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ecoENERGY
an ecoACTION initiative

SMART*DRIVER* FOR SCHOOL BUS

PARTICIPANT'S HANDBOOK

Canada

Acknowledgements

The development of the SMART*DRIVER* for School Bus training program would not have been possible without the assistance of a dedicated committee of volunteers from the school bus community.

The Office of Energy Efficiency of Natural Resources Canada would like to thank the following volunteer organizations for their professional knowledge and commitment to the content of this project:

- Algonquin College, Transportation and Building Trades, Ottawa, ON
- Allison Transmission, Riverview, NB
- Autobus Galland Inc., Laval, QC
- Autobus Laval, Beauport, QC
- Autobus Thomas Inc., Drummondville, QC
- Autobus Transco (1988) Inc., Lasalle, QC
- Cherrey Bus Lines, Drayton, ON
- L.A. Transit, Lethbridge, AB
- Lafleur School Transportation, Clarence Creek, ON
- Laidlaw Education Services, Burlington, ON
- Motor Carrier Passenger Council of Canada, Thornhill, ON
- North Okanagan-Shuswap School District No. 83, Salmon Arm, BC
- Office of Energy Conservation, Regina, SK
- Prairie Spirit School Division, Saskatoon, SK
- Southland Transportation, Calgary, AB
- Stock Transportation, Newmarket, ON

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Welcome to ecoENERGY for Fleets and Smart*Driver* for School Bus

ecoENERGY for Fleets is a program offered by Natural Resources Canada introducing fleets to energy-efficient practices that can reduce fuel consumption and emissions.

SmartDriver is a key component of this program.

Fuel bills represent one of a fleet's largest operating costs – second only to labour – but drivers can help reduce these costs by adopting the energy-efficient driving practices supported by Smart*Driver* training materials.

Energy-efficient habits also help Canadian fleets contribute to a healthier environment. Every litre of diesel fuel that's burned by a bus will generate about 2.8 kilograms of carbon dioxide, the principle greenhouse gas thought to be responsible for global warming and climate change. Teaching drivers how to save fuel will help reduce these emissions.

We recognize that fuel-efficient driving requires a high level of skill, and that school bus drivers face unique challenges. This is why Natural Resources Canada, with the help of volunteers from the school bus community, has developed this special Smart*Driver* for School Bus training program.

This package provides information on fuel efficiency, and suggested lesson plans. The content is relevant to new and experienced drivers, as well as other fleet employees.

The print and audio-visual components of Smart*Driver* for School Bus have been designed to support a comprehensive training strategy to introduce fuel-efficient driving skills to you and your colleagues.

Introduction: Take Care of Your Air

Fuel is one of a school bus fleet's largest operating costs, and the price continues to rise with every passing year. Look no further than your home's heating bills or the signs displayed at your local service station if you need proof.

Obviously it makes good business sense to use as little fuel as possible.

As a professional driver, you are the key to making this happen. Research has shown that a skilled driver can be 35 percent more fuel efficient than a poor driver. It's simply a matter of learning the right skills and adopting the best habits.

The benefits of fuel-efficient driving techniques are not limited to lower fuel bills. These same smart driving habits can help you prevent accidents, reduce job-related stress, and demonstrate that you want to ensure the safety of the children in your care. Meanwhile, vehicle components such as brakes and tires will face less wear and tear.

You will even contribute to a healthy environment.

Health matters

More than three million Canadians cope with serious respiratory diseases such as asthma, bronchitis, and lung cancer. They are more likely to feel the effects of air pollution, including shortness of breath, wheezing, fatigue, and nausea.

To make matters worse, the children that you drive to school are at a higher risk than adults. They breathe in 50 percent more air – and related pollutants -- per kilogram of bodyweight. Exposure to airborne contaminants leave children more susceptible to respiratory diseases and lung cancer when they grow up.

Healthy adults are not immune to the problems, either. They can face breathing problems when exercising outdoors on days marked by smog alerts.

Your actions at the wheel can help protect both children and adults.

Pollution

According to a study by the Ontario Public Health Association, in 2004 Ontario's 15,000 school buses emitted:

- 114 tonnes of particulate matter
- 718 tonnes of hydrocarbons
- 2,601 tonnes of nitrogen oxides (NOx)
- 285 kilotonnes of carbon dioxide (CO_2)

Every bus creates some air pollution, and diesel exhaust contains about 40 toxic air contaminants. But a combination of proper maintenance, reduced idling, and better driving habits can reduce air pollution and GHGs by as much as 10 percent.

By adopting SmartDriving habits, you can help reduce pollutants such as:

Smog

The burning of fossil fuels creates the nitrogen oxides (NOx), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter, and volatile organic compounds (VOCs) that contribute to the yellowish haze coating our cities, leading to health threats ranging from breathing problems to cancer.

Environment Canada suggests that current levels of smog cost our major cities $10 billion in annual health costs and related damage.

Particulate matter

Diesel exhaust contains tiny particles, known as particulate matter, that are small enough to sneak past your body's defenses and lodge in your lungs.

The finest of these particles (with diameters of 2.5 micrometres or less, smaller than 1/7 the diameter of a human hair) pose the greatest threat to human health because they can travel deepest into the lungs. Respirable particulate matter up to four times that size has also been linked to chronic respiratory disease and other health ailments such as cardiovascular disease.

Scientists now believe there is no safe level of exposure to respirable particulate matter, and it has been identified as a toxin under the *Canadian Environmental Protection Act*.

By adopting habits that burn less fuel, you're reducing the release of these toxins into the atmosphere.

Greenhouse gases

Our planet needs some GHGs to capture heat from the sun, much like the way glass retains heat in a greenhouse. Without GHGs, our average temperatures would drop from 15°C to -18°C. However, our growing use of fossil fuels has been overloading the atmosphere. Canada's transportation sector, for example, produces about 177 megatonnes (Mt) of GHGs every year, up from 147 Mt in 1990.

Current projections suggest that these emissions could grow to 197 Mt by 2010 – almost as much as the combined weight of EVERY human on the planet!

At the current rate, scientists project that climate change could cause Canada's annual average temperatures to rise **5 to 10°C by the end of the century** – if we don't do something about it. And the 1980s and 1990s were already the warmest decades on record.

As Canadians, the idea of a warmer climate may not appear to be a bad idea. But changes to the climate can also increase severe weather conditions, such as ice storms, floods, droughts and hurricanes. These would threaten farms, fisheries and our homes. Pests and diseases could migrate north, forests could become more prone to fires, and the quality of our drinking water could drop.

Improving Technology

Today's diesel-powered buses are cleaner than ever, producing 80 percent fewer emissions than those built in the 1970s.

You can thank advancing technology.

Engines built to today's standards tend to incorporate features such as exhaust gas recirculation systems, which inject exhaust gases into the combustion process. This limits the temperatures that can produce nitrogen oxides (NOx). Diesel particulate filters in the exhaust system (mandatory as of 2007) will collect much of the particulate matter that would otherwise be released into the air we breathe.

Studies have shown that bus exhaust can be almost as clean as ambient air when the vehicles use diesel particulate filters on the exhaust system, closed crankcase filtration devices to capture gases that would otherwise escape from the engine, and ultra low sulphur diesel (ULSD).

A report by the Ontario Public Health Association found that by adding diesel particulate filters to 9,000 buses built between 1994 and 2004 and calibrating their engines for lower NOx emissions:

- particulate matter would drop 51 percent
- hydrocarbons would drop 75 percent
- NOx would drop 15 percent

A technology called selective catalytic reduction (SCR), which has been long used to control NOx from stationary sources such as factories, may eventually be used to reduce NOx even more. They inject a chemical known as a reductant (usually urea or ammonia) to convert exhaust gases to nitrogen and oxygen.

Cleaner fuels

The equipment isn't the only thing that's getting cleaner.

On Jan. 1, 2005 the allowable sulphur level in Canadian gasoline was slashed by 90 percent, to 30 parts per million (ppm) or less. Meanwhile, Canada began mandating the use of low-sulphur diesel fuel in 1998 and ULSD

(introduced in 2006) will reduce sulphur levels by another 97 percent.

Why is it important to reduce the amount of sulphur in our fuel? The combustion process can turn sulphur into sulphur dioxide (SO_2), which leads to sulphuric acid that can damage bearings and cylinder liners. In the upper atmosphere it can become sulphur trioxide (SO_3), which contributes to acid rain that can harm lakes and vegetation.

On their own, the tightened gasoline-related standards will reduce 14,000 tonnes of SO2 from Canadian emissions every year. To put that into perspective, that weighs as much as 140 blue whales!

Even if you have access to older fuel, be sure to use ULSD in diesel engines. Higher sulphur levels could "poison" new equipment used to control particulate matter.

The work is just beginning

This is no time to rest. The growing number of vehicles on our roads and highways has outpaced improvements in vehicle designs and fuels.

Canada's demand for transportation-related fuel such as diesel, gasoline, and other fuels is expected to increase by 34 percent between 1990 and 2020. Road vehicles already account for about 70 percent of the energy used for transportation, according to Canada's Emissions Outlook: An Update, based on data from 2000.

Fossil fuels, such as diesel and gasoline, won't last forever. Since they are nonrenewable resources, we need to conserve the fuels that are available, while developing alternative fuel sources at the same time.

The children that you're driving today will depend on it.

As a Smart*Driver, you can play a significant role in reducing the use of these fuels by adopting fuel-efficient driving habits, reducing idling, and keeping a watchful eye on your equipment.*

This will reduce pollution, save your company money, and help extend the life of the vehicles you drive.

