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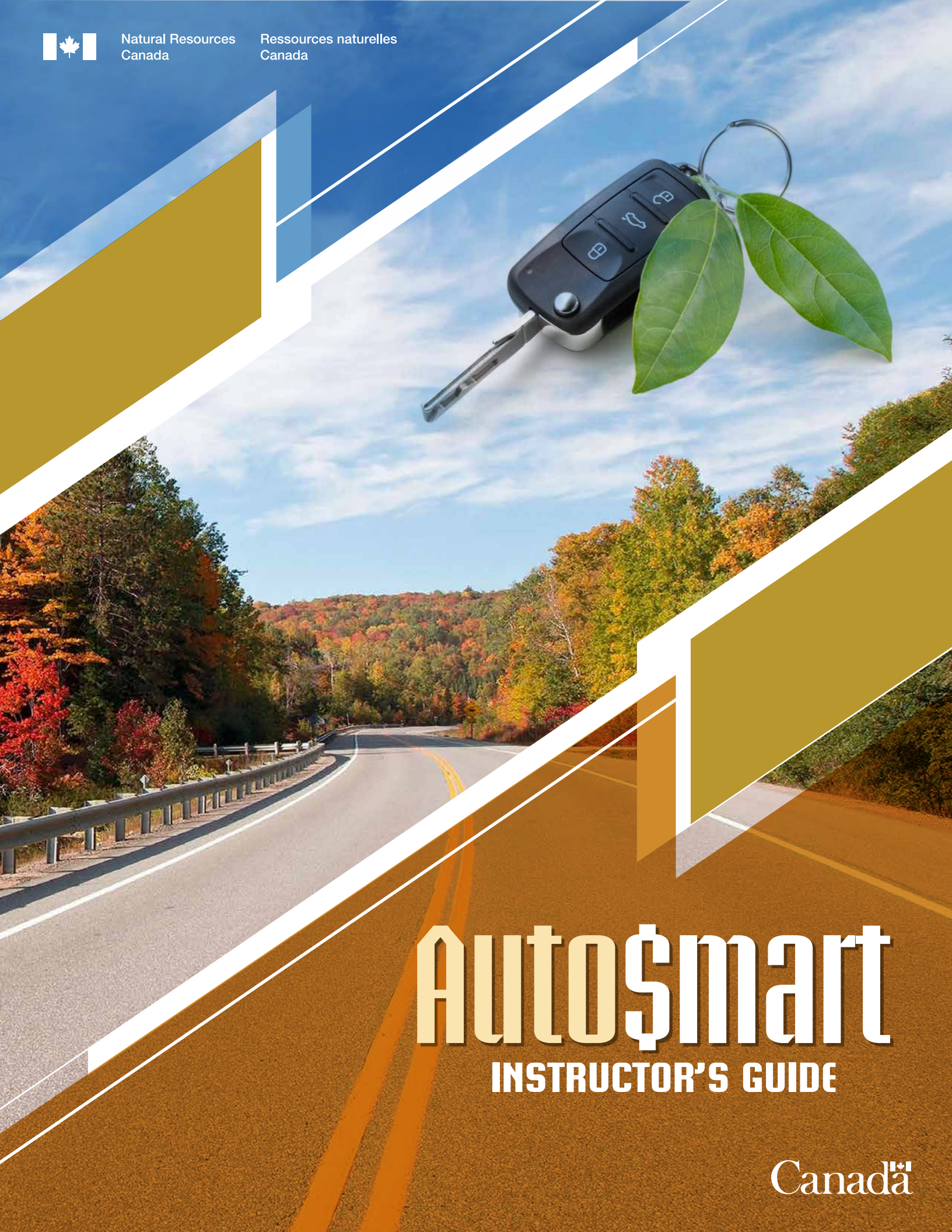

Auto$mart

INSTRUCTOR'S GUIDE

Canada

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Introduction for instructors

The purpose of the Auto$mart Driver Education Kit

The Auto$mart program provides driver educators with free tools and resources to teach students about zero-emission vehicles, the environmental impacts of transportation, and the benefits of energy-efficient driving. Designed to complement and reinforce the safety skills already covered in provincial and territorial driver education curriculums, Auto$mart enables educators to seamlessly integrate these topics into their course material at their own pace.

The program gives you:

- ➔ The flexibility to cover the program in its entirety or pick and choose specific units.
- ➔ The competitive advantage: Adopting the Auto$mart program sets your school apart from the increasing number of driver education companies across the country. The program is a perfect complement to defensive driving curriculums, and can rejuvenate long-standing courses with its fresh, contemporary content.

Why incorporate Auto$mart into your driver education program?

- ➔ It is designed to fit easily into existing curriculums, both in-class and in-car.
- ➔ It teaches the importance and benefits of energy-efficient driving.
- ➔ It demystifies a variety of energy-efficient vehicle technologies and powertrain options including hybrids and electric vehicles.
- ➔ It addresses the environmental impacts of our daily driving habits – an increasingly important concern for young drivers.

How to incorporate Auto$mart into your curriculum

If you are like most driver educators, you are pressed for time in the classroom. You have only a few hours to cover the huge volume of content your students need to know before taking the wheel. Conveniently, the Auto$mart program was designed with your tight teaching schedule in mind.

Parcelled into several small components, the program makes it easy for you to extract and make use of content in a way that fits within your curriculum.

As an instructor, you are encouraged to:

- ➔ Read all the material and identify the topics that can be easily integrated into your province or territory's curriculum standard.
- ➔ Consider the following Auto$mart learning objectives when developing your lesson plan, and tailor class activities to reinforce those that are most important to your students:

  a) Discover the importance of energy-efficient driving, the problem with greenhouse gas emissions, and how to become a part of the solution.

  b) Learn how to select the most energy-efficient vehicle that meets your everyday needs.

  c) Discover the different vehicle powertrains and their benefits, i.e. hybrid, plug-in hybrid, battery-electric.

  d) Bust myths regarding battery-electric vehicles.

  e) Explore how to optimize efficiency by practicing smart pre-driving habits.

  f) Know how to apply the five energy-efficient driving techniques.

