chevron’s emissions are trending down.

“That close connection with the community makes it easy for me to ask of my company what the world is asking of our companies, environmentally speaking.”

Donnelly has also seen huge progress on another front: “For the first time, I’m noticing that the number of women on the leadership team is in line with the number of men,” she says. When Donnelly arrived at the Burnaby refinery, she was one of only two women engineers. Today, the numbers of women and men are roughly equal.
If many of the mass-media reports can be believed, petroleum-fuelled vehicles are an endangered species. The future of the automobile is electric, the pundits proclaim, and petro-fuels and the engines that rely on them are obsolete. But, to paraphrase a famous quote attributed to Mark Twain, “The reports of their death have been greatly exaggerated.”

Gerry Malloy is a three-time winner of the Automobile Journalists Association of Canada’s (AJAC) Automotive Journalist of the Year award. The editor of autofile.ca and a columnist and feature writer for the Wheels section of the Toronto Star, Gerry is also a founder and director of the World Car Awards.

Lorraine Sommerfeld is a Toronto-based automotive writer, part of the National Post’s drive team and host of the Lemon Aid Car Show on Rogers TV.
What is true is that the automobile is changing and it is doing so at a faster pace than it has since the early days of the industry, more than 100 years ago. By the 1920s, the advantages offered by gasoline-fuelled internal combustion engines had already made them the preferred choice for most car buyers. Those advantages included ease and rapidity of refuelling, the ability to drive off immediately after starting and driving range limited only by the size of the fuel tank.

Gasoline has been the dominant automotive fuel ever since—challenged in any significant way only by its petroleum sibling, diesel fuel.

Improved engine efficiency

Two key technologies, direct fuel injection (DI) and turbocharging derived from racing cars, are not new but they are now achieving widespread adoption and they are core to ongoing efficiency improvements. In combination, they permit the use of much smaller and more fuel-efficient engines that still provide peak performance when it’s needed.

As an example of this trend, the base engine in the 2016 Chevrolet Cruze is a 1.4-litre turbocharged four-cylinder, with direct injection and a rated output of 153 horsepower. It replaces a 1.8-litre engine with 138 horsepower, standard in the 2015 model. As well as improving performance, the smaller, turbocharged engine is said to reduce highway fuel consumption from 6.6 to 5.9 L/100 km.

That engine is part of a new global family of three- and four-cylinder engines, ranging in size from 1.0 to 1.5 litres. And General Motors is far from the only automaker moving in that direction. Ford, FCA (formerly Chrysler), Volkswagen and others are doing so as well.

Multiple advances

Beyond reductions in size and adoption of direct injection and turbochargers, there are plenty of other technical advances contributing to greater efficiencies in the internal combustion engine.

Variable control technologies for the opening and closing of an engine’s valves have evolved from simple, step-function mechanical devices a generation ago to complex electronically controlled systems that individually control every valve’s operation on every cycle of engine rotation—ensuring optimum efficiency for every ignition pulse.
Another approach is the development of new engines from a clean sheet of paper—or a clean screen—rather than just improving on existing models and practices as has been common practice. In that way, every single component can be optimized, reducing weight and improving performance at every step. Such is the approach taken by Mazda, with its SkyActiv program, and by Honda with its EarthDreams engines.

One of Mazda’s accomplishments with that approach is to significantly increase the compression ratio of its engines. Increased compression ratios typically enhance both performance and efficiency. But very high compression ratios generally require the use of premium, high-octane fuel to prevent the onset of spark knock, which can damage the engine. By optimizing the design of the combustion chamber, Mazda has developed engines with compression ratios typical of premium fuel powerplants that work just fine on regular fuels.

There’s also a matter of reducing drag on the engine from internal friction and external loads, such as power steering, air conditioning and alternators. Electric power steering is now widespread and the use of regenerative braking, even in some non-hybrid models, relieves some load on the alternator. Even the use of LED lights helps in that regard.

A step further

Much research and development is underway on the development of gasoline engines with compression ignition—that is, gasoline engines that operate like a diesel. Rather than the fuel/air mixture being ignited by a spark plug, the mixture self-combusts when a critical temperature/pressure level is reached.