Be a Smart*Driver*

One of the most effective fuel-efficient driving techniques involves managing your road speed, since every unnecessary stop or acceleration burns more fuel.

By adopting Smart*Driving* habits, reading the road, and anticipating hazards, you can control the momentum of your vehicle. You won't have to waste your time and fuel rebuilding any lost speed.

There's an added benefit: You will help prevent accidents in spite of the actions of others around you.

What is Smart*Driving*?

Smart*Driving* is a combination of skills and attitudes. As a professional school bus driver, you need to hone a number of skills to make sure that you can safely and efficiently maneuver your vehicle. But you also need a positive attitude.

What's the difference? Attitudes are the strongly held convictions or habits of thinking that lead to fixed reactions. For example, you always need to be aware of your surroundings, to stay calm and alert, and accommodate any conditions that you encounter.

Smart*Drivers share the road with others, and even give a little despite the actions of those around them. These positive attitudes will ensure that you enjoy a healthy and perfect ride, consuming less fuel and arriving safely at your destination.*

Smart*Driving* is a matter of:

- A positive attitude – If you're feeling aggressive, you're much more likely to speed.
- Good driving skills – Fuel-efficient driving techniques should become second nature.
- Being vigilant – You can't be oblivious to the actions of everyone other than the vehicle in front of you. This includes ensuring that the students on

board your bus are properly managed. You're operating a classroom on wheels. Be fair, firm, and consistent when managing your passengers. Don't let them move from their seats when the bus is in motion.

- Good judgement – By reading traffic conditions around you, you will be able to determine the situations in which it's better to give a little.
- Being knowledgeable – Traffic congestion can cause some drivers to become aggressive. If you're aware of details provided by traffic reports, you'll be able to avoid these areas. You can also become frustrated yourself if you miss a turn of your own. This situation can be avoided by studying your routes.
- Being economical and fuel efficient – By driving within the speed limit you will save fuel.
- Good physical and mental health – You need to be calm and alert to be a defensive driver.

Key issues to consider as a Smart*Driver* include:

- Visibility
- Traffic
- Road conditions
- Weather
- Stops and starts
- Progressive shifting

Visibility

Everything from weather conditions to oncoming headlights can affect your visibility, reducing the safe cushion of space around your school bus.

Factors affecting visibility can include:

- the time of day
- weather conditions (including factors such as sunlight, rain, or snow)
- lights on the vehicle ahead of you, including brake lights and taillights.

In terms of your own bus, it's important to ensure that your lights are always clean and properly aimed, that your windshield is free of streaks, and that mirrors are not obscured by ice or snow. Equally, you should always look

through your windshield rather than staring at the surface of the glass – this will extend your view.

If conditions such as bright sunshine or the glare from a snow-covered road make it too bright to see clearly, wear sunglasses and use your vehicle's sun visors. Look above, beyond, and slightly to their right of oncoming headlights and use the markings on the side of the road as your guide.

Keep in mind that poor visibility also calls for reduced road speeds and increased following distances.

Notes

Traffic

The flow of traffic may require you to slow down below the posted speed limit to maintain a safe cushion of space between your vehicle and the vehicle in front of you. If someone cuts in front of you, you may need to slow down even more to reclaim that space.

Other traffic-related tips include:

- Adjust your speed
- Maintain distance
- Four-second rule

The four-second rule

When you're driving a school bus, it's important to maintain a four-second following distance between yourself and the vehicle in front of you. This will leave enough room for other vehicles to flow in and out of traffic without forcing you to apply your brakes and reapply your throttle – actions that waste fuel.

Think of your following distance as being elastic. The faster you travel, the further the space needs to stretch.

You can determine the four-second distance by noting when the back of the vehicle in front of you

passes a fixed marker, such as a utility pole. Simply count the number of seconds before the front of your vehicle reaches the same marker. If it takes less time than four seconds, slow down.

As well, think of your vehicle traveling in a cushion, and be aware of anything happening in that space. Look at least three seconds ahead for every metre of your vehicle's length when traveling on the highway. That means you'll probably be watching more than 30 seconds down the road if you're driving a 78-passenger school bus.

Read the signals

Even drivers who don't use their turn signals will offer you a number of clues about their intentions to turn. They may begin weaving within their lane, begin braking for no apparent reason, or suddenly change speeds. If you encounter these situations, lift your foot off the gas and cover your brake pedal. Your vehicle's momentum will slow down in case you have to stop, reducing the chance of a panic stop. You will also save fuel by ensuring that you don't continue under power until the very last second.

Be aware of blind spots

Keep a close watch on all spaces around your vehicle. This way, traffic won't suddenly appear out of your blind spot. You should know when a vehicle is entering that space to begin with. You'll also want to know that space is clear if you have to change lanes to avoid a mishap. (There's an added benefit to watching your mirrors. This exercises your optic nerve, keeping you alert.)

Don't be aggressive

Try to travel at the same speed as the traffic around you, remaining within the speed limit. But if most vehicles seem to be speeding, stay to the right. By giving way to other vehicles, you will avoid dangerous situations. Remember: you've been entrusted with the safety of the children on your bus. Never chase after a vehicle that has cut you off. By keeping a safe following distance, you will be able to brake easily and effectively, keeping complete control of your vehicle. Another advantage of this cushion of space is that you're less likely to become upset by a small inconvenience caused by another driver, and you won't find driving to be as tiring.

Ask yourself if you really need to pass

It's important to think defensively before you pass any vehicle. Can you legally and safely pass this vehicle? For that matter, is it really necessary, or are you simply feeling frustrated because the vehicle is traveling a little bit slower than the posted speed limit? They may simply be defensive drivers themselves, and aware of a hazard that you can't see.

As you pass a vehicle, you may also hold up traffic behind you, leading other drivers to aggressive actions. Also, you'll be burning an excessive amount of fuel to bring your vehicle up to speed.

If you do decide to pass, fall back so that you can get a clear view of the road ahead of you. Pay attention to any sudden changes by the vehicle you are passing. When the way is clear, and you have carefully checked your mirrors, signal your intention and pull out in a smooth fashion.

If someone is passing you, don't think of it as a competition. You're already winning by remaining calm and burning less fuel.

Don't wait and see

Anticipate the action of vehicles around you.

Don't race for the light

The traffic signal ahead of you may be green, but it's important to know when it might be a stale light. If it's been on for an extended period of time, it may be about to change at any moment. When approaching an intersection, be prepared to yield, no matter what the traffic signal says. Do not rely on other drivers to do the right thing. This means taking your foot off the accelerator and covering the brake pedal with your right foot. But if the lights are yellow or red, come to a complete stop.

Maintain your view…

If you maintain a safe following distance, you're less likely to suffer from tunnel vision, and will have a better view of the vehicles around you. If you have a safe cushion of space, you can also take advantage of your peripheral vision because you won't have to remain so focused on the vehicle that you're following.

… and maintain the views of others.

Do not travel in someone's blind spots. If you can't see the driver through their mirrors, they can't see you. Smart*Driving* techniques are also fuel-efficient driving habits. It's important to accelerate only when coming off the apex of a corner turn. By maintaining the appropriate amount of space in front of you, you can maintain the vehicle's momentum, and not burn additional fuel as you try to accelerate.

Road conditions

Your fleet may have selected routes specifically in the name of fuel economy. Smooth concrete and asphalt surfaces, for example, offer less rolling resistance than unpaved surfaces made of gravel or sand.

Straight routes may also be more fuel efficient than winding roads on which you need to lower your speed at each curve before accelerating on the next straightaway.

A 1997 study found that fuel consumption and emissions can be 25 percent higher along routes that include frequent accelerations, severe traffic congestion, and steep hills that require vehicles to accelerate against the pull of gravity.

Weather

All moving vehicles encounter a certain amount of rolling resistance, so some of your engine's power needs to be used to overcome everything from the grip of your tires to the force of the wind.

Weather can have quite an impact on safe and fuel-efficient driving when it increases this rolling resistance. Your vehicle can consume 15 to 20 percent more fuel when it needs to push

Courtesy of Southland Transportation, Calgary, AB

through heavy snow. Heavy rain can increase fuel consumption by 10 percent. A head wind of as little as eight km/hr can increase aerodynamic drag at highway speeds, causing your engine to work harder and reducing fuel economy by 10 percent. (Cross winds can have the same impact.) It's always important to drive in a manner that's appropriate for the weather conditions – and that can even help you burn less fuel in the process.

- If you're driving through deep snow, be sure to keep your wheels in any existing ruts, rather than plowing your own path
- Take the time to clear your vehicle of any wet snow, which can increase vehicle weight and reduce fuel efficiency. If left on your vehicle, the sheets of snow can also cause a road hazard, falling on vehicles behind you and affecting their visibility
- If you're driving into a strong head wind, reduce your speed by 10 km/hr to avoid wasting fuel
- When parking on ice, try to choose a slope that will allow you to move off in a forward direction. Since your tires will warm during a trip, they can melt holes in the ice when your vehicle comes to a rest. If you are pointing up hill, you may spin your wheels when you attempt to drive away, wasting fuel and time in the process

Stops and starts

Vehicles burn more fuel when they're starting from a dead stop than when they're maintaining a constant speed. As such, fuel-efficient driving involves:

- Maintaining a steady speed
- Maintaining safe following distances to avoid sudden stops
- Avoiding hard accelerations
- Not riding the brakes

This is why it's important to plan your stops.

When approaching a stop light or an exit, gradually ease up on your accelerator and let the rolling resistance of the bus slow you down. (The light may even turn green before your vehicle comes to a rest.) Also, try to anticipate changes in the traffic signals at intersections ahead of you. A stale light that has been green for a while could be ready to turn yellow at any moment.

