THE VOICE OF CANADA’S TRANSPORTATION FUELS INDUSTRY.
The Canadian Fuels Association represents the industry that produces, distributes and markets petroleum products in Canada—including 95 percent of the transportation fuels Canadians rely on to remain mobile and globally competitive. The fuels sector contributes $5.6 billion to Canada’s GDP each year and employs nearly 100,000 Canadians at 18 refineries, 21 primary fuel distribution terminals and 12,000 retail and commercial sites throughout Canada.
Canada’s petroleum fuels. Powering transportation today and tomorrow.

The petroleum fuels industry has long played a pivotal role in building Canada’s transportation capacity. Our members have established a comprehensive nationwide infrastructure that produces and delivers the 85 billion litres of high quality transportation fuels that keep Canada on the move each year. We continually lend our expertise to policy discussions about the essential role of transportation energy in this country. Fuel refining contributes $5.6 billion to Canada’s annual GDP. The fuels sector provides jobs for nearly 100,000 Canadians. It’s a record of achievement that Canadians have recognized by making our products their transportation fuels of choice.

This consumer preference comes with great responsibility. It falls on Canadian Fuels Association members to ensure that we continue fuelling Canada’s travel and trade to help keep our country competitive and contribute to our standard of living.

We believe it’s important for all Canadians to understand the fundamental connection between transportation energy and prosperity. Over the past year and a half, our association has actively engaged stakeholders in an open discussion about the vital importance and future of transportation fuels. As part of this work, we commissioned two of Canada’s leading independent public-policy think tanks to conduct a series of roundtables across the country.

The effort has struck a chord and fostered thoughtful discussions. Many fascinating and important points have been raised. It came as no surprise to us that amid the dialogue about the social, environmental and economic challenges of various fuel and vehicle technologies, it is well understood that petroleum is vitally important not only for today, but also for the central role it will continue to play in years to come.

The research concurs. In September, the U.S. Energy Information Administration published its *International Energy Outlook 2014*. The report examines the global future of petroleum and other liquid fuels to 2040. It characterizes global markets as very dynamic—especially in China, India and the Middle East—and projects petroleum fuels will remain the dominant energy source for transportation in Canada throughout the forecast period.

This is not simply the opinion of those in the petroleum sector. It is a position held by many experts who are eminently knowledgeable about transportation energy in Canada—past, present and future.

The Canadian Fuels Association welcomes the insights of four accomplished experts in this report. Interspersed throughout, you’ll read the opinions and predictions of David Bradley, CEO of the Canadian Trucking Alliance and president of the Ontario Trucking Association; Mark Nantais, president of the Canadian Vehicle Manufacturers’ Association; Bob Oliver, executive director of Pollution Probe; and Dr. Heather MacLean, professor of civil engineering at the University of Toronto.

They all believe that an increasing number of innovative fuel and vehicle technologies will populate Canadian roads in the future. While no expert can be precise about when that future will arrive—or what the technological mix will be—the best information we have today clearly indicates that a major transformation will take decades.

This underscores an important point. Petroleum is more than the fuel of choice for Canadians today; it is the transportation energy source that will power Canada—and the world, for that matter—well into the future, underpinning an increasingly diverse fuel and vehicle mix.

To remain viable and competitive, Canada’s petroleum fuels and vehicle manufacturing industries are taking bold and determined steps—and making major investments—to improve overall product performance. No single technology has a monopoly on innovation, and the advances being made in petroleum fuels and conventional vehicle technologies are truly remarkable.

Progress through innovation makes for a healthy, competitive market today, and ensures consumers—individual and commercial—will have greater choice when it comes to transportation options tomorrow.
Petroleum. Canada’s fuel.

Transportation fuels hold deep value for Canadians. We depend on them.

A long road in any weather

Canadians are well aware of the crucial role transportation plays in connecting us to each other and the world. Our quality of life has risen steadily as marine, railway, road and aviation arteries have threaded their way across the country and into many of its most remote regions. Today, transportation accounts for about 30 percent of our total energy use, making Canadians among the highest per capita users of transportation fuels in the world. Our level of fuel consumption comes as no surprise given our relatively small and widely dispersed population, as well as the extreme distances and varieties of terrains and climatic conditions we face when travelling across Canada.

Truckers have perhaps the greatest appreciation for the challenges of Canada’s geography, and few people have a better understanding of the vital importance of trucking than David Bradley.

FAST FACTS

- For-hire trucking accounts for 31% of the transportation services sector’s $53B share (4.2%) of Canada’s GDP—greater than air, rail and water transport combined.

- Trucks move 90% of all consumer products and foodstuffs.

- Between 2011 and 2020, the for-hire trucking industry is expected to experience an output increase of 26% from $17 billion annually to $21.4 billion in constant dollars.

- As a whole, the trucking industry (including for-hire carriers, private carriers, owner-operators and courier firms) generates more than $65 billion in revenues per year, with the for-hire sector accounting for over $40 billion alone.

- There are more than 300,000 truck drivers in Canada today. Approximately 180,000 (60%) are employed in the for-hire sector of the trucking industry.

- Nearly 1% of the Canadian population and more than 1.5% of the labour force are truck drivers.