Called homogeneous charge compression ignition (HCCI), it offers significantly reduced emissions and the potential for efficiency improvements of up to 30 percent. HCCI is not quite ready for prime time but it’s getting close and several automakers are working hard to get it there.

These innovations are being supported by dramatic advances in automobile transmissions. Just a few years ago, five- and six-speed automatic transmissions were at the cutting edge. Now six-speeds are the low-end norm, seven, eight and nine-speeds are common and ten-speeds are on the way. And continuously variable transmissions (CVTs) are already common.

The car you’re driving today features the signatures of many early technical breakthroughs, from air conditioning to disc brakes. What was once cutting edge in automation is now commonplace. Cruise control, which has been around for decades, now features warning systems that range from chimed alerts and vibrating seats to overrides that apply the brakes or steer to avoid a collision—sometimes before the driver clue in.

For proponents, the advent and obvious safety advantages of override systems signal that we are hastening towards a fully automated street fleet. Indeed, driver error is the automotive world’s biggest problem, and advocates of the automated car herald not only reduced fatalities, but also fuel savings.

But would automated vehicles really cut down on our fuel consumption? Would they really reduce congestion? These questions would be easier to answer if driver behaviour could be clearly separated from technology.

With automation, fuel consumption per driver would almost certainly be reduced. Inefficient driving—a huge consumer of fuel—would be drastically reduced by removing humans from the equation. At the same time, the technology would enable many people to use cars who couldn’t before. Longer trips would be more inviting. So it’s conceivable that overall consumption would rise even as vehicles on the whole are becoming more fuel efficient.

There are also some significant technical hurdles that suggest the transition time from conventional to autonomous vehicles will be protracted. For example, automated cars will require connectivity to everything else on the road, including all other cars, regardless of make and degree of autonomy. And then there are those people who have grown attached to hands-on driving.

Don’t expect them to give up the steering wheel without a fight.
Another key development gaining widespread adoption is the automatic stop-start system, which shuts off the engine during the most inefficient periods of vehicle operation, when fuel is consumed but no distance is traveled.

The hybrid connection

While the long-standing shortcomings of pure electric vehicles continue to limit them to very small niches, the combination of electric and conventional powerplants in hybrid vehicles is in many ways an ideal pairing. The improved efficiency of petroleum-fuelled engines can be complemented by the appropriate assistance of electric motors.

For example, an electric motor produces its highest torque when starting from stopped, where internal combustion engines are least efficient. Letting the motor handle that task permits the engine to be tuned more efficiently in its optimum speed range, and to ensure a driving range that consumers expect.

Looking further into the future

All these developments are pointing towards highly efficient future vehicles that combine the best elements of petroleum-fuelled engines and electric power.

The ideal solution in the medium term, over the next couple of decades, may be to use a very small engine running in a narrow, highly efficient speed range, solely to drive a generator charging a hybrid’s batteries—or perhaps ultra-capacitors. That powertrain would be wrapped in a highly-aerodynamic, lightweight structure constructed of aluminum and carbon-fibre.

Today’s BMW i8 just might be the blueprint for that future.

Whatever form they take, the reality is that conventional, petroleum-fuelled internal-combustion engines are well placed to maintain their dominance and public favour as the auto industry continues to evolve and innovate.

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INNOVATION = TECHNIQUE + TECHNOLOGY

When it comes to automotive innovation, driving techniques can offer as much promise as breakthrough technologies. Numerous experts have shown that petroleum-powered vehicles can deliver astonishing fuel efficiency when driven with care and attention to detail.

The key is an eco-driving technique called hypermiling. The great news is that all drivers can easily adjust their driving behaviour to achieve immediate savings in fuel consumption—and travel further on every tank of fuel.

Here are just a few hypermiling techniques courtesy of Chris Chase, winner of the 2015 Automotive Journalists Association of Canada EcoRun, which highlights and tests the latest vehicles each year:

1. **Accelerate gently, especially in the city.**
   In most situations, you’re only going to have to slow down or stop again shortly.

2. **Use the anticipation technique.**
   Once at speed, look well ahead and try to anticipate what other drivers and traffic signals are going to do. If a traffic light turns red up ahead, take your foot off the gas pedal and brake gently. The idea is to spend as little time as possible stopped.
   **REMEMBER:** petroleum-powered cars are least efficient when they’re idling or accelerating.