Keep in mind that riding your brakes can lead to premature component wear and lower fuel economy. It's always better to apply steady pressure prior to a stop.

When you do need to begin moving from a stopped position, avoid jackrabbit starts, quick accelerations from a dead stop that consume about 50 percent more fuel than gradual accelerations. Quick starts also increase the amount of pollution sent into the air because of the inefficient combustion of fuel.

Control your shifts

Even though today's school buses tend to be equipped with automatic transmissions, you still have control over the times when your transmission shifts.

When you push the accelerator to the floor, upshifts will occur at high engine speeds, which are not very fuel efficient. By depressing the pedal partially, the shifts will occur at lower engine speeds.

Watch your turns

Be careful not to miss any turns along your route. City intersections can be spaced 800 metres apart, and that could add just over three km to your route if you miss a turn and have to drive around the block. You don't have to miss too many turns before you will undo the advantages of any other fuel-efficient practices.

Watch your times

If you're running late, you may think about increasing your speed. Think again. Fuel economy decreases about two percent for about every 1.5 km/hr you drive over 85 km/hr.

For that matter, you may simply have to sit and wait if you arrive too far ahead of schedule, and an idling vehicle wastes a lot of fuel.

"Home dispatch"

Many school bus fleets dispatch drivers from their own homes rather than insisting that vehicles be parked in fleet yards. By adopting this practice, fleets can ensure you begin your workday closer to your first stops. You can even cut down on your personal fuel

consumption by eliminating traditional commutes to and from work.

If you are being dispatched from home, it's important to ensure that you keep a close eye on the mechanical state of your vehicle. Make sure that it is subjected to the appropriate number of maintenance intervals.

Also be sure to check that you comply with local zoning bylaws that can restrict on-street parking in your neighbourhood!

Progressive shifting

If your bus is equipped with a manual transmission, the most fuel-efficient way to use it involves progressive shifting.

With progressive shifting, you need to complete shifts as soon as you have enough engine speed to reach the next available gear, rather than letting it rev beyond that point.

While you may think you're reaching road speeds more quickly by revving the engines at a higher number of rpms, each gear produces only a specific amount of speed.

Progressive shifting allows you to steadily move through the gears to reach your ultimate road speed, ensuring that your highest gear produces the most speed for the bus at that point in time.

When starting from a stopped position, use only enough throttle to get the vehicle moving, and increase the application of the throttle with each gear, as it's needed.

As you drive, watch the tachometer or listen to the sounds of the engine. If the rpms suddenly increase, shift to the next gear. If the engine begins to "lug," shift to a lower gear.

Lugging occurs when the engine's speed drops below the current gear's normal operating range. The engine is producing too little power, and is struggling to maintain the speed. Not only does this consume more fuel, but it can damage the drivetrain.

Today's electronic engines lug at about 1,000 rpm. Check your vehicle's owner's manual for information specific to your engine.

Smart*Driver* Physical and Mental State

Your vehicle isn't the only equipment that has to be in good working order. As a Smart*Driver*, it's also important to ensure that you're in the proper physical shape and mental state of mind to follow fuel-efficient driving habits. If you're fatigued, you won't be able to anticipate the actions of others around you.

Smart*Driving* requires mental stamina. Alcohol, prescription drugs, over-the-counter drugs, and even the combination of different types of medication can all affect your reaction time. Even your emotional state can play a role. An aggressive attitude leads to frustration, which compounds aggressive behaviour. Anger, frustration, and worry can all affect your concentration.

You are what you eat

As clichéd as it might sound, you are what you eat, and the quality of your lunch can affect your skills as a driver. What you eat can affect how you feel, how you heal, and how you regenerate tissue, along with your energy levels, weight, and, ultimately, how long you will live.

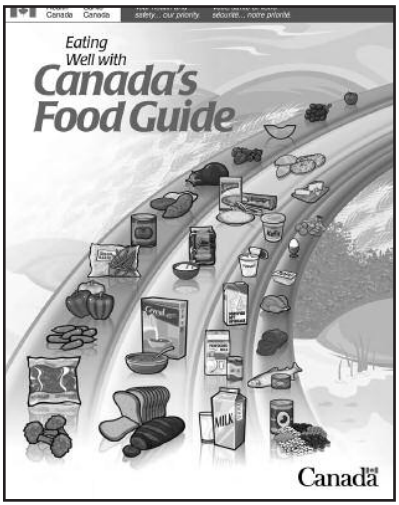
What should you eat?

Eating Well with Canada's Food Guide lists the foods that you should eat during the course of a day.

The Food Guide recommends the following servings per day for adults:

- 7–10 servings of vegetables and fruits, such as half a cup of carrots, a banana or half a cup of juice
- 6–8 servings of grains, such as 30-gram servings of cereal or a slice of bread. Choose whole grains and enriched sources, when possible.
- 2–3 servings of dairy products, such as a cup of milk. Choose lower-fat milk products, when possible.

- 2–3 servings of meat, fish, poultry or alternatives, such as half a cup of cooked or canned beans or one to two eggs. Include dried peas, beans and lentils more often in your diet.



Other dietary points to consider:

- Avoid greasy foods.
- Drink at least eight eight-ounce glasses of water every day. Coffees, teas and colas may give you a short-term buzz, but they are diuretics that will increase kidney activity and could lead to dehydration. This can stress your heart, increase your body temperature and pulse rate, and give you a headache.
- Save some cash. When you buy your lunch, it can be difficult to avoid the foods that are bad for you. By packing a lunch, you will be able to control your eating habits and save money. If you do eat in a restaurant, look for healthy choices on the menu. Leave behind the deep-fried chicken wings.
- Get a regular medical checkup. An annual medical exam will help you to maintain your health. Like a preventive maintenance check for your vehicle, it will alert you to minor issues before they become significant problems. You should consult your doctor before you begin a new exercise regimen.

Exercise

Some people may be surprised to find that professional drivers have a strenuous job, but they do. After sitting for extended periods of time, you might suddenly need to crawl under the bus during the course of a post-trip inspection. These tasks can often cause a shot of pain.

However, by following some simple ergonomic tips and exercises, you can reduce fatigue and prevent painful muscle spasms.

Reach for it

Adjust all your vehicle settings before you begin your trip. This includes moving the seat so that your knees sit slightly higher than your hips to improve circulation and eliminate pressure points in your legs. Ensure that your seat position gives you easy access to various vehicle controls that you will have to reach several times a day. Meanwhile, your head rest should not push your head forward when you're sitting upright. If you have to reach too far for the steering wheel, you'll be straining your upper arms as well as your neck.

Move your wallet

Don't keep a wallet in your hip pocket. This will apply pressure to the nerves in your legs. Use the arm rests on long trips.

Move it

Change your posture frequently to increase circulation and prevent fatigue.

Follow the three-point rule

Ensure that you have one hand and two feet, or two hands and one foot, in contact with the bus whenever getting in or out. Don't simply jump out the door. This sudden stress can be particularly damaging after you've been sitting for a long time.

Take a stretch break

If you're feeling tired, take the time to stretch your muscles. These exercises suggested by the Government of Alberta's Personnel Administration Office include:

1. ***Neck and shoulder stretch***
   Tuck your chin in to your chest. Move your left ear to your left shoulder while using your left hand to pull your right arm down and behind your back. Repeat on the other side.

2. Finger flex and stretch
Make a fist and squeeze it. Hold it for 10 seconds. Spread out your fingers and hold that position for another 10 seconds. Repeat this exercise three times on both hands.

3. The shoulder shrug
Raise the top of your shoulders toward your ears until you feel a slight tension in your neck and shoulders. Hold this position for three to five seconds and relax. Repeat this two to three times.

4. Wrist rotation
Rotate your wrists in both directions, repeating the stretch twice for each hand.

5. Middle/upper back stretch
Hold your right arm with your left hand just above the elbow. Gently push your elbow toward your left shoulder. Hold the position for five seconds and repeat this with your left arm.

6. Ankle turn
Sit down facing forward, knees bent, with your feet flat on the floor. Straighten one leg and lift your foot a few inches off the floor. Rotate your ankle in both directions. Repeat this with your other leg.

These simple stretches can ease tension and prevent fatigue.

A regular exercise program can also help strengthen the muscles that support your posture and can help battle fatigue. Be sure to see your doctor before starting any vigorous exercise.

The effects of fatigue

It's important to be alert when you're on the job, to ensure the children in your care remain safe, and help you maintain the many fuel-efficient driving practices that you'll learn in this course.

Characteristics of fatigue include:

- Decreased alertness
- Drowsiness
- Micro-sleeps (drifting in and out of sleep)
- Impaired judgement
- Shorter attention span
- Irritability
- Loss of motivation
- Visual distortion
- Impaired memory
- Loss of concentration

These can be caused by a number of factors:

- Work or rest schedule
- Time of day
- Type of work
- Weather
- Traffic conditions
- Physical environment
- Body clock
- Quantity of sleep
- Quality of sleep
- Sleep disorders
- Physical fitness
- Emotional state
- Diet
- Family factors

Most adults require seven to eight hours of quality sleep every day. If you don't get enough sleep, you will accumulate a sleep debt. The only way you can make up the difference is to sleep.

Sleep disorders

If your sleep is interrupted frequently throughout the course of the night, you may be suffering from a sleep disorder such as sleep apnea, a condition that is common among people who snore loudly and those who are overweight.

Symptoms of sleep apnea include:

- Loud, disruptive snoring
- Waking with gasping or choking
- Non-refreshing sleep
- Morning headache
- Excessive daytime sleepiness or fatigue
- Poor memory
- Clouded intellect
- Irritability
- Decreased sex drive and impotence

However, there are several tips to ensure that you get a good night sleep.