- For-hire trucking accounts for 278,000 direct jobs and provides for almost 480,000 jobs overall, resulting in $24 billion in personal income and $4.2 billion in personal income taxes.

- The total economic footprint of the for-hire trucking industry was almost $37 billion in 2011.
“I DON’T SEE ANY ALTERNATIVE DISPLACING DIESEL AS THE PREDOMINANT FUEL FOR THE TRUCKING INDUSTRY IN MOST OF OUR LIFETIMES.”

**CONTRIBUTOR**

**DAVID BRADLEY**  
CEO, Canadian Trucking Alliance  
President, Ontario Trucking Association

David earned his master’s in economics from Queen’s University following undergraduate work at University of Toronto. Beginning his career with roles in management consulting and financial market analysis, he took over leadership of the Ontario Trucking Association in 1991, and the Canadian Trucking Alliance in 1997. David Bradley is passionate and outspoken about the crucial value of truck transport, having guided the industry in Canada and its largest province through some of trucking’s most turbulent and transformative times. His expertise is regularly sought by federal, provincial and international organizations to ensure boards, committees and advisory groups benefit from the industry’s vital perspective.

**Canadian Trucking Alliance (CTA)**  
The CTA is a federation of the country’s provincial trucking associations. Representing approximately 4,500 carriers, owner-operators and industry suppliers, the CTA is the industry’s voice on national and international policies, and on regulatory and legislative matters that affect trucking.
“Without fuel the trucks don’t move, and no other fuel compares to diesel in terms of economy and energy output.”

- David Bradley
If you got it, a truck brought it.

According to Bradley, that statement is as true today as it’s ever been. Approximately 90 percent of all consumer products and foodstuffs in Canada are moved by truck. “The reason is that we provide an efficient service,” says Bradley. “Trucking isn’t always the cheapest mode, but it’s the service that’s able to provide the flexible, time-sensitive service most shippers need.”

Figure 1.1: Shares of Canada-United States trade by mode, 2012

Trucks move more goods (57% by value) to and from the U.S.—our largest trading partner—than all other modes of transportation combined.

Where railways’ niche is the long distance transport of heavy bulk commodities, trucking is ideally suited to the short distance, smaller-by-volume marketplace and moving high value-added manufactured and consumer goods.

“Trucking is a hyper-competitive industry that’s been highly innovative in the constant pursuit of efficiency,” adds Bradley. Little wonder that fuel efficiency has been a growing concern in recent decades.

Truck manufacturers have responded with new fuel-efficient engines, advanced drivetrains and more aerodynamic cabs and trailers. Fleets have optimized routing procedures and examined ways to improve driver training and performance. Governments have introduced new fuel economy standards.

When it comes to fuel, diesel remains the trucking industry’s first choice.

“It’s pretty basic,” says Bradley. “Without fuel the trucks don’t move, and no other fuel compares to diesel in terms of economy and energy output.”

The trucking industry is Canada’s largest consumer of diesel fuel. Diesel accounts for between 15 and 40 percent of a company’s operating costs—and it’s the greatest single expense for the more than 45,000 individual owner-operators.

“The petroleum producers operate to a very high standard and the quality of the fuel is very good,” says Bradley. “I don’t see any alternative displacing diesel as the predominant fuel for the trucking industry in most of our lifetimes.”

Bradley acknowledges close ties between the trucking and petroleum fuels industries. It’s a relationship built over more than a century, and one he believes could be improved with greater communication, particularly with regard to factors that influence fuel prices, and the need for adequate Canadian refining infrastructure to consistently meet demand.
“Reliability of supply historically has not been an issue,” says Bradley, “but when a refinery goes down for maintenance it can really have an impact. And if something goes wrong at another one, then we find ourselves quickly in a situation where companies are scrambling for fuel.”

Canada’s petroleum refiners believe the key to a secure supply is a viable and competitive Canadian refining industry, which will ensure truckers won’t need to rely on imported fuels and find themselves at the end of a long and potentially less reliable foreign fuel supply chain.

Comparing the alternatives

Bradley supports all fuel solutions that work and reduce costs, but he’s skeptical about bio-diesel. “I don’t believe bio-diesel is an alternative in the true sense of the word,” says Bradley. “It’s not where we want to go as an industry; it’s not where the manufacturers of heavy trucks want to go. We think it’s so 1990s. It’s presented as part of an off-oil strategy and being good for the environment. That’s nonsense. Bio-diesel was introduced in North America as a gesture to the agricultural sector to create a market for farmers. I don’t think it’s worked; and the concerns of manufacturers and the trucking industry about the impact of biofuels on engines and warranties have been virtually ignored.”

In Bradley’s opinion, electricity holds near-term promise as an energy source only in smaller trucks and short-haul pick-up and delivery applications.

“If you look at real alternative fuels, the one that has the most potential for us is liquid natural gas [LNG],” says Bradley. “The technology works, the fuel is plentiful, the technology is made in Canada and the GHG impact is lower. But LNG has challenges too. The distribution infrastructure isn’t there right now and LNG tractors cost 60 to 100 percent more than traditional vehicles. It’s going to take time, but certainly it is the alternative fuel with the most potential.”