Integrating Auto$mart units into your beginner driver education curriculum

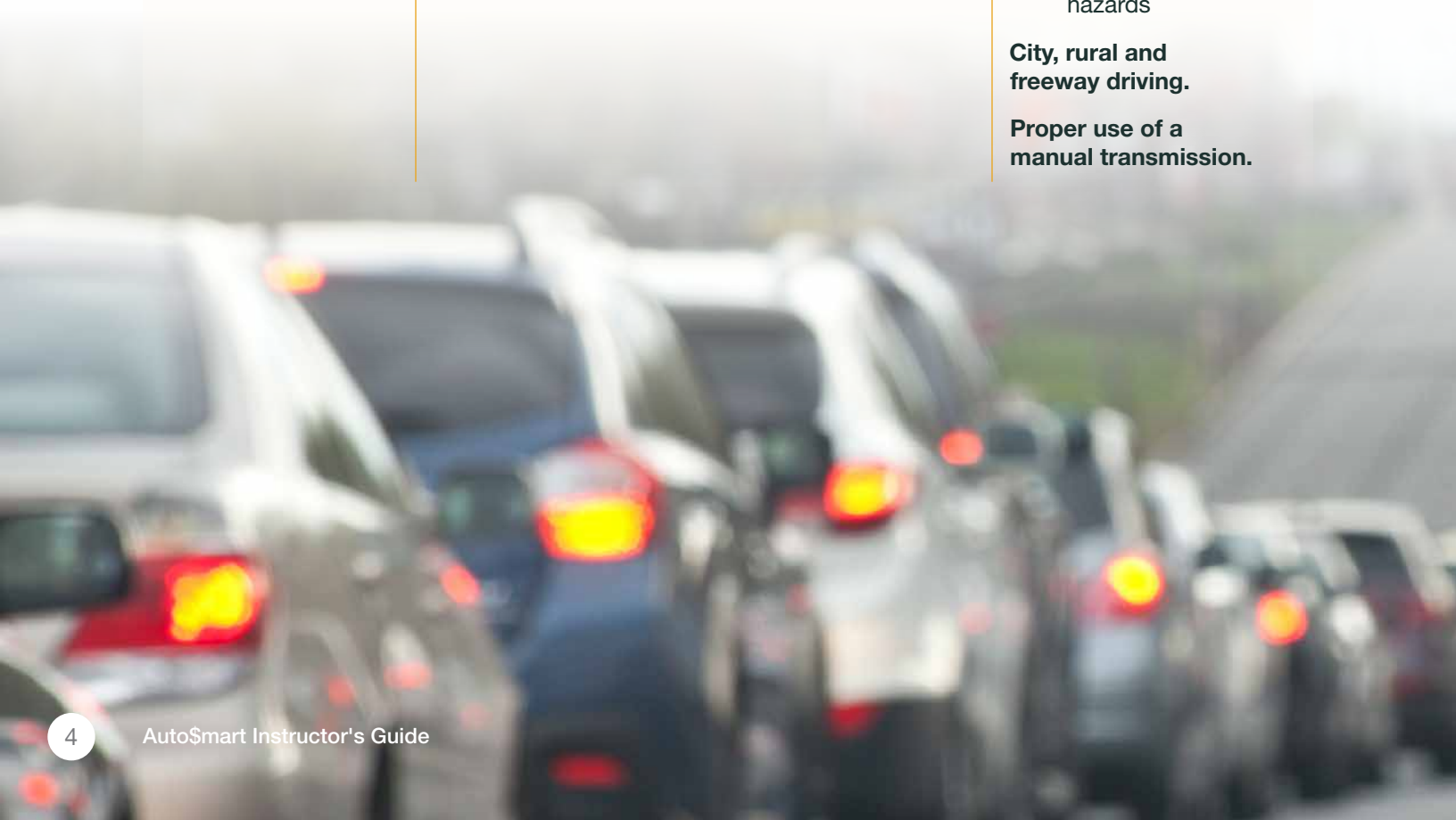
Here is a list of the five Auto$mart units and where they can converge with conventional beginner driver education (BDE) material. By using this as a guide, you can strategically integrate Auto$mart content into the core of your lesson plan. Remember: You can incorporate these units into your curriculum in any order!

Auto$mart Unit	Auto$mart Unit Topics	Relevant BDE Topics
1. Driving and the environment	• Introduction • The problem with GHGs • Energy consumption and the environment	**The importance of driver education** • Becoming a responsible driver **Sharing the road** • Legal, safety, and ethical responsibilities toward other road users

Auto$mart Unit	Auto$mart Unit Topics	Relevant BDE Topics
2. The vehicle for you	• Introduction • How to select the vehicle that fits your needs • Consider your powertrain options • Public charging • Electric vehicle myths • Four more tips to help you find the most energy-efficient vehicle	**The vehicle and its components** • Features and devices of the vehicle

Auto$mart Unit	Auto$mart Unit Topics	Relevant BDE Topics
3. Before you drive	• Introduction • Consider your transportation needs • Plan your route • Lighten your load – take only what you need • Remove roof or bicycle racks • Consult your owner's manual • Follow your vehicle's recommended maintenance schedule • Check your vehicle's fluid levels • Look for any puddles or leaks under or near your vehicle	**Pre-driving checks** • External circle checks • Internal checks **Vehicle maintenance and breakdowns** **Perception and risk management** • Defensive route planning • Identifying potential hazards

Auto$mart Unit	Auto$mart Unit Topics	Relevant BDE Topics
4. Behind the wheel	• Introduction • Five energy-efficient driving techniques 1. **Accelerate gently** 2. **Maintain a steady speed** 3. **Anticipate traffic** 4. **Avoid high speeds** 5. **Coast to decelerate** • More energy-efficient tips - Use a manual transmission properly - Use a fuel consumption display - Track your vehicle's fuel consumption - Use air conditioning sparingly	**Traffic laws and regulations** • Rules of the road **Laws of physics** • Friction • Gravity • Inertia • Kinetic energy • Force of impact **Defensive driving** • Principles and foundations • Differences between proactive and reactive driving • Applications – how it works • Identification and response to on-road hazards **City, rural and freeway driving.** **Proper use of a manual transmission.**