1. ***Avoid caffeine and alcohol before going to bed.***
   Coffee isn't the only source of caffeine. You may also want to control your intake of chocolates and colas. A small amount of caffeine early in the day can keep some people from falling asleep as many as 12 hours later. And while alcohol may help you fall asleep, it will increase the number of times you wake up in the latter half of the night. In fact, too much of any beverage will cause you to wake up to urinate.

2. ***Heartburn can make it difficult to fall asleep, or can wake you up in the middle of the night.***
Avoid eating large meals just before bedtime, or tomato-based products and spicy foods that can lead to heartburn.

3. ***Avoid cigarettes at bedtime.***
Nicotine is a stimulant.

4. ***Control the temperatures.***
Your bedroom thermostat should be set below 21 degrees Celsius.

5. ***Sleep in a dark room with few distractions.***
Granted, some noises may be outside your control. You may live near a fire station, or a neighbour with a barking dog. Other solutions include using ear plugs or creating white noise with something like a fan or relaxing music. You may even be able to muffle some of the noise with heavy curtains or double-paned windows.

6. ***Wind down.***
Read to take your mind off a stressful day or take a warm bath.

7. ***Get up.***
If you're unable to sleep, step away and listen to some soothing music.

8. ***Involve your family in your sleep strategy.***

The Smart*Driver* state of mind

Ultimately, the key to being a Smart*Driver is to be open to change. Always look for every opportunity to improve your skills, your habits, and your attitudes. Learning is a life-long experience – as is the potential for a career at the wheel. You're taking an important step by taking this course.*

Vehicle Factors that Affect Fuel Efficiency

Internal combustion engines

As its name might suggest, an internal combustion engine uses the power of combustion to release the energy that is stored in fuel. This explosive energy is used to produce hot gases that can move engine pistons, creating the mechanical motion that is transferred to vehicle wheels.

Unfortunately, by the time it reaches the wheels, the mechanical energy can account for less than 25 percent of the chemical energy originally stored in the fuel – and that's under ideal conditions. Some of the energy is wasted by such things as the need to overcome the friction between moving parts.

Poor maintenance practices, increased rolling resistance, improper combustion and poor driving habits can all lead to further losses, leaving you with an inefficient vehicle that's quite costly to operate.

School bus fleets can consume less fuel and lower operating costs by choosing fuel-efficient equipment, selecting the best fuels, and adopting the best driving techniques.

How gasoline engines work

If you look under the hood of your family car, you'll likely find a gasoline engine. But did you ever wonder how it turns burning fuel into motion?

Gasoline and oxygen are mixed and compressed inside each of the engine's cylinders, where the mixture is ignited by a spark generated by the spark plug. The resulting combustion creates the hot gases used to move the piston found inside the cylinder. The motion of a connecting rod attached to the bottom of the moving piston then turns the engine's crankshaft, like you would turn the hand crank on the side of a Jack-in-the-box. A series of gears in the transmission transmit this power and torque

(a measurement of twisting force) to the differential, which delivers the power and torque to turn your vehicle's wheels.

However, gasoline engines don't tend to be sufficient for moving heavy loads, such as buses full of children.

How diesel engines work

Heavier jobs are usually left to diesel engines, which use pressure to ignite their fuel.

First, a supply of intake air is drawn into the cylinders, where the air is heated by the compressing action of a moving piston that's found inside. Diesel fuel is injected above the rising piston, just before the higher temperature and pressure cause the fuel to ignite. The resulting combustion creates the hot gases that push down the piston, which moves a connecting rod. The old gases are expelled, and the process is repeated.

Smaller diesel engines, such as the one that may be in your school bus, often rely on glow plugs or intake heaters to preheat the supply of intake air. These electric coils can be found in the combustion chamber or the air intake passageway can heat up to more than 1,000 degrees Celsius!

Most bus fleets prefer to use diesel engines for some obvious reasons:

- They can extract a little more energy from their fuel.
- They generate the power and torque needed to move something as heavy as a bus.
- Diesel tends to be less expensive than gasoline.
- They can last three to four times longer than gasoline-powered designs because they're built to withstand higher pressures and enjoy the lubricating properties of the diesel fuel itself.

Unfortunately, the benefits of diesel engines come at the cost of increased emissions.

Since diesel is a middle distillate (meaning that it's drawn out midway through the process that transforms crude oil into useable fuels), it generates more GHGs when it's burned. Every time we burn a litre of diesel fuel, 2.8 kg of GHGs are released into the atmosphere, along with several other gases and tiny particles known as particulate matter.

Even though a litre of diesel weighs less than a kilogram,

it combines with the oxygen in the air that makes combustion possible – and even the oxygen weighs something.

In comparison, 2.5 kg of GHGs are released when we burn a litre of gasoline.

These are not the only ways that fuels can differ.

Fuel quality

If you've ever built a campfire or lit a woodstove, you'll know that some woods will burn longer and hotter than others. Hardwoods, like oak, can burn for hours at a time. A softwood like pine may provide a quick, hot flame, but it will quickly turn to ash.

There can even be differences in diesel fuels.

Cetane number

A diesel fuel's cetane number (usually ranging from 40 to 60) indicates how easily the fuel will self-ignite when exposed to a cylinder's hot, compressed air. The higher the cetane number, the more easily the fuel will ignite.

If the cetane number is too low, you may have trouble starting the engine. And once the engine starts, it may make a knocking sound and spew white smoke from the exhaust system.

(Knocking is heard if the fuel explodes at the wrong point in the cylinder. This problem can reduce the fuel efficiency of your bus and can destroy the engine.)

Summer versus winter

Diesel fuel can also be created for specific seasons. Summer diesel can be three percent more fuel efficient than its winter counterpart. But below zero degrees Celsius, a wax in this summer diesel begins to form crystals. This gelling can block fuel filters, making it difficult or impossible to start an engine in colder weather. Additives in winter diesel ensure that this "waxing" or "gelling" doesn't occur. (At least it won't form until it's much colder.) But the blend of fuel also holds less energy. Winter diesel holds about 40,680 BTUs of energy per litre, and summer diesel holds 42,000 BTUs per litre.

A British thermal unit (BTU) is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.

Premium diesel

If a fuel is known as "premium diesel," refiners have improved its typical properties, raising the cetane number. This is done by adding lubricants to extend the life of the engine's fuel pump, introducing detergents to clean injectors, or increasing the value of the heat that the fuel will produce.

Sulphur levels

In the fall of 2006, the amount of sulphur in on-road diesel fuel sold in Canada dropped to a maximum of 15 ppm from the previously allowable limit of 500 ppm.

In addition to helping reduce the pollutants that can damage engine components and lead to acid rain, ULSD will help maintain the next generation of pollution control equipment being designed to trap some of the tiny particles that would otherwise be released into the air we breathe.

New regulations that govern diesel engines built for and after the 2007 model year will pay particular attention to this particulate matter.

When fueling your bus with diesel:

1. Secure your vehicle. Put your transmission in neutral, secure the parking brake, turn off the headlights, and shut down the engine.
2. Remove the cap from the tank and place the fuel nozzle in the spout, setting it on the first catch (the low setting).
3. Ensure that you are using the correct fuel (i.e., diesel instead of gasoline). Turn on the diesel pump.
4. When the nozzle clicks off, gently remove it from the spout, being careful to prevent spills.
5. Shut down the pump and replace the nozzle. Be sure to replace the cap on your fuel tank.
6. Record the kilometres you have driven and the volume of fuel you required. This will be the key to tracking improvements or losses in fuel economy.

***NEVER** smoke or leave a vehicle unattended while fueling a vehicle.*

Alternative Fuels

Other fuels may offer environmentally friendly alternatives to gasoline or diesel, as long as the following advantages and disadvantages are carefully considered:

- School buses may need to be modified to use the fuels
- New equipment may require specialized maintenance procedures
- Additional fuel tanks may increase the vehicle's weight
- Alternative fuels may not offer enough power for a particular task
- Many equipment designs aren't available in popular vehicle sizes
- Locating refueling stations may be difficult.

The following are some of the commercially available alternative fuels that have been used in school buses:

Biodiesel

Biodiesel is produced through a chemical process using vegetable oil, waste frying oil, animal fats, or tall oil (from the processing of pulp and paper). The resulting sulphur-free and oxygen-rich mixture can be blended with petroleum-based diesel.

The B-20 form of the blended fuel, of which 20 percent is biodiesel, can emit 12 to 18 percent fewer emissions than traditional diesel. The exhaust will also contain fewer pollutants such as carbon monoxide and particulate matter. (It can even smell like popcorn or French fries!)

Still, the amount of biodiesel in the final mixture has to be limited because it is thicker than traditional diesel and it doesn't flow as easily in low temperatures.

Ethanol

Ethanol is an alcohol produced by fermenting sugar or a converted starch found in something like corn or wheat. Fuel ethanol – sometimes known as "gasohol" – is distilled and dehydrated to create a high-octane alcohol that can be blended with gasoline.

The most common form of the blended fuel is known as E-10, which indicates 10 percent of the mixture is ethanol. It can be used in traditional gasoline engines.

Higher percentages of ethanol are available, but they're used to power modified equipment. Some manufacturers of this modified equipment include enlarged fuel tanks because ethanol contains less energy than gasoline. Also, special fuel rails can be made from polymers that won't swell or crack when exposed to the high alcohol content.

Regardless, at least 15 percent of the final blend needs to include gasoline to ensure that vehicles can start at lower temperatures, and the federal government is committed to running a growing share of its fleet on this ethanol-rich E-85 fuel.