LNG is an attractive alternative partly due to its cost. “LNG is cheaper than diesel right now,” acknowledges Bradley, “but it’s not being taxed. That will change as fleets transition to LNG, and governments see tax revenue decline. The price will go up. The same thing happened with propane, which was supposed to be the big solution 30 years ago.”

A partner in regulatory change

According to Bradley, truckers also want to see greater collaboration with governments to develop new fuel economy standards.

“People may think, ‘We did it for cars, we can do it for trucks,’” says Bradley in reference to recent and successive tiers of federal fuel and light-duty vehicle standards. “But they are two completely different vehicle types. We can’t take the same approach as the Americans to achieving greater fuel economy, nor can we simply adopt U.S. standards in Canada. Our industry is different. We face dramatically different conditions here; there’s a greater range of equipment, engines and applications in Canada’s heavy-duty fleet.”

Bradley emphasizes the trucking industry’s support for new heavy-duty vehicle fuel standards, but this support is tempered by a strong conviction that trucking’s expertise must be at the table to inform an effective and realistic regulatory framework. Greater government and industry partnership is key to achieve mutual goals for greater efficiency and environmental performance—while upholding trucking’s vital contribution to Canada’s economy.

“We want to make sure these standards work,” says Bradley. “It’s in our interest to improve fuel economy, but we’re going to have to get more sophisticated in terms of how we approach these things in Canada.”
The key to a secure supply of petroleum fuels is a viable and competitive Canadian refining industry.

For-hire trucking traffic is expected to continue growing through at least 2020.

While gasoline sales are essentially flat to declining, diesel sales are rising due mainly to demand in truck transport.
Building on a history of progress

Pollution Probe’s Bob Oliver, and Mark Nantais of the CVMA, talk about how transportation fuel formulations have changed substantially over the years—and continue to improve in response to changing vehicle and consumer needs and expectations.

Exceeding emissions standards

“The light-duty on-road transportation sector is the only economic sector to demonstrate a continuous and sustained reduction in smog-causing emissions year over year from 1985 to 2012,” says the CVMA’s Mark Nantais. “It’s really quite a success story.”

During that time, the automotive and petroleum refining industries were subjected to a range of successive government regulations aimed primarily at reducing levels of criteria air contaminants including nitrogen oxides, sulphur oxides, volatile organic compounds and particulate matter.

In response, Canada’s new vehicle fleets have outperformed emissions-standard requirements, in part through a history of collaboration.

“I’ve been in the business more than 30 years,” says Nantais, “and there’s always been a technical forum where the oil and auto industries meet regularly throughout the year to identify appropriate fuel quality for the efficient operation of engines and emissions-control technologies.”

FAST FACTS

- Canada is the world’s ninth largest vehicle producer, generating nearly 4% of global output.
- The automotive sector is Canada’s biggest contributor to manufacturing GDP.
- More than 20% of all trade with U.S. is associated with vehicle manufacturing—approximately $100B each year.
- Approximately 500,000 Canadian jobs are directly and indirectly associated with the automotive industry including eight assembly plants, multiple components plants, more than 400 parts manufacturers, and nearly 3,700 dealerships.
- For every assembly line job, the industry creates nine others to benefit surrounding communities.
MARK NANTAIS
President, Canadian Vehicle Manufacturers’ Association (CVMA)

A native of Windsor, Ontario, Mark Nantais has a long family history in the automotive industry on both sides of the Canada-U.S. border. He joined the CVMA in 1984 and has been president since 1994. His responsibilities include policy development and the overall strategic direction of the organization. His educational background in biological and environmental studies, computer science and systems analysis has served him well in leading the CVMA’s activities in the areas of engineering, environmental performance, alternative fuels, energy efficiency and technical standards harmonization. A member of numerous boards and councils, Nantais has served as the automotive industry representative on several government consultative groups, as well as Canada’s delegation to the Canada-U.S. Air Quality Agreement specifically in the area of ground level ozone.

Canadian Vehicle Manufacturers’ Association
For nearly a century, CVMA members have helped ensure Canada enjoys the economic and social advantages of a strong domestic automotive industry. Today, the CVMA continues to represent the Canadian auto industry’s largest manufacturers, giving them a single voice on issues of strategic national importance.

“The light-duty on-road transportation sector is the only economic sector that’s made continuous and sustained reductions in smog-causing emissions year over year from 1985 to 2012.”
Striking a fair balance

Pollution Probe’s Bob Oliver agrees that the joint achievements do constitute a success story. “It’s clear that there’s a healthy and robust collaboration,” says Oliver. “There’s also a healthy tension, but we end up with a fair balance between the burden on the automaker to make the vehicle that runs as clean as possible, and the petroleum refiners to deliver the fuel that enables automakers to make clean-running vehicles.”

According to Oliver, the distinction is important. When he delved into an examination of transportation fuels beginning in 2004, Oliver quickly realized that the goal wasn’t so much about cleaning up the fuel as ensuring it enabled vehicles to achieve what was technically possible in terms of emissions reductions. “Fuels are formulated specifically to enable the vehicle to limit emissions.”