3. **Decelerate on uphill stretches.**
   If you drive at 110 km/h on the highway, let the car slow down to 95 or 100 km/h going uphill, and regain your speed on the next descent.

For more tips, visit canadianfuels.ca
IN SYNC

How Helen Bennett helps Shell work well with the community

Having lived most of her life in Sarnia, Helen Bennett has a vested interest in keeping her community strong and healthy. She has an obvious interest in doing the same for her employer.

The 17-year veteran of Shell Canada has worked in a number of roles supporting Shell’s Sarnia refinery since she joined in 1998 as a gasoline blender and product scheduler. Today, Bennett is an Emerging Regulatory Policy Issue Advisor who supports Shell’s downstream business in Canada.

Bennett tracks environmental regulations as they develop and represents Shell at discussions about the refining industry’s environmental policies.

“When regulations are being developed for the downstream business, my role is to bring in the industry perspective,” she says. Bennett works closely with government, representing the best interests of refineries, terminals and the communities in which they reside.

Bennett has a large personal stake in her work. She owns 30 acres that she and her husband, a fruit grower and blacksmith by trade, are working to transform into a small fruit farm. They bought the property in 2013 and have planted a 5,000-tree nursery, cultivated the flowers and wild pears, and continue to encourage the birds and wildlife that live there. The farm is where Bennett eventually plans to retire with her husband and their horses.

“My work on environmental issues strikes close to home,” she says. “We want to protect the environment so families like mine can continue to enjoy this world out here. At the same time, we need to keep the refinery active and the community viable economically. I’ve lived and worked all my life here and I’d like that to continue.”

“We need to keep the refinery active and the community viable economically.”
A nyone who can recall the retail petroleum landscape of 35 years ago would likely agree that today’s bears only a passing resemblance. Gone for the most part are the full service stations that ensured there was fuel and a licensed mechanic on duty on just about every major thoroughfare, and most of the minor ones. Today’s measure of convenience is a speedy fill-up, coffee and a doughnut, basic groceries and a car wash.

These changes didn’t occur overnight, and much of the subtlety in the industry’s evolution is evident in the 2014 National Retail Petroleum Site Census. A product of The Kent Group and MJ Ervin & Associates, the annual census—now in its eighth year—is the only study of its kind in Canada.

The number of stations it tallies is perhaps the most significant change. According to the census, the number of Canadian retail fuelling stations peaked at approximately 20,360 in 1989. Since then, the numbers have declined by 42 percent to 11,811 in 2014. Retail efficiency, however—expressed as throughput—has risen impressively during this same period, from roughly an average of 1.6 million litres per station per year in 1991 to more than 3.6 million in 2014.

The marketplace is diverse. The census identified 66 different companies involved in the marketing of retail petroleum fuels with 94 distinct brands of gasoline (down only four compared to 2004). In numbers that seem at odds with the traditional public image of the industry, the three major oil companies (Shell, Suncor and Esso) control price at only 15 percent of retail gas stations in Canada. The prices at 81 percent of stations are controlled by proprietors or companies not involved in the refining of petroleum products.
This underscores a trend, according to census author Michael J. Ervin, toward a greater number of marketers. “Decades ago, retailing was dominated by big oil companies having direct relationships with dealers. Over the last decade, big oil has been getting out of the retailing of fuels, and more local or regional marketers are directly responsible for the relationship with the dealer on the street. That’s a pretty big change.”

Tricia Anderson has noted it. President and CEO of the Canadian Independent Petroleum Marketers Association, Anderson says her members’ facilities are becoming more sophisticated and diverse—and their share of transportation fuel sales is growing. “That could be in light of the approach major refiners are taking to divest retail business.”

For Ervin, this sophistication and diversity underscore one of the main reasons for major refiners’ withdrawal from retail. “More and more gas stations rely on back-court revenue for viability—things other than gasoline and diesel fuels.”

Fuels have always been a low margin business, whereas most convenience store offerings are relatively high margin. As the back-court has grown so has its revenue stream, vastly outpacing the revenue growth in gasoline over the last decade.

“The best gas stations in Canada now actually make more of their revenue from the back-court than they do from the sale of gasoline,” says Ervin.

More and more gas stations rely on back-court revenue for viability—things other than gasoline and diesel fuels.