Natural gas

Canada is one of the largest producers of natural gas in the world. Natural gas can be a viable choice for fleets that make short and frequent trips, such as school buses.

Vehicles equipped to run on natural gas draw their fuel from compressed gas cylinders that are large enough to hold the equivalent of 11 to 44 litres of a liquid fuel. Gasoline engines can run exclusively on natural gas, or be modified to run on gasoline when the supply of natural gas is depleted. But in diesel-type engines, a small amount of diesel is still needed to ignite the gas in a modified diesel engine.

These engines produce 75 to 90 percent less soot than their diesel counterparts. (Although the next generation of diesel engines with particulate traps is expected to match the lower levels of soot that are generated by natural gas engines without pollution controls.)

While natural gas buses will emit higher levels of formaldehyde, this pollutant can be controlled by devices known as an exhaust catalyst.

If you drive a natural gas vehicle, however, it's important to allow the engine to warm up before beginning your trip to ensure that engine parts are properly lubricated. You should also note that the engines tend to provide less power than models that run on traditional fuels. This can affect your speed while passing.

Hydrogen compressed natural gas (Hythane®)

Hydrogen compressed natural gas, often known by the brand name Hythane®, is a blend of compressed natural gas (CNG) and hydrogen. Tests have shown that a mixture of 20 percent hydrogen and 80 percent CNG can help reduce NOx emissions from 30 to 50 percent without affecting the performance of a traditional natural gas engine.

The Cummins Engine Company worked with Westport Innovations of Vancouver and California's SunLine Transit Agency in 2003 to develop a bus capable of running on hydrogen CNG. Compared to a diesel engine built in 2002, it would produce 65 percent less NOx, 80 percent less particulate matter, and reduce GHG emissions by 10 tonnes per year.

Propane (liquified petroleum gas)

Propane is pressurized, stored as a liquid, and burned as a gas. It also has a higher octane rating than gasoline (about 104), and creates fewer carbon deposits when it's burned.

The various sizes of tanks used to store this fuel can be mounted under your bus, and can be smaller than those used to store natural gas.

Still, propane-powered buses have faced problems in extreme weather conditions. Vaporizers (can-shaped devices that are usually mounted on the right side of the engine) can fill with condensation and prevent an engine from starting. If it freezes, you may need to thaw the device with hot water.

Fuel gauges on these buses will also indicate only "full" or "empty", so you'll need to closely track your mileage to ensure you don't travel beyond the maximum number of kilometers.

Fuel cells

Fuel cells are electrochemical units that convert oxygen and hydrogen into electricity, producing heat and water vapour in the process. Until your local fueling stations have pumps that sell hydrogen, vehicle manufacturers are working to produce devices known as reformers that can be used to extract hydrogen from fuels such as natural gas and methanol, or even gasoline and diesel.

One of the first commercial examples of a vehicle powered by a fuel cell was a bus built by B.C.-based Ballard Power Systems.

Fuel cells have also been used to build auxiliary power units for vehicles, powering such things as climate control systems (heaters and air conditioners), stereos, computers, and microwaves. Fuel cells could be used to encourage less idling.

Hybrid electric vehicles (HEV)

Hybrid vehicles feature two or more sources of power, combining the benefits of each of them. You're probably most familiar with the automotive versions that incorporate a gasoline-powered engine and an electric motor powered by a battery pack.

Diesel hybrid electric vehicles (HEV) combine a diesel engine with one or more electric motors. Designs that run "in series" use electric motors to provide traction and a diesel engine to power the electric motors. Designs that run "in parallel" use a diesel engine to power the drive train and generate electricity for the electric motors.

Parallel hybrid vehicles will actually turn off their diesel engines when less power is required (e.g., in stop-and-go traffic). Series designs, meanwhile, allow equipment buyers to choose diesel engines that are smaller than would otherwise be required.

HEVs usually incorporate on-board batteries and regenerative braking capabilities that can capture energy produced when the vehicle's brakes are used.

Fuel facts

The energy in a litre of gasoline can be matched by consuming:

- 1.36 litres of propane
- 1.39 litres of E-85 (85 percent ethanol, 15 percent gasoline)
- 1.76 litres of M-85 (80 percent methane, 15 percent gasoline)
- 0.80 litres of diesel
- 0.66 kg of compressed natural gas
- 2.00 kwh of electricity

Source: Alternative Fuels Market Research Study, Transport Canada

Vehicle Components and Fuel Economy

Buses need to use the energy in their fuel to perform a number of jobs, from accelerating, to pushing through the air, and overcoming the friction associated with everything from tires to engine components and the weight of your passengers.

Unfortunately, less than 25 percent of the fuel's energy is actually used to move a bus and control devices such as power steering.

The rest is wasted. Consider this:

- 66.6 percent of fuel is consumed in engine losses (such as friction between components, pumping fluids, and generating heat)
- seven percent is used for auxiliary devices such as hydraulic pumps and the alternator
- just under three percent is wasted through driveline losses

(*Source:* Technology Roadmap for the 21st Century Truck Program)

That leaves less than 15 percent of the fuel's energy to overcome aerodynamic drag, and nine percent to overcome rolling resistance.

Vehicles that are too large or over-powered for their tasks will burn more fuel, produce more exhaust emissions, increase aerodynamic drag, and generate the excessive GHGs that contribute to climate change.

This is why it's important to choose fuel-efficient vehicles. Lighter buses, for example, can help reduce the energy that's lost while accelerating, and modern tire designs can reduce rolling resistance.

A bigger engine may not be worth its cost. A high-horsepower design may cost $5,000 to $10,000 more than its smaller counterpart, and the related expenses don't end there. Typically, the larger engines will burn more fuel and need to be matched to a heavy-duty drivetrain and stronger suspension.

Choosing components

The streets that you drive can be a key factor in your fleet's choice of a bus. When some of your route involves a grade of more than five percent, for example, gradeability will be particularly important. (This is a measure of your vehicle's ability to idle up a hill when you release the brake.)

When stopped on a grade in a vehicle equipped with a diesel engine, you should be able to move forward simply by releasing the brake, without applying the throttle.

Since a bus makes several starts and stops throughout the day, its "startability" ensures it can easily get moving in the first place.

Transmissions

To understand the role of a transmission, you need to consider the difference between horsepower and torque.

An engine's horsepower will provide you with speed as you travel and will also provide you with the ability to accelerate through traffic. Torque, however, is the twisting force that will help move your bus full of children in the first place.

With enough horsepower at its disposal, a transmission can convert an engine's power into more speed and low levels of torque to the wheels, or provide more torque during lower speeds at the expense of highway speeds. It's always a matter of a trade-off.

Overdrive

A transmission's overdrive feature will help you improve your bus's fuel economy.

When the overdrive feature is used, the transmission's output shaft can spin completely around with a partial rotation of the engine. This allows the bus to move at highway speeds while the engine runs more slowly.

Differentials

The differential is responsible for transferring all this power to the wheels. Several related component packages are usually available, based on an engine's horsepower rating, vehicle weight, and the desired speed.

Tires

The use of smaller tires can help reduce a bus' aerodynamic drag by allowing it to sit closer to the road. But it's always a matter of trade-offs. The smaller tires, for example, can cause a rougher ride on rural roads.

If the size of your tires is changed, and the engine's computer isn't reprogrammed to take this difference into account, your fleet may not get an accurate reading of fuel consumption.

Notes

Turbochargers

Turbochargers are designed to force additional air into your engine, and can increase horsepower or reduce the consumption of fuel by supplying more oxygen to the combustion process.

(The improved combustion has also helped ensure newer diesel engines don't belch black smoke when driving up hills or when they begin to move after a dead stop.)

A turbocharger pulls exhaust gases through fast-spinning turbines that also drive an intake blower used to force air into the engine. In fact, they turn so fast – from 10,000 to 200,000 rpm – that they can't use bearings. Instead, the shaft connecting the turbine and blower floats in oil delivered by the engine's oil pump. The resulting zero-gravity effect allows them to turn with ease.

Unfortunately, they turn so fast that the air can heat up and lose the oxygen that helps fuel burn more effectively. But air-to-air aftercooling systems can cool the air before it enters the engine, ensuring a better supply of oxygen that will allow the fuel to burn more efficiently.

Cruise control

A vehicle's cruise control can help you improve fuel economy – and avoid speeding tickets in the process. On larger engines, the control can offer you extra power when going up hills because it

controls the air and fuel going to the engine.

Granted, school buses need to make many stops and starts throughout the day, picking up students every three to four minutes, but rural bus routes or chartered trips may offer opportunities to apply the cruise control.

Economy mode

This is a switch on the dash that can be activated to control the shift timing. Automatic transmission will shift earlier in order to keep engine rpm down and possibly increase fuel economy when the switch is activated.

Engine retarders

Brakes aren't the only tools that can be used to slow a bus down. Engine retarders use the compression of the engine for their stopping force, while other forms of retarders can be found on the transmission or at the flywheel.

Compression brakes that use exhaust gases are not always appropriate in urban areas that are often governed by noise bylaws. These communities will often have signs that ban "Jake Brakes" (referring to a brand name used by Jacobs Vehicle Systems), which applies to any retarder that emits a similar sound known as a bark.

When traveling on level ground, it's better to slow the vehicle by releasing your throttle sooner, rather than using an engine retarder, which will simply require you to apply more throttle to make up for the lost speed.

Under the right circumstances, such as when a bus is traveling down a steep grade, the retarders can improve fuel efficiency by slowing the vehicle and restricting the supply of fuel to the engine. But when you don't need the device, be sure to turn off the master switch. Otherwise, it will activate the moment you release the clutch and throttle.