“That’s what we call the total systems approach,” says Nantais, “where the technology is supported concurrently by appropriate levels of fuel quality in the marketplace. That’s how you optimize emissions reductions and emissions control efficiencies, and that’s what delivers the optimum environmental benefits consumers expect.”

“In the context of regional air-quality management and smog causing pollutants, light-duty vehicles built to the new standard are nearing the point where their emissions could be considered all but negligible.” - Bob Oliver

FAST FACTS

- Pollution Probe was instrumental in the passage of provincial legislation in the late 1990s that led to implementation of Ontario’s Drive Clean program.

- In the early 2000s, the organization played a central role in supporting stringent sulphur-in-fuel regulations and tighter air pollution standards for light- and heavy-duty vehicles.

- In 2004, Pollution Probe began significant research to explore ways to improve the fuel efficiency of new vehicles. These efforts were instrumental in informing development of federal regulations to limit GHG emissions from all new light-duty vehicles in Canada beginning with the 2011 model year.
“REDUCING SULPHUR CONTENT HAS ALLOWED AUTOMAKERS TO BRING FORWARD MORE EFFECTIVE EMISSIONS CONTROL TECHNOLOGIES AND THUS CONTRIBUTE TO MUCH LOWER LEVELS OF SMOG-FORMING POLLUTANTS.”

**CONTRIBUTOR**

**BOB OLIVER**

Executive Director, Pollution Probe

Bob Oliver is a mechanical engineer with more than 15 years experience managing industrial projects and developing strategies for energy efficiency and GHG reduction. At the helm of Pollution Probe since 2008, he has built strong relationships with governments and industry to advance practical solutions to environmental challenges. He is credited with establishing Pollution Probe’s Transportation Program through which the organization launched effective campaigns to help reduce transportation-related GHG emissions across Canada. The researcher and author behind several major reports on transportation technology and policy, Mr. Oliver is also a member of many expert panels and committees including the National Advisory Committee on Energy Efficiency and the Steering Committee for Canada’s Electric Vehicle Roadmap.

**Pollution Probe**

Pollution Probe is one of Canada’s longest-serving and most respected non-profit environmental organizations. Since 1969, it has worked effectively to improve the health and well being of Canadians by advancing policies that achieve positive, tangible environmental change.
2013 was a record year for light vehicle sales in Canada, with 1,743,112 vehicles sold. 2014 is on track to set a new sales record.

Since 2005, petroleum refiners have invested $5 billion to reduce sulphur levels in gasoline by more than 90%, and in diesel by 97%.

The fuel and vehicle industries’ total systems approach has delivered dramatic reductions in light-duty vehicle emissions of sulphur oxides, nitrous oxides and volatile organic compounds. These reductions were achieved without any sacrifice to the high energy output of gasoline.
“Any change in the composition of fuels to accommodate alternatives to gasoline and diesel... will require an associated change in the design and operation of engine emissions control technology.”  - Bob Oliver

Back in the 1980s, this meant eliminating lead from gasoline. The heavy metal impeded the effectiveness of early automotive catalytic converters, first introduced in 1975. In the past decade, the main target was sulphur for much the same reason.

“Sulphur poisons the reaction in a catalytic converter,” explains Oliver. “Reducing sulphur content has allowed automakers to bring forward more effective emissions control technologies and thus contribute to much lower levels of smog-forming pollutants.”

Federal Sulphur in Gasoline Regulations introduced in 2000 lowered sulphur levels in gasoline from 150 parts per million (ppm) on average in 2002 to less than 30 ppm by 2005. Sulphur in Diesel Fuel Regulations implemented in 2006 cut sulphur in on-road diesel from 500 ppm to 15 ppm (see Figure 2.2).

Both the automotive and petroleum fuel industries are now preparing to meet new, tougher Tier 3 regulatory requirements, which will reduce vehicle emissions another 80 percent from the Tier 2 standards while cutting sulphur in gasoline to just 10 ppm beginning in 2017—approximately 97 percent lower than in 2004. “The Tier 3 vehicle emissions standards will be the most stringent of their kind in the world,” says Mark Nantais.

Driving emissions toward zero

“The Tier 3 standards will further reduce the contribution that light-duty vehicles make to urban air pollution,” says Oliver. “We are already seeing cleaner air as a result of lower vehicle emissions, and we are looking at even cleaner air in the future. In the context of regional air-quality management and smog causing pollutants, light-duty vehicles built to the new standard are nearing the point where their emissions could be considered all but negligible.”

Mark Nantais agrees with Oliver’s assessment. “The Tier 3 standards will take us down to virtually zero-emission vehicles.”

As impressive as those specifications may be, they pose technical and investment challenges to develop sophisticated new emission-control systems, since the vehicles, by regulation, will have to meet the standard not just on the showroom floor, but also for their full useful life—roughly 240,000 kilometres.

“Concurrently,” says Nantais, “new technology-forcing GHG emission standards will basically double fuel efficiency over that which was implemented in 2010. Every category of vehicle that a company produces will have to meet stringent standards. That will take us to 54 miles per gallon [4.4 l /100 km], roughly a five percent year-over-year improvement, which is unprecedented in the history of the automotive industry.”