Focused on innovation, the industry is continually re-examining its core competencies. Ervin considers petroleum refiner-marketers to be the best at producing and selling at the wholesale level. “Given that the retail side is increasingly dominated by smaller players, that signals to me a mindset change to one in which gasoline is just another product. I think that’s a healthy attitude and more representative of how to be successful at retailing gasoline to motorists.”

Peter Kilty, Vice-president of Retail at Parkland Fuel Corporation, thinks volatility in the retail marketplace is another reason refiners may prefer to focus on core upstream business. But he sees the trend among Canadian refiners to divest retail operations as, to date, more limited than in some other countries.

“It’s certainly the trend worldwide,” says Kilty. “It’s been happening in Germany and Australia recently—but not to the same extent in Canada.”

Parkland has been among the most active companies to seize acquisition opportunities, which have helped make it one of the fastest growing independents in North America.

<table>
<thead>
<tr>
<th>Share of market by number of outlets (by marketer)</th>
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<tbody>
<tr>
<td>Suncor Energy Products, Inc. 11.0%</td>
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<tr>
<td>CST Canada Corporation 6.7%</td>
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<tr>
<td>Shell Canada Limited 6.0%</td>
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<tr>
<td>Parkland Income Fund 5.8%</td>
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<tr>
<td>Couche-Tard Alimentation Inc. 5.5%</td>
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<td>Federated Co-operatives Limited 4.3%</td>
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<tr>
<td>Imperial Oil Limited 4.0%</td>
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<td>Sobeys 3.3%</td>
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<td>Husky Energy Inc. 3.3%</td>
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<tr>
<td>Pioneer Energy LP 3.3%</td>
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<tr>
<td>Canadian Tire Petroleum 2.5%</td>
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Volatility in the retail marketplace is another reason refiners may prefer to focus on core upstream business. But he sees the trend among Canadian refiners to divest retail operations as, to date, more limited than in some other countries.

“Subsequently, we purchased retailers of the fastest growing independents in North America. The bottom line appears to be a healthy mix of independents and refiners. “In that market,” says Peter Kilty, “I don’t think consumers will be anything but well served.”
Canada’s petroleum fuels manufacturing and distribution infrastructure is one of the country’s most complex supply systems. It’s also one of Canada’s most vital, delivering the 85 billion litres of high quality transportation fuels that our economy and our way of life depend on each year.

The system evolved over nearly a century to serve two supply orbits: the west, from the Ontario-Manitoba border to BC; and the east, from Ontario through the Maritimes and Newfoundland and Labrador. Since 2005, these basic supply orbits have been incrementally fragmented and complicated by a growing list of renewable fuels regulations. Varying by jurisdiction—first provincial, then federal—these regulations require gasoline and diesel fuels to contain specified percentages of renewable fuel content on an annual basis.

Canada’s petroleum fuels manufacturers take regulatory compliance very seriously. We also acknowledge the objectives of renewable fuels mandates in Canada.

We share Canadians’ desire for progressive fuels that continually achieve greater environmental performance. We strive for efficiency to deliver a quality product at competitive prices. We believe regulatory efficiency makes sense as well.

Today’s advanced regulatory development processes generally take a reasonable approach to set standards without placing undue burden on the regulated parties. That balance is sorely lacking when an industry is faced with six different mandates—five provincial and one federal (12 when you consider gasoline and diesel separately). A framework in which the fuel on one side of a provincial...
border must be different than on the other makes little sense from a market or a security-of-supply standpoint.

**Case in point: irrational provincial blending requirements**

Under one national mandate for renewable content in diesel, Canada’s petroleum refiners would optimize by maximizing blending in import-accessible zones where moderate temperatures are compatible with a long blend season (such as the west coast or the Quebec City to Toronto corridor). However, provincial requirements in Manitoba and Saskatchewan currently force refiners to haul renewable diesel—most of which must be imported from Singapore, Finland and the U.S.—via truck and rail over long distances into the centre of Canada and the coldest zones that are the least suited to biodiesel blending.

**Regulatory harmonization is key**

Climate change is not a localized challenge; it is global. The best way—the most efficient way—for us to tackle this phenomenon is as a country, which gives us greater voice and impact internationally. We believe regulatory harmonization is key to overcoming the challenge. One national regulatory standard for renewable content would give fuels manufacturers a single reasonable, attainable target. The result: optimized manufacturing; simplified, streamlined distribution; reduced administrative burden and costs; and fuels that achieve uniform environmental performance across Canada.