When a compression brake is activated, it:

- Cuts fuel to the engine
- Reverses the cycle of the exhaust valves, and instead of letting them open, keeps them closed to build compression within the cylinder
- Once the piston reaches the top of the cylinder, the exhaust valve opens and releases the compressed air. This action turns the engine into a compressor that slows the vehicle.

Unfortunately, the compression released through the exhaust valves also makes a great deal of noise, a staccato burst that's known as a bark.

Notes

Transmission retarders

Transmission retarders use torque converters to slow vehicles down.

Unlike engine brakes, they don't make any noise when they're used, but they can overheat the transmission if the vehicle is heavily loaded or descending a steep grade.

Driveline retarders

Meanwhile, driveline retarders will often use magnets to slow the rotation of your driveshaft.

The magnets in these devices are mounted on the driveshaft and frame, and can be activated with a master switch or a hand-operated lever known as a wand. When you apply the retarder, it reverses the polarity of the magnets to slow the rotation of the drive shaft.

The amount the vehicle will slow down depends on the amount of time that the wand is activated, and when it's released. Most of these devices will shut off once you depress the clutch or throttle, but will reactivate once you release either of them.

Driveline retarders can overheat when used for extended periods of time, but you can often adjust the settings to ensure that they're not applied to maximum all the time.

Courtesy of North Okanagan-Shuswap School District No. 83, Salmon Arm, BC

Preventive Maintenance

Pre-trip inspections

Inspecting your school bus on a regular basis is an important matter of safety and fuel-efficiency.

Pre-trip inspections, which are required by law, enable you to identify equipment-related problems before they cause a breakdown or reduce your vehicle's performance.

En-route inspections should also be conducted when your bus is parked for an extended period of time, such as when you're waiting for children to return from a field trip. Walk around the bus, keep a close eye on tire condition, and watch for fluid leaks.

Courtesy of Lethbridge Transit

If you have noticed any unusual noises, or changes in the way the bus is driving, try to determine the cause and be sure to make note and advise your supervisor.

You should also note that some companies will also require you to perform post-trip inspections.

Regular pretrip, enroute, and post-trip vehicle inspections help to ensure safe operating conditions and identify minor equipment problems before they lead to costly breakdowns.

(A vehicle may not burn fuel when it's broken down at the side of the road, but your passengers will hardly appreciate being stranded!)

Smart*Drivers* need to check the condition of their vehicles on a regular basis, advise fleet managers of any problems, and record defects that develop over the course of their shift. If such damage isn't

documented, the negligence could even be the foundation of civil action in the event of an accident.

There are other benefits to sound maintenance practices. A well-tuned vehicle not only reduces the amount of fuel that you use, but it also reduces air pollution.

There are several aspects of a preventive maintenance inspection that can have a significant impact on fuel economy.

Fluids

Oil is used to cool your engine, wash components with detergents, dampen vibration, and reduce wear. It's important to note that extreme temperatures can require more frequent oil drain intervals.

If you need to top up oil, look for "energy conserving" designations that can lower fuel consumption by 2.7 percent or more, and use the lowest recommended multigrade formula to improve starts at low temperatures.

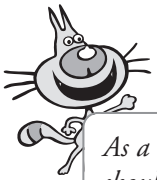
Notes

Filters

It's important to ensure that all filters are changed on schedule.

A blocked fuel filter, for example, could fail to catch the contaminants that can clog injectors and affect the even spray of fuel that ensures efficient combustion. Dirty air can lead to boost-related problems with the turbocharger and air-to-air aftercooling system.

Clogged air filters, meanwhile, can reduce fuel mileage by as much as 10 percent, since a diesel engine needs 15 to 20 times more air than fuel to ensure proper combustion.



As a Smart*Driver, you should also look for damage to any of the hoses that feed the air cleaner and ensure that all of their connections are secure.*

Tires

Even though a tire is lined with a mesh of steel belts and strong rubber, it's the air inside it that actually supports the weight of your bus – and you lose a little bit of that air every day.

Tires will typically lose about two psi of their air every month, and even more air can escape if the tire hasn't been properly mounted. So it's important to keep an eye on inflation pressures.

A 20 psi drop in air pressure can lead to a two-and-a-half percent drop in fuel economy, shortening the life of your tires in the process. A tire that has been underinflated by as little as 10 percent can see the life of its tread drop 9 to 16 percent because of things such as the heat created by the flexing of a sidewall, called deflection. (If you bend a paperclip back and forth, you'll notice that it generates heat in the same way.)

The only tool that can accurately measure tire air pressure is a calibrated air gauge. Without an air gauge, you won't be able to identify the minor changes in air pressure that can make a major difference.

Air pressure should be checked when the tires are cold, since air expands as it warms up. Loads, speeds, and ambient temperatures can all heat up a tire. After traveling 20 minutes at highway speeds on a summer day, for example, a tire inflated to 100 psi can read 115 to 120 psi. This is why the equipment should be allowed to sit for several hours before you take a reading. Tire pressure readings should be taken before you pick up your first student of the day, at least once a week. However, tire inspections should not end with the use of the pressure gauge.

Tires also need to be inspected for missing valve caps, bulges, cuts, or flat spots that can lead to the loss of air. Make sure that each tire on a dual wheel assembly is the same type and size, and inflated to the same pressure. Pay particular attention to damage to sidewalls that may have been caused by scrubbing against curbs.

The tread of a tire should wear evenly across the surface of the tire. Signs of excessive wear on one side of the tire could be a sign of an alignment problem. A misaligned vehicle can lower fuel economy by one to two percent.

The uneven wear could also be a sign of a dragging brake or aggressive driving practices. These can also decrease your fuel efficiency.

If your bus fleet uses retreaded tires, they should only be used on the rear wheels.

Engine accessories

As much as 18 percent of a bus engine's power can be used to power everything from compressors to fans, so it's important to ensure these accessories are in proper working order. Part of that can involve checking belts, to ensure they are not damaged or stretched.

Fans that idle at a reduced speed or shut off until they are required can improve your fuel economy by one-and-a-half to five percent compared with fans that are on all the time. But they're only effective if they're maintained. A cooling fan can draw as much as 50 hp, and the energy may be wasted if the fan's clutch isn't disengaging the device when it's not needed. (The excessive running time can also lead to premature fan clutch failures.)

Air conditioning

A properly functioning air conditioning system can sometimes increase the fuel efficiency of a moving bus, even though it draws power from a running engine.

If you choose to drive with all the windows rolled down on an extremely hot day, the flow of air may actually turn your bus into a giant parachute, forcing the engine to burn extra fuel to maintain your road speed.

Keep in mind that the air conditioning system needs to be working effectively to make a difference. Signs of trouble can include:

- a fan or blower that is louder than usual
- the frequent engaging and disengaging of the compressor that can be spotted with a surge or drop in engine rpms
- or higher engine temperatures that occur whenever the system is activated

Still, it's important to use the air conditioner as little as possible. Consider adjusting vents to allow fresh air to flow into your vehicle, or opening the windows when the vehicle is shut down and parked.

Engine Starting Techniques

Engines face more wear and tear in the first three minutes after a cold start than they will face during the remainder of the day. That's why proper starting techniques are particularly important to the life of your engine.

When preparing to start your bus, ensure coolant and oil levels are topped up, apply the parking brake, unplug the block heater, and turn the key.

Newer engines with electronic fuel injection systems deliver a preset amount of fuel, so the accelerator does not need to be depressed during starting. The engine computer will control the throttle, using sensors to measure when the engine has warmed up to the appropriate level.

(If your bus is equipped with a carbureted engine, you may have to depress the accelerator once before starting.)

If the engine does not start within 15 seconds, allow the starter to cool off for two minutes before trying again. Excessive cranking can damage the engine, solenoid, and starter.

Once they're started, engines should not be allowed to idle for more than a minute, even in cold temperatures, to ensure the turbocharger is properly lubricated. Then you should slowly drive away as soon as practical – setting the bus in motion without applying the throttle – warming up the transmission, rear end, and tires as you go.

Glow plugs and intake heaters

The diesel engine in your school bus may need glow plugs or intake heaters (electric coils found in the combustion chamber or the air intake passageway) to preheat the supply of charge air that's used during the combustion process.

When activated by pre-programmed timers, an electrical current will quickly heat these

coils to more than 1,000 degrees Celsius, depending on the temperature of the ambient air.

Before attempting to start the engine, you must allow the glow plugs or intake heaters to complete three full cycles. Typically, you will want to wait for the orange "wait to start" light to extinguish. (The "wait to start" light could be a manufacturer-specific label, so be sure to consult your vehicle's operating manual to determine the kind of indicator that will guide you during cold-weather starts.)

Ether

Ether is sometimes used to help start diesel engines in extremely low temperatures (particularly in older engines), because it is very flammable and has a low flash-point, but it should only be used sparingly, if ever at all.

When it's used, the vapours are introduced into the engine when a piston is dropping in its cylinder. But ether can also cause cylinder walls to dry out and engine oil to dissipate. The result leaves the metal of the piston to rub directly against the metal on the piston wall, leading to premature engine wear.

Courtesy of Lethbridge Transit

To make matters worse, engines can develop an ether dependency. The use of this starting aid may cause the top of cylinders to wear away, requiring ever-higher compression ratios to ignite any fuel. That means ether could become required for all starts. It can even become necessary in hot weather.