Every option is on the table

According to Nantais, automakers will take a broad range of approaches to meet fleet targets. “There’s no silver bullet,” says Nantais. “We will see continued improvements to internal combustion engines [ICE] and drive trains, changes to aerodynamics, use of light-weight materials, even the way we manufacture these vehicles. The ICE is going to be around for a long time, so the need for petroleum fuels is ongoing, but there’s no single technology pathway that is the solution here. Alternative fuels must be part of the slate to help us meet upcoming standards.”

To that end, the industry continues to explore hybrid vehicles and battery electric vehicles, as well as natural gas and biofuel options.

“We have to be careful that biofuel blends are properly formulated,” says Nantais, “and that the distillation curve essentially mirrors gasoline’s to ensure the vehicle can perform as intended. You just can’t add more ethanol because you think it’s a good idea.”

Oliver notes that the emissions performance of vehicles depends on an alignment of fuel formulation with the requirements of emissions control systems. “Any change in the composition of...
Mark Nantais feels the demand for boutique fuels as a result of varying provincial fuel standards is troublesome. “Petroleum refiners need consistent requirements nationwide the same as we do.”

**Going forward together**

This alignment of fuel and vehicle technology reflects an increasingly integrated North American market. With the formation of the United States–Canada Regulatory Cooperation Council (RCC) in 2011, the two countries set out to align their regulatory approaches, reduce red tape and make it easier for companies to do business on both sides of the border. Tier 2 and 3 fuel and vehicle standards, for example, are harmonized in Canada and the U.S.

“We are strong supporters of the RCC,” says Nantais. “Our vision remains one product, tested once and certified once for sale across one integrated U.S. and Canadian market.”

“I don’t think there is an alternative to gasoline or diesel.” - Bob Oliver

The automakers’ vision by extension means that fuels must also be harmonized on a continental basis while correcting for seasonal differences. “It’s in support of the total systems approach,” says Nantais, “where appropriate fuel quality supports vehicle performance and emissions control technology concurrently in the marketplace.”

He feels the demand for boutique fuels as a result of varying provincial fuel standards is troublesome. “Petroleum refiners...
need consistent requirements nationwide the same as we do,” says Nantais. “That consistency is presently driven by Canadian General Standards Board specifications, but not all provinces adhere to CGSB specs. We need to work on that to ensure a consistent market.”

**Uniquely Canadian challenges**

As for other alternatives, Nantais sees most facing the same hurdle—infrastructure—imposed in part by Canada’s formidable geography and the long distances we must travel.

“It’s the total systems approach again,” says Nantais, “the technology supported by the fuels and, in this case, the infrastructure. We have very few E-85 filling stations in Canada. Natural gas is a very good fuel with low emissions, but it’s always had an infrastructure issue. Fuel cells: we know how to do that. We have to get the cost down, but where is the infrastructure? We are seeing increasing electrification of the fleet, but we need the recharging infrastructure.”

Bob Oliver questions whether the word alternative is appropriate to the fuel discussion. “I don’t think there is an alternative to gasoline or diesel,” he says. “Technically speaking, the clean substitute for gasoline is cleaner gasoline. Fuels are different and each offers its own value proposition. You cannot simply drop any alternative fuel into an engine and expect it to operate as efficiently as on the fuel for which it was designed.”

Oliver is of the opinion that cleaner petroleum fuels and more efficient conventionally powered vehicles challenge the appeal of alternatives. “As you address air pollution and GHG emissions—and both are going down as a result of sustained improvements to the incumbent technology—the value proposition for natural gas, electricity or biofuels will increasingly have to rest on superior economic and technical performance, because environmental performance is going to be a reduced advantage over time.”

He points to electric vehicles, the focus of much of Pollution Probe’s recent work. “We’re not pushing electric vehicles exclusively as a clean-air solution,” says Oliver. “We’re interested in them from an energy management perspective, too. When you put gas in a car’s tank, there’s only one use for it. A plug-in electric vehicle, however, can offer utilities a range of value-creation opportunities in terms of power management and energy storage capability, for example.”

**Innovation through regulation**

According to Oliver, the effect of government fuel and vehicle regulations has been to motivate technological change within the fuels and automotive sectors, and to drive the deployment of new, emissions-reducing and fuel-saving technologies in the marketplace. “These changes would not otherwise happen in response to basic economic forces,” says Oliver. “The result of increased, regulation-induced technological sophistication in vehicles and fuels is cleaner air and mitigation of greenhouse gas emissions.”

Oliver would like to see the regulatory momentum continue. “Gasoline and diesel are going to be with us for some time,” says Oliver. “The opportunity now is to replicate the success we’ve had with the light-duty fleet throughout the transportation sector: heavy-duty vehicles, off-road vehicles, small engines, marine vessels, rail.”

**Promoting a holistic view**

Mark Nantais believes one of the major current challenges is to ensure that governments don’t pick technology winners and losers. “Particularly on the GHG side, there will be no one technical solution,” says Nantais. “We’re encouraging governments to look at things holistically. There are complementary technologies, and there’s more diversification on the fuel side. It’s the combination of all these things that’s ultimately going to drive greater environmental benefits.”