Auto$mart Unit	Auto$mart Unit Topics	Relevant BDE Topics
5. Winter driving	• Introduction • Energy-efficient tips in the cold - Park in warm areas when possible - Use your EV's pre-timed heating system - Use a block heater - Don't idle to warm up - Measure your tire pressure	**Adverse driving conditions** • Getting the vehicle ready • Adjusting to winter driving: loss of friction and visibility

Conclusion

BDE is a fundamental aspect of our society. Driver educators teach their students the core knowledge and skills that they'll need to safely and efficiently operate their vehicle for years to come. Once drivers complete their BDE and obtain their, there are no further provincial/territorial driver training requirements until the age of 80 years old. This emphasizes the importance of instilling in students safe and efficient driving habits from the very start of their driver education.

UNIT 1 Driving and the environment

Introduction

The way Canadians consume energy has long-term implications for Canada's climate. By the end of this century, scientists expect the average annual temperature in Canada to increase by between 1.8°C and 6.3°C.[1] This climate change will have far-reaching consequences for the environment. By adopting energy-efficient driving practices and purchasing a zero-emission vehicle, or the most fuel-efficient vehicle that meets their needs, Canadians can significantly reduce the impact their driving has on the environment.

Transportation accounts for roughly a quarter of Canada's total greenhouse gas (GHG) emissions, making it the second largest emitting sector of our economy. Canada consumes more energy per person than almost any other country, due in part to our reliance on automobiles. Together, we own about 25 million vehicles and drive more than 300 billion kilometres (km) each year, consuming up to 44 billion litres (L) of gasoline.[2] That's over 100 billion kilograms (kg) of carbon dioxide (CO_2) emitted each year!

Our climate, vast and dispersed population partly account for our energy use. But Canadians must take responsibility, too. We often waste energy without realizing it. We tend to buy bigger, less efficient vehicles than we need and waste excessive energy on the road because of speeding and other poor driving habits.

Fast facts

With more than one vehicle for every two people, Canada has one of the highest rates of car ownership in the world.

The problem with GHGs

Too many GHGs in the atmosphere cause temperatures around the world to rise – dangerously. Consider for a moment the devastating impact even a modest increase in temperature will have.

- ➔ Sea levels will rise, threatening the safety of coastal communities.
- ➔ Dry conditions in some areas will lead to forest fires, droughts and crop failures.
- ➔ Summers will intensify, diminishing the air quality of urban areas and compromising the health of people affected by asthma and other respiratory conditions.
- ➔ Floods, droughts, rainstorms and other extreme weather events will become more frequent and severe, posing numerous dangers to Canadians and their property.

[1] Environment and Climate Change Canada (2017). Climate data and scenarios: synthesis of recent observation and modelling results. Government of Canada.

[2] Statistics Canada. Table 23-10-0066-01, Sales of fuel used for road motor vehicles, annual (x 1,000)

Energy consumption and the environment

A gasoline- or diesel-powered internal combustion engine emits dozens of gases, air contaminants, and particulates that can impact air quality and the environment. CO_2, the principal GHG, traps heat from the sun near the earth's surface and contributes to changes in global climate.

CO_2 emissions are directly proportional to the amount of fuel consumed. A vehicle produces about 2.3 kg of CO_2 for every litre of gasoline it burns. To help visualize this, stretch out your arms and legs and imagine there is a large bubble around you. That's roughly the space required to hold 2.3 kg of CO_2!

For every litre of diesel it consumes, a vehicle produces about 2.7 kg of CO_2. On average, cars produce roughly three times their weight in CO_2 emissions every year.

How is this possible?

How can 1L of gasoline, which weighs only 0.75 kg, produce 2.3 kg of CO_2? The answer is chemistry.

To move a vehicle down the road, an engine converts energy stored in the fuel into mechanical energy that propels the wheels. Gasoline and diesel require oxygen to burn. That oxygen comes from the air drawn into the engine. During combustion, each carbon (C) atom in the fuel combines with two oxygen (O_2) atoms from the air to produce CO_2. So, the additional weight comes from oxygen.

The solution: Buy, drive and maintain your vehicle with energy efficiency in mind

In the following units, you will learn how to help minimize the impact your driving has on the environment by choosing an appropriate vehicle for your needs, driving in an energy-efficient manner, using your vehicle only when needed and following the manufacturer's operation and maintenance recommendations for your vehicle. Since energy is an ongoing expense, using less will save you money for years to come!

UNIT 2 The vehicle for you

Introduction

Choosing what vehicle to buy is a big decision. There are many things to consider when you purchase a vehicle: powertrain, price, comfort, size, styling, and more. Choosing the most efficient vehicle that meets your everyday needs can save you money and reduce the impact that your driving has on the environment.

It's worth putting some time into your choice. Consider that fuel consumption can range from less than 2.0 gasoline litres equivalent per 100 km (L_e/100 km) for a battery-electric vehicle to more than 20.0 litres per 100 km (L/100 km) for a large SUV. So, driving 20,000 km a year can cost from less than $500 to more than $4,000. Meanwhile, annual CO_2 emissions can range from 0 to more than 9,000 kg, depending on the vehicle you buy.

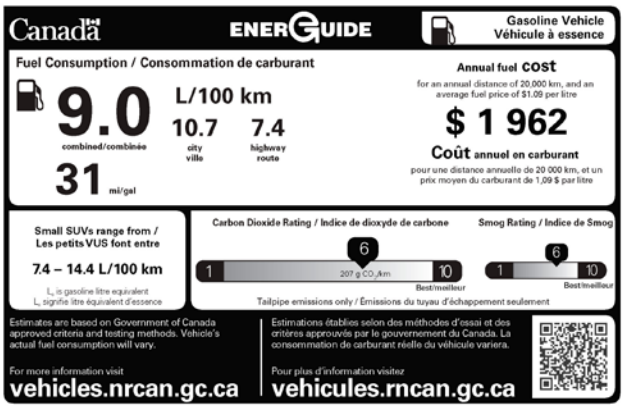
Fast Facts

The average Canadian vehicle releases more than four tonnes of CO_2 – roughly the weight of eight full-grown dairy cows – every year.