Brian Ahearn
Vice-president, Western Division with the Canadian Fuels Association

canadianfuels.ca
North American air quality received a boost in 1991 when Canada and the U.S. established the Air Quality Agreement (AQA) to address transboundary air pollution. Administered by the International Joint Commission, the AQA initially focused on reductions to acidic deposition in both countries. In 2000 the agreement was expanded to address ground-level ozone (O₃), a major component of smog. The 2014 AQA progress report notes substantial improvements to air quality in both jurisdictions since 1990, including reductions in emissions of sulphur oxide, nitrogen oxide and volatile organic compounds.

Canadians care about our air quality. So does Canada’s transportation fuels industry.
Canadian on-road emission inventories, total heavy and light-duty vehicles

* includes direct sulfate and non-sulfate exhaust emissions

Source: Environment Canada

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Clearing the air together

The AQA findings align with those of Environment Canada, as seen in the department’s on-road emission inventories (charts, page 33). Tracking and projecting the total emissions for light- and heavy-duty vehicles from 1985 to 2030, the inventories provide clear evidence of sustained success in improving the environmental performance of fuels and vehicles.

“Overall, air quality has improved significantly over the past 10 years, especially for nitrogen dioxide (NO₂), sulphur dioxide (SO₂) and carbon monoxide (CO)—pollutants emitted by vehicles and industry…”

– Air Quality in Ontario, 2013 Report, Ontario Ministry of the Environment and Climate Change

Progress on two fronts

On one front, Canada’s transportation fuel and vehicle manufacturing industries have worked for decades to continually improve vehicle efficiency and the quality of fuels. Now, Tier 3 fuel and vehicle regulations set ambitious new standards that will deliver unprecedented emissions reductions.

Once in full force with the 2025 vehicle model year, the new standards will contribute to reductions in smog-forming air pollutant emissions of up to 80 percent compared to Tier 2 levels.

“The Tier 3 standards are the most stringent smog-related emission standards in the world.”

– Mark Nantais, President, Canadian Vehicle Manufacturers’ Association

Tier 2 standards resulted in dramatic reductions to sulphur emissions beginning in the 2005 model year. In fact, a 2005 or newer vehicle produces 90 percent less smog-forming emissions than a 1993 model.
New Sulphur in Gasoline Regulations—part of the Tier 3 regulatory regime—build on this foundation. Starting in the 2017 model year, the allowable sulphur content in gasoline will be cut by a further 70 percent. This new fuel formulation will enable advanced emission-control technologies to operate effectively—and will also lead to air-pollutant reductions in vehicles from previous model years.

Cleaner air means better health

It is estimated that new fuel and vehicle standards will deliver approximately $7.5 billion in cumulative health and environmental benefits from 2015 to 2030.

On another front, Canada’s refining industry has made substantial contributions beyond improving the properties and performance of its fuels. Progressive environmental stewardship—including investments of $10.4 billion since 2000—has led to significant emission reductions at refineries. The sector’s carbon dioxide emissions have been reduced by 12 percent since 1990.

Harmonization is key

Tier 3 fuel and vehicle standards are effective in large part for their harmonization of U.S. and Canadian regulations. Harmonization acknowledges the integrated nature of the North American economy. It also supports the competitiveness of the Canadian automotive and fuel refining sectors by providing long-term regulatory certainty that minimizes the administrative and compliance burden.

Most important, perhaps, our national governments continue to pursue progressive actions to address fuel quality and vehicle and engine emissions because they know that while we are separated by a border, we breathe the same air.
MEMBERS

We’ll take you there

Canadian Fuels Association
Perspectives 2015
Fuel the conversation

The future of transportation fuels is a national dialogue. Join in.

As the industry that produces, distributes and markets petroleum products in Canada, we believe all Canadians should have a voice in the future of transportation fuels.

Does transportation make a difference in your life? What future do you see for the fuels that power our economy and keep us on the move?

We want to hear from you. In turn, we'll share the latest fuels information and insights from other Canadians participating in this important conversation.

Add your voice.

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