“The result of increased, regulation-induced technological sophistication in vehicles and fuels is cleaner air and mitigation of greenhouse gas emissions.” — Bob Oliver
Crystal balls and silver bullets

All anyone can really predict about the future of transportation fuels is that the options will continue to evolve, ensuring Canadians have a greater variety of fuel choices in years to come.

An informed perspective

“No one can predict the future of fuel and vehicle development, so I won’t try,” says Dr. Heather MacLean. Yet her experience may give her a clearer view into the crystal ball than many other experts in the field of fuel and vehicle technology. Her perspective is based largely on exhaustive studies that compare, from an interdisciplinary perspective, numerous fuel and vehicle options and combinations.

“Our research has evaluated a fairly wide set of options including conventional gasoline-powered vehicles, hybrids, plug-in hybrids, and battery-powered vehicles,” says MacLean. “We’re also looking at the production and use of biofuels in vehicles—primarily second generation ligno-cellulosic biofuels rather than those produced from animal feed crops.”

MacLean and her colleagues rely on life cycle assessment (LCA) to conduct their evaluations. LCA has emerged in recent years as the method best suited for making equitable comparisons of different fuel and vehicle technologies.

“Life cycle assessment is frequently employed to evaluate and quantify the environmental implications of a product,” says MacLean. In the case of a conventional gasoline-powered vehicle, an LCA would span extraction of the raw material—including oil—manufacturing, use and vehicle disposal.

Two LCA models currently dominate in North America. The U.S. Department of Energy developed and uses GREET (greenhouse gases, regulated emissions, and energy use in transportation). GHGenius is the primary model in Canada. Both address more than 100 fuel production pathways and more than 70 vehicle/fuel combinations.

“The second-generation biofuel option will not cover a very large portion of the vehicle fleet in the near term.”

- Heather MacLean
Over the past 15 years Heather MacLean has worked closely with the public and private sectors to evaluate conventional and alternative energy systems. Her main research focus since studying for her doctorate and joining the faculty at University of Toronto has been in the development and application of improved methods to evaluate the environmental and techno-economic impacts of a broad range of transportation fuel and vehicle technologies.

MacLean has been affiliated with Auto21 (see below) since 2002, leading a variety of research projects. Collaborating with research partners at the University of British Columbia and University of Windsor, she has examined technological change in the automotive industry, the evolution of life cycle assessment, and emerging automotive technologies. The research is interdisciplinary, involving public and private sector partners and spanning the fields of public policy and environmental, chemical and mechanical engineering.

MacLean received a degree in civil engineering from the Technical University of Nova Scotia (now part of Dalhousie University), and an MBA from St. Mary’s University. She earned her MSc. and Ph.D. at Carnegie Mellon University in Pittsburgh.

Research for a sustainable domestic automotive sector

Auto21 is a national research initiative supported by the Government of Canada through the Networks of Centres of Excellence Secretariat. The organization connects nearly 200 leading Canadian researchers at 48 universities with more than 130 industry and government partners. Focusing on six key themes, including powertrains, fuels and emissions, Auto21’s goal is to create a dynamic R&D community that contributes to a sustainable and globally competitive Canadian automotive sector.
Across years of complex fuel and vehicle comparisons and analysis, MacLean and her collaborators have found there is no overall winner.

Pursuing greater accuracy

LCA is far from a perfect science, but models are being continually refined to improve their accuracy. “Comparing conventional and alternative fuel vehicles is very complex,” says MacLean, who feels that although the analysis models are well maintained, there can always be improvement.

“The LCA models are generally focused only on environmental impacts,” says MacLean. “There is a social component of LCA, but it’s in its infancy. So if one is looking more broadly at sustainability—balancing economic and environmental tradeoffs—LCA doesn’t really provide a complete picture.” Her work is also addressing financial and techno-economic aspects, which are critical to evaluating the attractiveness of fuel and vehicle technologies.

The refinements to LCA are enabling analysis that’s exceptionally granular. In a recent Auto21 study, MacLean and her team determined that ethanol (E85) use in a hybrid electric vehicle and bioelectricity use in a fully electric vehicle can have similar life cycle fossil energy use and net GHG emissions. The team’s findings differ with those in the literature, which report better bioelectricity performance on these metrics compared to ethanol. Yet the results in a prior study were skewed by the use of vehicles with demonstrably different performance characteristics that favoured the bioelectricity option. Using simulation software, the Auto21 team created vehicles that featured different powertrains but were otherwise identical in size and acceleration capability. The work shows the data sensitivity of LCA and the significance of careful and accurate comparisons.

A vehicle for where you live and the way you drive

Across years of complex fuel and vehicle comparisons and analysis, MacLean and her collaborators have found there is no overall winner; every option involves some trade-offs, be they environmental or economic. She sees a gradually fragmenting vehicle market in which various technological solutions have their place depending on where you live and how you drive. “A battery powered vehicle would be a good option for someone with a short commute and living in a jurisdiction with a low-carbon electricity grid,” says MacLean. “Someone who faces a lot of stop-and-go traffic would be well served with a hybrid electric vehicle. A diesel vehicle would be a better choice for driving long distances.”