How to select the vehicle that fits your needs

Knowing how much energy your prospective vehicle is going to consume is a good place to start. Consult Natural Resources Canada's *Fuel Consumption Guide* and fuel consumption ratings search tool at **vehicles.gc.ca** to compare vehicles based on their fuel consumption ratings, estimated CO_2 emissions and annual fuel costs. To help you compare vehicles that use electricity, a conversion factor is used to convert electrical energy consumption values, expressed in kilowatt-hours per 100 kilometres (kWh/100 km), into gasoline litres equivalent per 100 kilometres (L_e/100 km). One litre of gasoline contains the energy equivalent to 8.9 kWh of electricity.

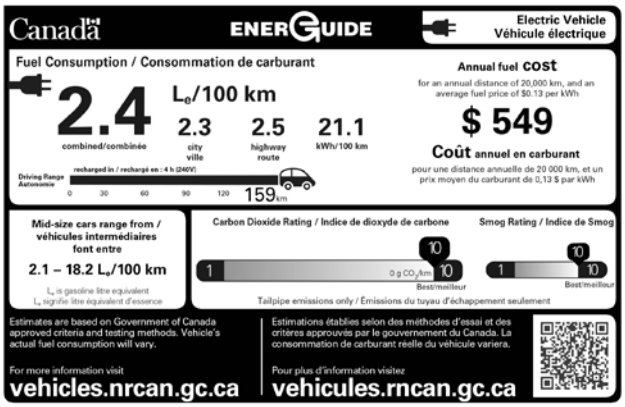
You can also find fuel consumption information on the EnerGuide labels affixed to the windows of new vehicles for sale at dealerships.



Remember, the lower the L/100 km or L_e/100 km rating, the better the consumption.

EnerGuide labels for electric vehicles also show the estimated time (in hours) to fully recharge the battery using a level 2 charger. These chargers use a 240-volt power source, like the one used for your stove and clothes dryer. The vehicle's estimated driving range (in km) on a fully charged battery is also included on the label.

With a little research, and a lot of consideration about your everyday driving needs, you can find an energy-efficient ride that's perfect for you.



Consider your powertrain options

A vehicle's powertrain is made up of the components that make the vehicle go, such as the engine, transmission, suspension and wheels. Today, you can choose from a wide range of powertrain options.

Hybrid-electric vehicles

Hybrid-electric vehicles, or so-called conventional hybrids, use an internal combustion engine and a battery-powered electric motor to improve efficiency. The electric motor is most often used in stop-start traffic and lower speed applications. The engine takes over when the batteries need to be recharged and, in higher speed applications, is assisted by the electric motor when accelerating or climbing a hill.

Most hybrids reduce idling emissions by shutting off the engine when the vehicle is stopped. The engine restarts when the brake is released.

Hybrid batteries are recharged with electricity generated by the vehicle – they can't be plugged in. When hybrids are operating in electric-only mode, they emit no CO_2 or other emissions. The typical hybrid offers fuel savings and CO_2 reductions of 20 to 40% over a comparable internal combustion engine (ICE) vehicle.

Electric vehicles

Electric vehicles (EV) use electricity from an external power source for some or all of their motive power. Battery-electric vehicles do not burn any fossil fuels, so they emit no GHGs or other pollutants.

As Canadians learn about the many benefits of EVs, their popularity across the country continues to grow.

Two types of electric vehicles

There are two types of electric vehicles – plug-in hybrid electric and battery-electric – and each has its benefits.

- **Plug-in hybrid electric vehicles (PHEV)** use both an internal combustion engine and a battery-powered electric motor to power the vehicle. They have larger batteries and longer electric-only driving ranges compared to conventional hybrids and can be recharged by plugging them in. This may allow drivers to use no gasoline – and produce no tailpipe emissions – for much of their daily driving.

- **Battery-electric vehicles (BEV)** use electric motors powered by high-capacity battery packs. When the batteries run low, they must be plugged in to recharge. BEVs do not have an internal combustion engine, so they produce zero tailpipe emissions.

Know your charging levels

If you own an EV, knowing the different charging levels and the speed at which they charge your battery is an important part of making sure you're prepared for the trip ahead.

EVs can be plugged into a standard 120-volt wall outlet to charge. This is known as Level 1 charging. Level 1 charging adds about 8 km of driving range per hour.

Level 2 chargers use a 240-volt system and can add 30 to 50 km of range per hour.

Direct Current Fast Chargers, or Level 3 chargers, use a 480-volt or higher system and can add more than 100 km of range per hour – perfect for long trips.

Public charging

There are a few things to keep in mind when using a public station to charge your EV. Some public charging stations are free to use, while others may require a membership or charge a fee based on the amount of time you're plugged in. Fees for charging are set by the station owner, with level 2 charging typically costing between $1 and $5 per hour. Most level 3 chargers will cost you an average of about $15 an hour to charge.

When possible, charge at home and take advantage of off-peak electricity rates. Consult your utility provider to find out the best time to charge your EV at home.

Electric vehicles are energy and cost-efficient

Electric-drive motors are much more efficient than combustion engines and drivetrains. The efficiency of energy conversion from on-board storage to turning the wheels is nearly five times greater for electricity than gasoline, at approximately 76% and 16%, respectively.

EVs also use regenerative braking technology to recover energy that would otherwise have been lost, increasing their efficiency even more.

Electric vehicle myths

Myth 1 **BEVs do not have a long enough driving range to meet my daily requirements.**

The average Canadian motorist drives about 50 km a day – well within the range of a BEV, even under more energy-demanding winter conditions.[3] With the ability to charge your BEV at home while you sleep, this myth is simply untrue in most cases.