As such, ether should be used only in extreme cases and under the direct supervision of a mechanic. Even then, very small amounts should be introduced. It can simply be sprayed on a rag and held up to the engine's air intake while you crank the engine. You can saturate an air cleaner with ether if you spray the starting aid directly into the air intake.

Engine revving

Most engines will switch to a high-idle mode when they're first started, to build up oil pressure and keep the engine from stalling. Some designs that incorporate electronic fuel injection systems may even have a high idle switch that can be used to increase the engine's rpms for this purpose.

Be sure not to let the engine idle at this higher speed for too long.

Under normal operating conditions, your bus should only be allowed to idle for less than five minutes. In extremely cold weather, it should not be allowed to idle for more than 10 minutes.

Don't assume that a simple increase in engine noise is a sign of higher rpms. The noise may be created by a warm-up device known as an exhaust system restrictor, which holds back exhaust gases to increase the load on the engine. (Check the operating manual to see if your bus has such a device.)

The true indication of engine speed is found on your tachometer.

Cold-start idling

Many drivers are under the misconception that they should apply full throttle when starting vehicles in low temperatures, or rev engines to a high idle of more than 900 rpm to help them warm up quicker. This can actually lead to premature engine wear and burns an unnecessary amount of fuel. (The black plumes of smoke are caused by unburned fuel.)

Most vehicle components should warm up under load, while you're driving. Unlike their idling counterparts, moving vehicles are also able to warm up differentials and transmission oils. For that matter, tires also become more fuel efficient as they become warmer.

Once a vehicle has begun to warm up, deliver a low, steady amount of throttle to ensure smooth shifts until the driveline components warm up. Automatic transmissions are designed to react to the engine's power output. By applying a heavy amount of throttle, the transmission will downshift, increasing the number of rpms and burning an excessive amount of fuel.

Added heat

Buses used in extremely low-temperature environments can be equipped with supplementary devices to ensure a smooth start.

This equipment includes:

- Engine block heaters
- Fuel heaters
- Oil pan heaters
- Auxiliary heaters that heat the engine block and passenger compartment. (These tend to use only 10 to 15 percent of the fuel that would be needed for idling.)
- Battery blankets
- Weather fronts

Electric engine block heaters should be equipped with timers that will turn them on two to three hours before you plan to start on a cold day – say, at five a.m. to prepare to begin a journey that begins at seven a.m. This will raise the temperature of your coolant and ensure that your oil is thin enough to coat components and reduce the strain on your starting system.

Don't worry about the draw on your house's electricity bill if you are dispatched from home. An electric block heater will draw a mere 600 to 1,000 watts, or 5.5 to 10 amps of electricity.

If you don't have access to a plug for the block heater, your fleet may specify an engine coolant heater for the bus, to ensure fluids are ready to flow when you turn the key. Although they burn diesel fuel, these heaters consume about 80 percent less fuel than an idling engine.

Notes

Horsepower and Torque

Horsepower is a measure of an engine's ability to accelerate and reach cruising speeds. Modern engines can reach these levels at lower rpms than ever. Meanwhile, an engine's torque measures its ability to start the bus in motion and to climb grades. The peak levels of torque can be maintained over wider rpm bands, reducing the need for frequent gear shifting.

Still, there can be problems associated with choosing a bus engine that doesn't have enough horsepower. British Columbia's North Okanagan-Shuswap School District No. 83, for example, began ordering 72-passenger buses with a minimum of 230 hp instead of 210 hp because the more powerful engines didn't have to work as hard to maintain speeds along its local routes.

In general, your best fuel economy is always offered at lower engine rpms. Shift points for diesel engines now tend to range from 1,200 to 1,600 rpm, so always try to keep your engine speed low when you're on the road. Not only is this more fuel efficient, but you will reduce GHGs and increase the life of the engine in the process.

Overdrive

Some automatic transmissions have overdrive features that should be used all the time to ensure fuel efficiency.

Cruise control

If your vehicle is equipped with cruise control, you can use it to maintain a constant speed when you're on an open stretch of road. By setting the device for slightly less than the speed limit, you won't have to reset it frequently. This will eliminate the need to ride the brakes or make lane changes.

Road speed

Aggressive driving, such as speeding, rapid acceleration, and hard braking, wastes fuel. A lot of it. At highway speeds, these practices can increase your fuel consumption by 33 percent, and by up to 50 percent on city streets.

Road speed is the number one cause of fuel consumption, although it's the easiest to control. Keep in mind that you need 60 extra horsepower to travel at 115 km/hr instead of 100 km/hr.

In comparison, sensible driving can:

- Result in safer roads
- Reduce wear and tear on components
- Save fuel
- Reduce driver fatigue

As speed increases, a vehicle produces more aerodynamic drag and rolling resistance and loses more energy through the driveline, so the engine needs to work harder and use more fuel to compensate for these forces.

You can overcome some of this effect by holding a steady speed, staying off the brake (which will simply require you to accelerate to resume your initial speed), and driving defensively.

- Plan your drive
- Look ahead to anticipate traffic patterns
- Do not overuse the brakes. Watch the intersections ahead of you to gauge changes in traffic lights
- Don't be on and off the accelerator
- Use your cruise control whenever possible
- Adjust driving habits to conditions on the road

Notes

Manage your Idle Time

Some engine idling is a fact of life. You can't avoid every traffic light or traffic jam. But unnecessary and excessive idling, such as running an engine while you're waiting for the school bell to ring, wastes money and can damage your engine.

It's also a health concern. After all, idling usually occurs in areas where children, drivers, and other members of the school community are exposed to the pollutants in your exhaust.

Many schools are limiting the amount of engine idling that's allowed on school grounds, reducing the exhaust that can flow through air intakes and into classrooms. School boards, such as the New Brunswick Board of Education, have introduced formal anti-idling policies. By encouraging students to be at their appointed pick-up points five minutes before you arrive, your fleet can ensure that you are not left idling at the side of the road.

Consider how excessive amounts of nonproductive idling can lead to:

Higher fuel bills

Say that an idling bus burns four litres of fuel per hour. If this nonproductive idling adds up to just an hour a day for 200 days of the year, that means that 800 litres of fuel are being wasted every year. If fuel costs 80 cents a litre, a fleet of 50 buses could be wasting $32,000 every year.

Increased maintenance costs

Prolonged engine idling can contaminate oil, increase deposits in cylinders and clog fuel injectors, particularly in diesel engines. At 600 rpm, for example, excess intake air will cool the cylinder liners, leading to incomplete combustion. The unburned fuel will then be drawn into the sump that holds the oil, reducing the effectiveness of your lubricant.

This can reduce the life of your engine oil by 75 percent, from 600 engine hours to 150 engine hours. An engine needs to idle no more than three minutes before shutting down to lubricate turbocharger bearings.

Fines

Many Canadian cities have introduced laws that restrict non-productive idling as a tool to reduce smog and noise. Other jurisdictions will likely follow. The Federation of Canadian Municipalities has voted in favour of supporting the reduction of GHGs, and this is one way to accomplish that goal.

Courtesy of North Okanagan-Shuswap School District No. 83, Salmon Arm, BC

Increased emissions

Every minute that you don't idle, you're reducing pollutants such as GHGs and particulate matter. Excessive idling can clog fuel injectors, leading to the incomplete combustion that can increase emissions.

Shortened engine life

According to a report by the Argonne National Laboratory, one hour of idling can cause the same engine wear as 11 kilometres of driving (if the bus gets just under seven mpg or three km/litre). That's better than previous estimates of wear that were the equivalent of three to five hours of highway driving, thanks to a combination of lower idle speeds and lower sulphur levels in fuel, but it's still wasteful.

Fleets can reduce the need to idle by adding specific equipment to your bus. Block heaters will lower the time required to warm the engine, while auxiliary heaters that heat the engine block and passenger compartment will use a fraction of the fuel consumed by an idling engine.

Today's bus fleets can also accurately track your idling

habits by measuring movements recorded by downloading reports from a modern diesel engine's electronic control module (ECM). This computer can also be programmed to shut down an engine after it idles for a predetermined period of time.

If you rev an idling engine to overcome the shutdown, you're doing more than wiping out the benefits of reduced idling. You're even increasing the amount of fuel burned by idling at lower rpms.

Engine cool down

Working engines and turbochargers need to cool down for three to five minutes at the end of their trip to prevent the burning of the turbocharger's lubricating oil. Any idling beyond that point will simply waste fuel.

If you're paying attention and know when you need to stop your vehicle, you can also begin to cool down the equipment when the wheels are still rolling.

Begin easing up on the accelerator to operate at a lower rpm to slow the turbocharger and cool the engine. Once you've stopped, idle just long enough to complete your midtrip or post-trip inspection.

An engine will remain warm for a long period of time. If you cool it down slowly, you'll be able to restart it within an hour and drive away as soon as the oil pressure rises.

Shut your windows

Studies of conventional diesel school buses have found that idling engines can add a significant amount to the pollutants inside your school bus. So when you do need to idle, keep the doors and windows closed and avoid caravanning on roadways.