Regional geographic differences can create conditions under which one option is preferred over another. MacLean believes this is particularly true when considering electric vehicles. “The regional electricity grid mix varies greatly across Canada,” says MacLean. “From a GHG-emissions perspective, an electric vehicle that draws on a hydro-electric grid is far more promising than one that relies on electricity generated by the high carbon intensity of coal.”

The main barrier facing electric vehicles is the absence of battery technology breakthroughs. “There are promising options out there,” says MacLean, “but electric vehicles still have limitations with respect to performance, infrastructure and affordability.”
Tracking biofuel progress

For biofuels, MacLean notes that the variety of feedstocks, production methods and sources of energy for production are all very significant in determining life-cycle GHG performance.

“There continues to be a lot of focus on second-generation biofuels,” says MacLean, “but development has been much slower than people in the sector would hope to get commercial scale facilities up and running.”

Progress has been made recently, but a number of challenges have yet to be overcome, specifically with regard to clarifying environmental aspects of the technology, as well as financing and risk management. “The second-generation biofuel option will not cover a very large portion of the vehicle fleet in the near term,” says MacLean.

Improving conventional solutions

MacLean and her colleagues have studied petroleum fuels and conventional internal combustion vehicles in many projects. She expects the fuel economy and overall performance of these vehicles will continue to improve. Some improvements will depend on the use of new lightweight materials, changes to vehicle size and power, and advances in powertrain technology. (See Figure 3.1.)

“Some of these improvements may require tradeoffs from a life cycle perspective,” observes MacLean. “For example, increases in fuel economy could be offset by a greater amount of energy required to manufacture lightweight materials that enable higher efficiency.”

Manufacturing processes may also require highly specialized materials for which recycling protocols have not yet been established. Careful LCA provides valuable information about many of these tradeoffs.
The coming decades will deliver significant efficiency improvements in conventional gasoline and diesel powered vehicles through powertrain innovations, use of new lightweight materials and increased hybridization, among other advances.

MacLean believes the use of petroleum-based fuels may face challenges if carbon intensity or GHG emissions are a key regulatory focus—even as emissions of conventional pollutants are virtually eliminated through Tier 3 fuel and vehicle emission standards. Nonetheless, she agrees that the movement away from petroleum fuels will be slower than many people anticipate.

A healthy mix of technologies

When it comes to transportation fuel and vehicle technology, there is no silver bullet. “I have to keep saying this and some people consider it a downer, but there’s no clear or optimal solution,” says MacLean, who sees the benefits of an increasing number of fuel and vehicle options. “Choice encourages development on a number of different fronts. There obviously are some winners and some losers, but we should be careful not to abandon any technological option prematurely.”

While she expects we will witness some breakthroughs in fuel and vehicle technologies, various wild cards play havoc with predictions. The future mix of technologies and the speed of their adoption will depend on a range of factors including fuel price and supply, and public policy—about which there’s considerable uncertainty.

To reveal viable pathways, MacLean believes LCAs and supplementary analyses must begin to address other environmental impacts as well as financial, supply and logistical issues.

“Although I feel global climate change is an important issue, I’m hoping that a lot more of the focus is on the overall perspective and not just GHG emissions,” says MacLean. “There are other considerations: water use and availability, bio-diversity, land use, emissions other than GHGs, and efficiency of production—energy use more generally.”

Promoting a broader approach

MacLean also believes an additional perspective is necessary to further minimize the environmental impacts of the transportation sector. She is concerned the work to increase vehicle efficiency and reduce emissions will be for naught if we don’t address traffic congestion—a particular problem in urban North America and transition economies where the number of vehicles continues to rise.

“Even the most efficient, lowest polluting vehicles won’t necessarily solve the larger issue if we’re just putting more and
more vehicles on the road,” says MacLean. “We need a broader approach—beyond the questions of what fuels or vehicles we should be using—to look at government policies, consumer behaviour, infrastructure financing, public transit, land-use planning and other issues over the next few years.”

The future mix of technologies and the speed of their adoption will depend on a range of factors including fuel price and supply, and public policy—about which there’s considerable uncertainty.

Dr. MacLean would like to acknowledge the support of two University of Toronto collaborators in her contribution to this section: Jason Luk, a Ph.D. student in the Department of Civil Engineering; and Bradley Saville, a professor in the Department of Chemical Engineering & Applied Chemistry.
SECTOR PERFORMANCE
Production

To meet demand, Canada’s refineries operate around the clock, producing an average of more than 300 million litres of refined petroleum products per day. They contribute $5.6 billion in direct GDP to the Canadian economy and employ over 18,000 highly skilled workers.


Canadian supply and demand, 2013

Canada is a net exporter of refined petroleum products, with a production that exceeds domestic demand.

Sales by product, 2013*

Driven by increased freight transport, diesel represents a growing share of Canada’s petroleum product slate.

*Other* includes propane, butane, petro-chemical feedstocks, lubricating oils, petroleum coke, asphalt, etc.