[3] Transport Canada (2012). *Transportation in Canada 2012 overview report*.

Myth 2 **Charging a BEV will cost more than fuelling an ICE vehicle because of to the higher electricity bills.**

The cost of electricity per km is much lower than that of gasoline. A BEV costs about 2 to 3¢/ km (at 13¢/kWh), compared to a typical 4-cylinder gasoline vehicle at 7 to 8¢/km (at $1.00/L). While your electricity bill will increase (after all, you're adding to your overall electricity load every month), these expenses are minimal compared to the regular trips to the gas station required with an ICE vehicle. Many EV owners charge at home overnight at off-peak electricity rates, making this option even more affordable compared to fuelling an ICE vehicle.

Myth 3 **There aren't enough places to charge a BEV.**

Over the last few years, thousands of publicly accessible electric vehicle chargers have been built across Canada (along highways, at public and commercial places, service stations, etc.) with more being installed all the time. To find a station near you, visit Natural Resources Canada's Electric Charging and Alternative Fuelling Stations Locator Map.

Fuel cell electric vehicles

FCEVs use compressed hydrogen gas and a fuel cell to power the electric motor that propels the vehicle. The vehicle's fuel cell converts hydrogen into electricity, which is used to charge a small battery that powers the electric motor. FCEVs emit water vapor and warm air only, meaning that they release none of the harmful tailpipe emissions produced by ICE vehicles. Driving range and fuelling of newer-generation FCEVs are comparable to that of ICE vehicles.[4] After only about five minutes at the hydrogen refuelling station, you can be back on the road with a full tank. While FCEVs are still new to the roads of Canada, the number of available models and hydrogen refuelling stations grows every year.

Internal combustion engine vehicles

ICE vehicles are currently still the most common vehicle type. ICE vehicles use fossil fuels (i.e. gasoline or diesel) to generate motive power. As the name suggests, the fuel is ignited and combusts inside the engine's cylinders to convert thermal energy into the mechanical energy that moves the vehicle.

The burning of fossil fuels produces GHG emissions, primarily CO_2, that contribute to global climate change, as well as other smog-forming emissions that impact health and the environment.

Manufacturers continue to improve the fuel efficiency of their ICE vehicles. Fuel-efficient technologies – such as cylinder deactivation, turbocharging, variable valve timing, direct injection and idle stop-start systems – can save you money and reduce emissions.

- ***A cylinder deactivation system (CDS)*** in a 6- or 8-cylinder engine shuts down cylinders when only a small amount of the engine's power is needed. This happens in situations such as highway or downhill driving. A CDS can lower fuel consumption by 4 to 10%.
- ***Turbochargers*** force air into an engine's cylinders – unlike a standard engine, which draws air in at atmospheric pressure. This means that a smaller, turbocharged engine can produce the same power as a larger standard engine – and can lower fuel consumption by 2 to 6%.
- ***Variable valve timing (VVT)*** and lift systems adjust the timing of the engine valves to improve efficiency over a wide range of engine operating speeds. This leads to better operation of the engine and a 1 to 6% reduction in fuel consumption.
- ***Direct fuel injection*** increases your engine's combustion efficiency because of a higher level of precision over the amount of fuel injected into the cylinder, the timing of the injection and the spray pattern. This precision also gives the engine greater power, which allows for a smaller engine. Direct injection can lower fuel consumption by 1 to 3%.
- ***Idle stop-start systems*** lower fuel consumption and exhaust emissions by turning off the engine when the vehicle is idling and during deceleration at low speeds. Idle stop-start technology can lower your fuel consumption during city driving by 4 to 10% or more.

[4] National Renewable Energy Laboratory (2019). *On-Road Fuel Cell Electric Vehicles Evaluation: Overview*. Retrieved from **https://www.nrel.gov/research/publications.html**

Four more tips to help you find the most energy-efficient vehicle

Tip 1 Remember: The smaller, the better

Generally, the bigger the vehicle, the more it weighs. The more an ICE vehicle weighs, the more fuel it consumes and CO_2 it produces. Case in point – a large sport utility vehicle (SUV) produces an average of 6,000 kg of CO_2 annually, while a mid-sized car produces an average of only 4,000 kg per year.

Vehicles that use four-wheel or all-wheel drive consume up to 10% more fuel than their two-wheel-drive cousins, because of to the weight and friction of additional drivetrain parts. Narrow your options to the smallest and lightest vehicle that adequately meets your everyday needs.

Tip 2 Reign in the horsepower

The size of the engine you choose will affect the energy consumption of your vehicle. Don't be oversold. Car makers often offer two or more engine choices for a vehicle model. Choose the smallest engine that meets your needs. For example, opting for a four-cylinder engine, rather than a six-cylinder engine, could save you a significant amount of fuel – and money – for every kilometre you drive.

Tip 3 Gear up your transmission

Whether you're leaning toward an automatic or manual transmission, try to choose an option that provides as many gears as possible. Additional gears enable an engine to operate at optimal efficiency, keeping your fuel consumption – and fuel costs – down. Continuously variable transmissions (CVT) are the most fuel-efficient because they enable your vehicle's engine to perform at optimal efficiency over a broader range of speeds.

Tip 4 Think aerodynamic

Energy efficiency is not only smart but also stylish. Sleek contours, rounded edges and smooth textures make for a sophisticated, aerodynamic design that reduces wind resistance and improves energy efficiency.

Fast facts

EVs have access to most of their torque right from a complete stop. Compared to ICE vehicles that need engine revolutions to reach their maximum torque, EVs are significantly more responsive to acceleration.

UNIT 3 Before you drive

Introduction

Whichever vehicle you use, remember: think before you drive. Consider the following tips before you get behind the wheel to help you stay safe, save money, and reduce the environmental impact of your daily transportation.

Consider your transportation needs

The most obvious way to consume less energy is to drive less. When possible, avoid the daily drive to work by busing, carpooling or telecommuting. On short trips, consider walking or biking to your destination. Even on longer excursions, you can dramatically reduce the time you spend on the road by thinking before you drive.