Canadian exports and imports of refined petroleum products

Canada has become less reliant on refined petroleum product imports, while exports have gradually risen in recent years. The U.S. represents 92 percent of Canada’s export market.

*Certain product shares are based on NRCan analysis.
Safety

Canadian Fuels members are continuously working to improve the sector’s safety record, which is one of the best in Canadian manufacturing. In the past 10 years, total recordable injuries for refining, distribution and retail employees have decreased by 80 percent.

Data: Canadian Fuels Association member companies only. Canadian Fuels membership changed in 2012 and 2013.

Total employees – Total recordable injury frequencies
Environmental performance

Effective environmental stewardship is one of the core values of our members. Over the past 10 years, they have invested more than $7.2 billion to improve the environmental performance of their refineries and the fuels they produce by reducing air emissions, GHGs and water use.

Data: Canadian Fuels Association member companies only. Canadian Fuels membership changed in 2012 and 2013.

CO₂ emissions

The refining sector’s CO₂ emissions have been reduced by 16 percent in the past 10 years, even while refining has become more intensive to comply with new, more stringent fuel quality standards. The refining sector accounts for less than 2.5 percent of Canada’s total GHG emissions. GHG emission reductions from refineries have been driven in part by a 14 percent drop in energy fuel consumption.

Energy fuel consumption of petroleum refineries, annual

Total CO₂ emissions, Canadian refining industry

Data: Statistics Canada
Air emissions
Canada's refiners work continually to improve their processes, leading to significant improvements in air emissions.

Data: Environment Canada's National Pollutant Release Inventory (NPRI).

Carbon monoxide (CO) ↓ 46%

Sulphur oxides (SOx) ↓ 45%

Nitrogen oxides (NOx) ↓ 39%

Volatile organic compounds (VOCs) ↓ 38%

Total particulate matter (TPM) ↓ 37%

Benzene (C6H6) ↓ 29%
**Water**

Canadian Fuels members are committed to using less water and returning it to the environment in a cleaner state. Water intake is down 22 percent since 2005, while effluent deposits continue to be well below maximum allowable limits.

Data: Canadian Fuels Association member refineries only. Canadian Fuels membership changed in 2012 and 2013.

**Surplus site remediation**

Since 2009, Canadian Fuels members have remediated 828 surplus sites, including 152 in 2013, making them available for industrial, recreational, residential or commercial use.

Data: Canadian Fuels Association members only. Canadian Fuels membership changed in 2012 and 2013.

**Total Canadian Fuels member sites remediated**
**Fuel quality**

Fuels have changed significantly in the past decades. Lead was entirely phased out of gasoline and benzene was cut to less than 1 percent of volume. Refiners have invested over $5 billion to cut sulphur to less than 30 ppm in gasoline and less than 15 ppm in diesel.

Data: Canadian Fuels member companies (excluding Husky Energy Inc. and NOVA Chemicals (Canada) Ltd.). Data includes imports. Quarterly volume-weighted averages are shown for sulphur in gasoline and on-road diesel.

**Sulphur in gasoline**

Sulphur content in gasoline is 90 percent lower than it was 10 years ago. New Tier 3 regulations will cut sulphur content in gasoline by 97 percent in 2017 compared to 2004 levels.

**Sulphur in on-road diesel**

Sulphur in Diesel Fuel Regulations implemented in 2006 cut sulphur in on-road diesel from 500 ppm to 15 ppm.

**Benzene in gasoline**

Benzene content is far below the maximum allowable.
Refining sector economic indicators

The refining sector is an important contributor to Canada’s economy, adding $5.6 billion to GDP.

Data: Statistics Canada, The Conference Board of Canada

Refining sector investments (millions of Canadian dollars)

Canadian refiners have invested over $2.2 billion a year on average over the past decade.

Refinery employment

Canada’s refining sector employs over 18,000 highly skilled workers, earning 70 percent more on average than the overall manufacturing sector average.
Welcome new members

The Canadian Fuels Association is pleased to have welcomed two new members in 2014.

**Federated Co-operatives**

Saskatoon-based **Federated Co-operatives Limited** (FCL) is the 45th largest company and the largest non-financial co-operative in Canada. FCL’s Co-op Refinery Complex (CRC) was the world’s first co-operatively-owned petroleum refinery. Located in Regina, the CRC manufactures and supplies petroleum products for FCL members through the Co-operative Retailing System. With a total capacity of 130,000 barrels per day, the CRC is recognized as one of Canada’s high value-added petroleum refining facilities. It employs more than 900 people.

**Irving Oil**

Founded in 1924, **Irving Oil** is a family-owned and privately-held regional energy processing, transporting and marketing company with headquarters in Saint John, New Brunswick, and U.S. marketing operations in Portsmouth, New Hampshire. The company operates Canada’s largest refinery, producing 320,000 barrels of finished products per day. Operations include ten distribution terminals, a fleet of delivery trucks and more than 900 fuelling locations serving wholesale, commercial and retail customers in Atlantic Canada, Quebec and New England.

For more information, please visit our website, [canadianfuels.ca](http://canadianfuels.ca)

To comment, contact [president@canadianfuels.ca](mailto:president@canadianfuels.ca)
We’ll take you there.