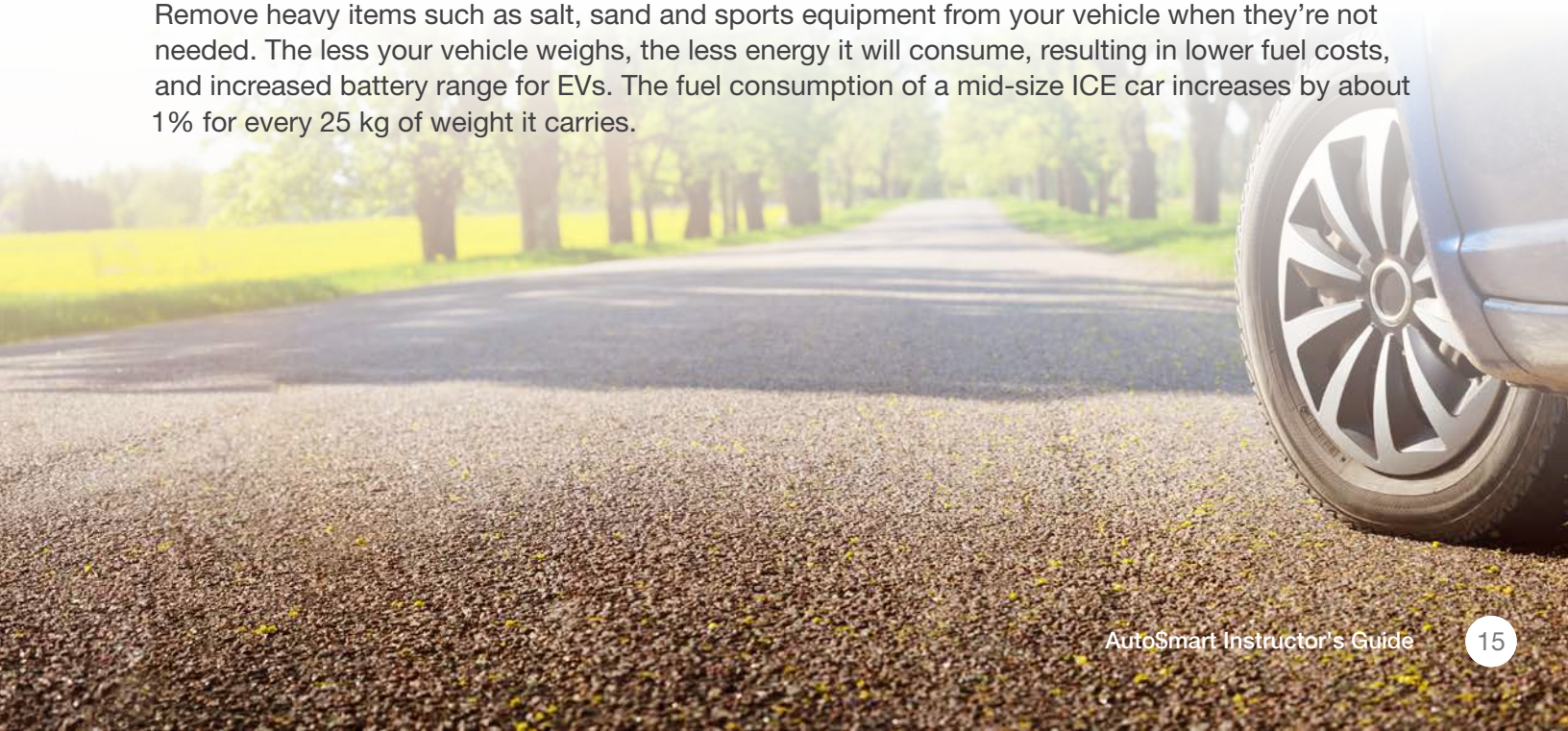
Plan your route

A little travel management can help you realize big energy savings. Combine trips and run several errands one after the other. Separate trips of less than 5 km do not allow a cold ICE to reach its peak operating temperature, resulting in increased fuel consumption and emissions.

Plan your route to avoid stoplights, backtracking, rush-hour traffic and steep hills that require your vehicle's engine to work hard. Listen to traffic reports to steer clear of accidents, road construction and other trouble spots. Give yourself plenty of time to get where you're going.

Lighten your load – take only what you need

Remove heavy items such as salt, sand and sports equipment from your vehicle when they're not needed. The less your vehicle weighs, the less energy it will consume, resulting in lower fuel costs, and increased battery range for EVs. The fuel consumption of a mid-size ICE car increases by about 1% for every 25 kg of weight it carries.



Remove roof or bicycle racks

Streamline your vehicle by taking off the racks when you're not using them. Aerodynamic drag can increase the energy consumption of a vehicle by as much as 20% on the highway.

Consult your owner's manual

It contains important information about how to drive and maintain your vehicle for optimum performance and efficiency.

Follow your vehicle's recommended maintenance schedule

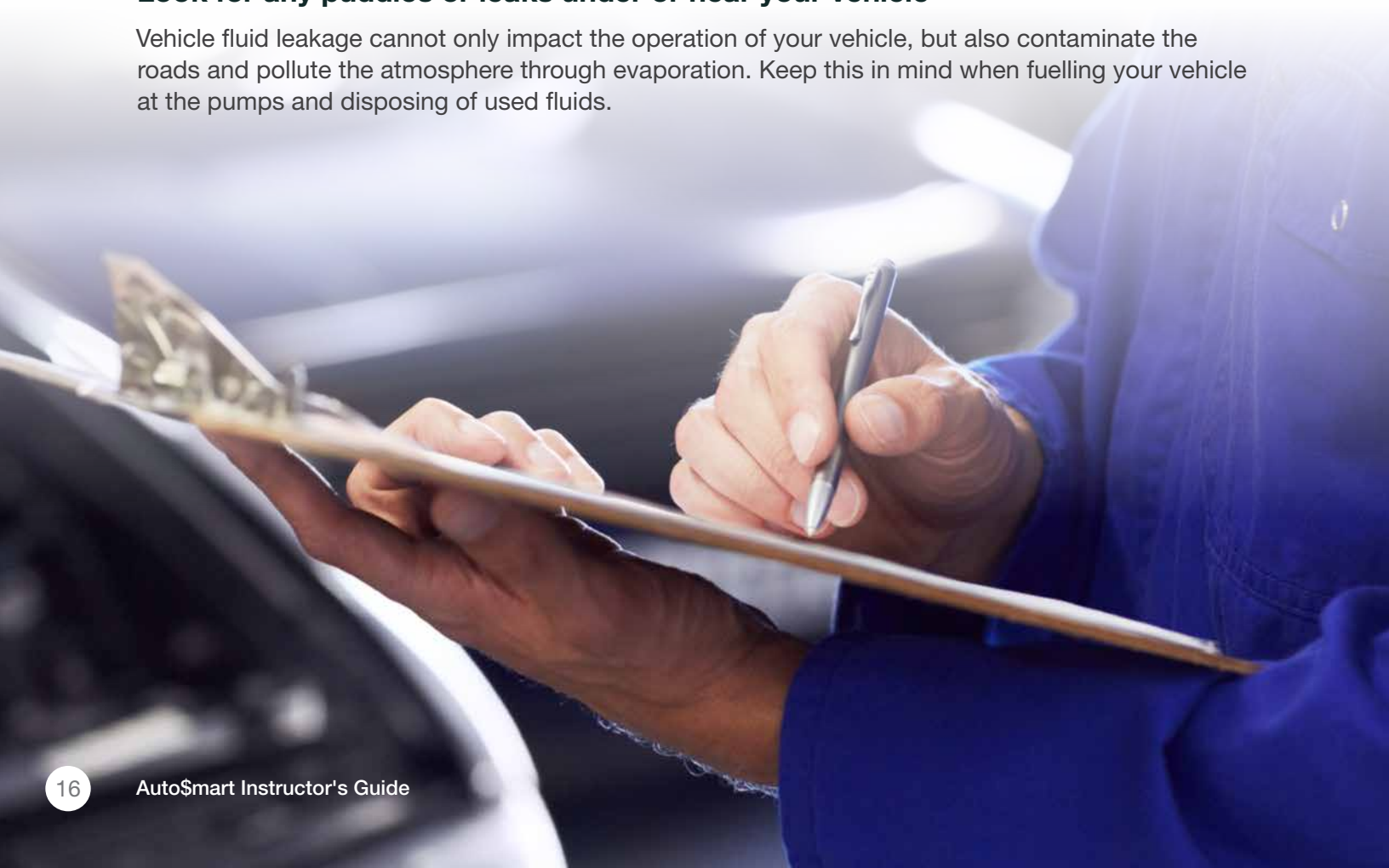
A poorly maintained ICE vehicle may consume more fuel. Poor maintenance adversely affects performance and often leads to expensive repairs and lower resale value. EVs, on the other hand, require no oil changes, exhaust system repairs, or transmission work because of having roughly 90% fewer moving parts under the hood. This translates into less money spent annually on maintenance.

Check your vehicle's fluid levels at least once a month

Check and change the engine oil, engine coolant, automatic transmission and other fluids according to the manufacturer's recommendations in your owner's manual.

Look for any puddles or leaks under or near your vehicle

Vehicle fluid leakage cannot only impact the operation of your vehicle, but also contaminate the roads and pollute the atmosphere through evaporation. Keep this in mind when fuelling your vehicle at the pumps and disposing of used fluids.



UNIT 4 Behind the wheel

Introduction

Your actions behind the wheel can impact your vehicle's energy consumption by as much as 25%. By avoiding aggressive acceleration, keeping your speed down and steady, anticipating traffic and changes in road conditions, and coasting to decelerate, you can save money on fuel and reduce your on-road GHG emissions. Adopting these simple techniques can save the average ICE vehicle driver about $500 in fuel and prevent 1,000 kg of CO_2 from entering the atmosphere each year. Remember – the benefits of driving efficiently apply to all powertrains and vehicle types. Practicing these techniques in your EV can help you get the most out of your battery's range and minimize wear and tear on vehicle components.

Five energy-efficient driving techniques

1 Accelerate gently

Stopped? Get your vehicle going again by pressing the pedal down gently. Take about 5 seconds to accelerate up to 20 km/h. Imagine an egg under your accelerator pedal and an open cup of coffee on your dashboard. Don't break the shell or spill the drink! It's not only safer, but will also save you fuel and money.

2 Maintain a steady speed

Dips in speed, followed by sudden acceleration to speed up or keep pace, take a toll on your fuel consumption or EV battery – and your wallet. Even small fluctuations of 5 km/h can have a considerable impact. To maintain a steady speed and optimize your savings, consider using cruise control for highway driving where conditions permit. You'll reach your destination just as quickly and use less fuel.

3 Anticipate traffic

It pays to be safe – literally. You can lower your fuel costs (not to mention your insurance bills) simply by observing vehicles, pedestrians, and obstacles on the road ahead and around you. Pay particular attention to slow-moving vehicles, children and animals that may dart into traffic, and signs of construction up ahead. Leave plenty of space between your vehicle and the one in front of you, and plan your manoeuvres well in advance to maintain your vehicle's momentum and avoid unnecessary stops. Keeping your eyes and ears peeled will help you conserve fuel by avoiding the need to slam on your brakes and prevent traffic irregularities from becoming traffic emergencies.

4 Avoid high speeds

What's the rush? Most ICE cars, vans, pickup trucks and SUVs operate most efficiently between 50 and 80 km/h. Above this optimal speed zone, vehicles consume increasingly more fuel the faster they go. For example, at 120 km/h, a vehicle uses about 20% more fuel than at 100 km/h. On a 25 km trip, this increase in speed – and fuel consumption – would cut just 2 minutes from your travel time.

5 Coast to decelerate

Next time you need to come to a stop under normal circumstances, take your foot off the accelerator. Unless you're on a downward slope, your vehicle will gradually slow down – saving wear on your brake pads and keeping fuel in your tank and cash in your pocket. Most vehicles today are equipped with fuel-injection systems that automatically shut off the flow of fuel to the engine when you take your foot off the accelerator. So, coast to slow down instead of using your brakes. Avoiding hard braking in an EV will allow the brakes to recapture most of the energy used to slow the vehicle down through a process called regenerative braking, helping you get the most range out of your battery.

More energy-efficient tips

Tip 1 Use a manual transmission properly

Pay attention to the tachometer, which shows engine speed. Use it to know when to shift a manual transmission for the best fuel efficiency. The higher the rpm, the more fuel the engine is burning. So, shift through the lower gears smoothly and quickly, and build up speed in the higher gears.

Tip 2 Use a fuel consumption display

See the impact of the five energy-efficient driving techniques first-hand with the help of a fuel consumption display, a feature now standard on many vehicles. Some newer vehicles come equipped with even more sophisticated displays that analyze speed variations, shift points for manual transmissions, and driving behaviours such as acceleration and braking times.

Many drivers consume 15% less fuel by acting on the feedback that fuel consumption displays provide.

Tip 3 Track your vehicle's fuel consumption

How long can you go without filling your tank? Two weeks? A month? Challenge yourself to refill as seldom as possible, and your monthly costs will come down.

Tip 4 Use air conditioning sparingly

Because of the extra load on the engine, air conditioning can increase a vehicle's fuel consumption by as much as 20%.[5] Open the windows when you're driving in the city and use the flow-through ventilation system with the windows up on the highway.

Driving with open windows at higher speeds creates aerodynamic drag – forcing your vehicle's engine to work harder and burn more fuel.

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[5] R. Farrington and J. Rugh (2000). "Impact of Vehicle Air Conditioning on Fuel Economy, Tailpipe Emissions, and Electric Vehicle Range." NREL Conference Paper

UNIT 5 Winter driving

Introduction

Winter driving conditions can increase energy consumption significantly. A drop in temperature from 24°C to 7°C can increase an ICE vehicle's fuel consumption during city driving by 12 to 28%.[6] Cold, dry winter air is denser than warm, humid summer air, which increases wind resistance. As a result, highway fuel consumption increases by about 1.3%.

Roads are rougher in the winter, with increased asphalt deterioration and a mix of snow, ice, slush, water, salt, gravel and sand. An engine works harder to offset the increased rolling resistance. The snow and ice also increase wheel slippage, which causes higher fuel consumption. Fuel consumption can increase 7 to 35% because of poor road conditions.

A vehicle's electrical load is also normally higher in cold weather because of greater demands from heating, defrosting, headlights, heated seats and mirrors, and other accessories drawing more power from the engine, which increases fuel use.

At -18°C, EV battery range is reduced by an average of 29%. However, losing range in the cold is not exclusive to EVs. At the same temperature, ICE vehicles experience a 19% drop in their range.[7] The benefits of driving an EV in the winter such as nighttime charging, preheat functions, and better or equal traction in snow compared with their ICE equivalents, more than make up for this loss of range.

Energy efficiency in cold weather

Park in warm areas when possible

Whether you drive an ICE vehicle or an EV, try to avoid extreme temperatures when parking. Keeping your vehicle in a garage during the winter will help mitigate cold weather's impact on your fuel consumption and unnecessary wear and tear on vehicle components. In the case of EVs, protecting your vehicle from extreme temperatures can help to optimize your driving range.

Use your EV's pre-timed heating system

Many EVs have programmable pre-timed heating systems that can warm up the vehicle cabin and battery while plugged in to a charger. Warming the vehicle and its components while plugged in at home prior to a trip will prevent you from having to crank up the heat inside the vehicle and can extend your range by 10 to 15%.[8]

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[6] EPA (2006). United States Environmental Protection Agency: *Final Technical Support Document – Fuel Economy Labeling of Motor Vehicle Revisions to Improve Calculation of Fuel Economy Estimates*. December 2006

[7] FleetCarma. Cold Weather Fuel Efficiency – Electric versus gasoline showdown, 16 Jan, 2014.

[8] https://chargedevs.com/features/fleetcarma-digs-deep-into-cold-weather-ev-data/

Use a block heater

Since a warm engine is more efficient than a cold one, using a block heater is a good idea in the winter. Use a block heater with a timer set to turn on 2 hours before you start the engine. A block heater will warm up the coolant, which in turn warms up the engine block and lubricants. The engine will then start more easily and reach its peak operating temperature faster – reducing the duration of high fuel use as the engine warms up.

Don't idle to warm up

Eliminating unnecessary idling is an easy step you can take to reduce fuel use, save money and limit GHG emissions. Turn off your engine when you're stopped for more than 60 seconds, except when in traffic. Ten minutes of idling burns 0.25 to 0.50 litres of fuel and emits 600 to 1,200 grams of CO_2, depending on the vehicle and conditions.[9]

In most cases, you need no more than 60 seconds of idling from a cold start on winter days. Driving at a moderate speed for a few minutes is the most efficient way to warm the engine, drivetrain and the cabin. So, letting your vehicle run for 10 minutes to warm up the cabin is just wasting fuel.

Measure your tire pressure

Tire pressure fluctuates with temperature, decreasing in colder temperatures.[10] Pressure should be measured at least once every month and more often with significant temperature changes to ensure the proper level of inflation. Operating a vehicle with tires under-inflated by 56 kilopascals (8 psi) can reduce the life of the tires by more than 10,000 km and increase fuel consumption by up to 4%.[11]

[9] CAA (2009). Pollution Probe: *Primer on Automobile Fuel Efficiency and Emissions*. June 2009.

[10] http://www.rma.org/tire%5Fsafety/tire%5Fmaintenance%5Fand%5Fsafety/

[11] CAA (2009). Pollution Probe: *Primer on Automobile Fuel Efficiency and Emissions*. June 2009.