Notes

Activities and Games

1 Alternative Fuels

Draw lines to connect each fuel type to the correct definition

(Answers on page 58)

Biodiesel	*Engines running on this produce 75-90% less soot than diesel engines*
Natural Gas	*Converts oxygen and hydrogen into electricity*
Hythane®	*Stored as vaporized liquid but burned as a gas*
Propane	*Contains fuel produced from waste vegetable oils or animal fats*
Fuel Cell	*Blend of compressed natural gas and hydrogen*

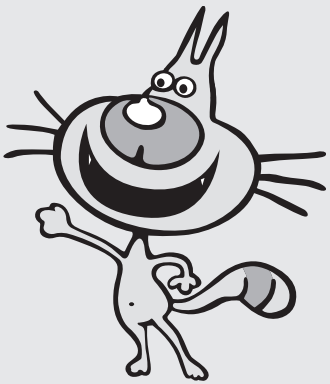
2 *Collector Route*

It's school-trip time, and you are leaving the airport having just dropped off a group of students. You are turning left onto Airport Road. (See start arrow)

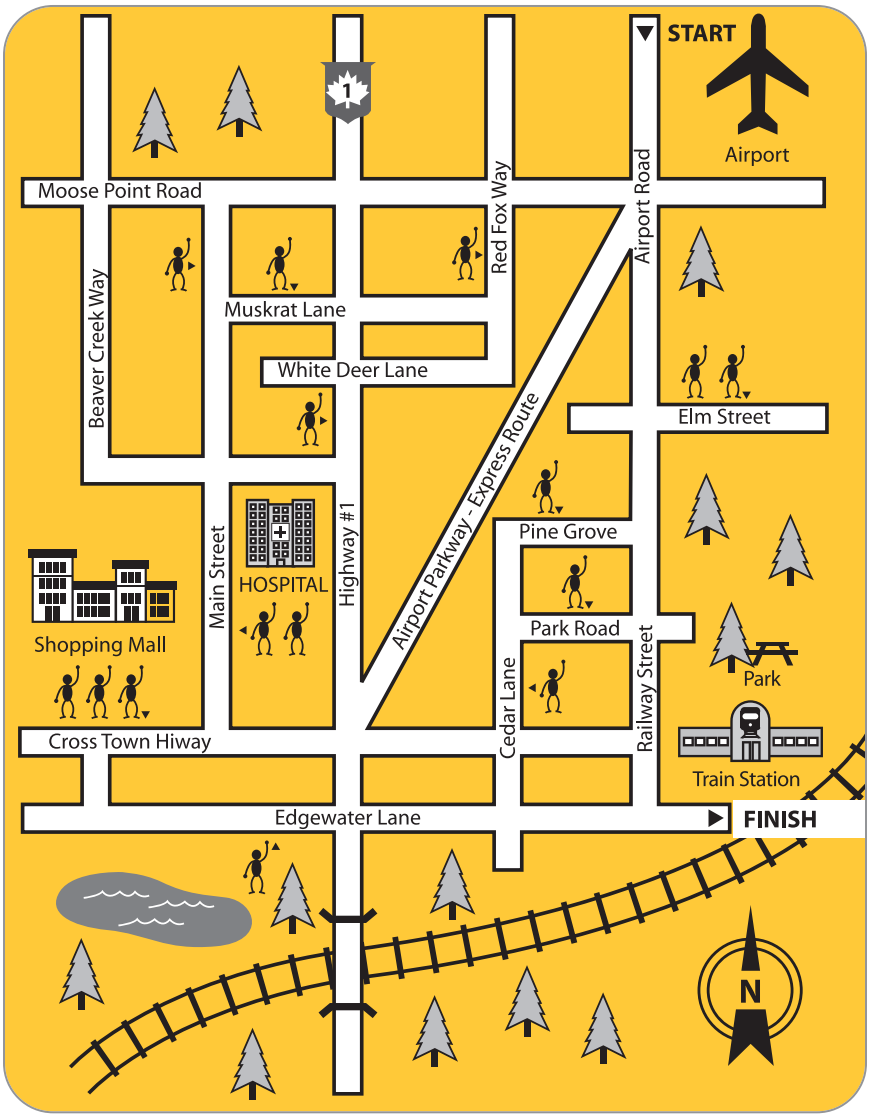
Now you are asked to pick up some students from along your city route (indicated by the waving students). Those waiting at the listed pick-up points below want to go to the train station, and it's your job to get them there.

Please pick up all the following passengers and deliver them safely to the train station. They are waiting at these locations:

Edgewater Lane
Elm Street
Hospital
Muskrat Lane
Park Road
Pine Grove
Red Fox Way
Shopping Mall



1. *How many students will you be collecting?*
2. *Trace the most fuel-efficient route for you to follow.*



3 Fun time – Not Idling Time!!

Keep your brain in gear by solving these puzzles
(Answers on page 58)

Anagrams

An anagram is a word or phrase formed by rearranging the letters of another word or phrase.

Examples:

Listen = Silent	*The eyes = They see*

Try these:
They all have a connection with vehicles or driving.

Anagram

1. Lovebirds chorus _____ ___ _____
2. Ill used fee _____ ____
3. Trailer cub _____
4. Reevaluate flint _____ ____
5. Sheep or row _____
6. On circle tours _____ _____

4 How Did They Get a Bus In There?

It's amazing where you can find a bus!
Look at the clues below and somewhere in each of the correct answers, you'll find the word **bus**.

(Answers on page 58)

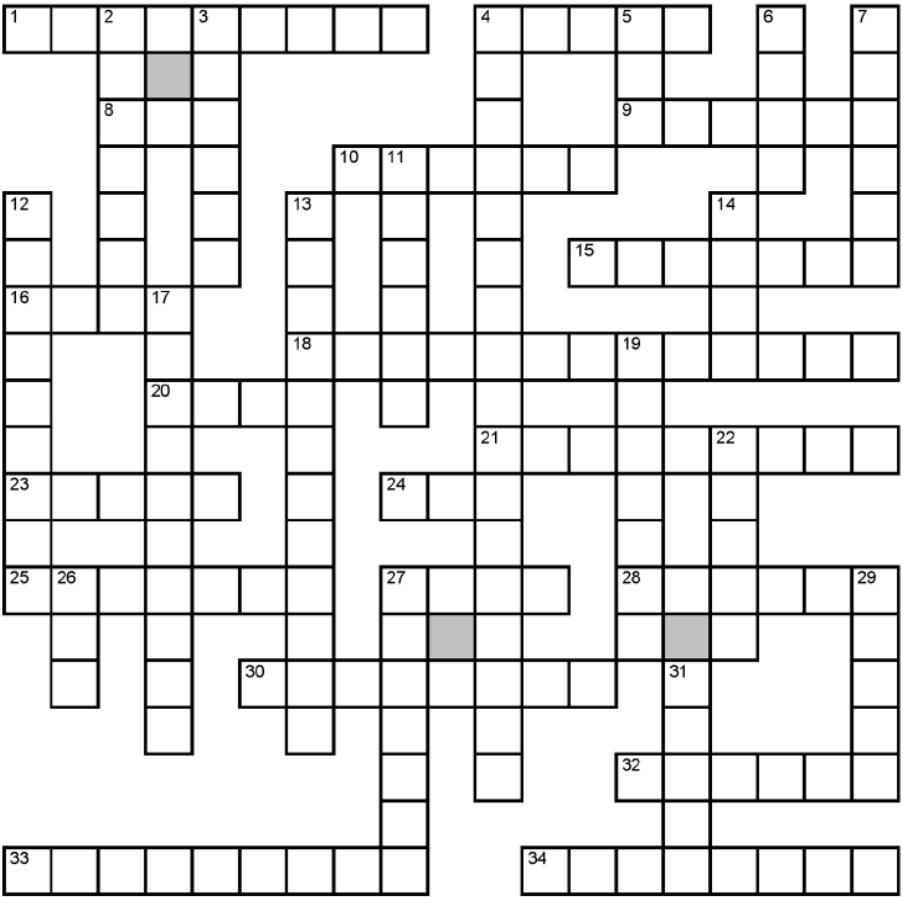
Example:

Natural, undeveloped area = ***Bus****hland*

Clue	
1 Street musician	_____
2 Russian headwear	_____
3 Lie in wait	_____
4 Musket	_____
5 French composer	_____
6 This can be burned	_____
7 It has four equal sides, but it isn't a square	_____
8 A course of study	_____
9 Profit-based activity	_____
10 Physically strong	_____

5 SmartDriver School Bus Crossword

(Answers on page 59)



Across

1 Rider (9)

4 Force (5)

8 Choke up (3)

9 Device that removes something from whatever passes through it (6)

10 Coupling that connects or disconnects parts of a driving mechanism (6)

15 Tiredness (7)

16 Change direction (4)

18 Ice lion jet fun: Avoids the need for a carburetor (Anagram) (4, 9)

20 Rubber cushion around a wheel (4)

21 Vehicle used to transport children to or from school (6, 3)

23 Follows second (5)

24 Basic unit of electric current (3)

25 Fluid that transfers heat away from engine (7)

27 Measured rate of movement (4)

28 Reflective device (6)

30 Volatile fuel derived from petroleum (8)

32 A rating for diesel oil that indicates how easily the fuel ignites and how fast it will burn. (6)

33 High gear used at high speeds to maintain driving speed with less output power (9)

34 The signal to stop (3, 5)

Down

2 Element when combined with oxygen creates toxic gas that causes acid rain (7)

3 Motor (6)

4 Check-out procedure conducted before departure (7, 10)

5 Imp (3)

6 Power unit (4)

7 A twisting force (6)

11 Laden (6)

12 Self-regulating gear shift (9)

13 Gear that permits rotation of two shafts at different speeds (12)

14 Food and drink consumed regularly (4)

17 Fossil fuel in a gaseous state (7, 3)

19 Thriftiness (7)

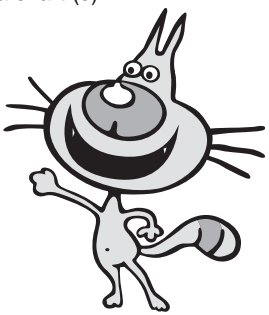
22 Metric unit equal to the volume of 1 kilogram of pure water (5)

26 Doesn't mix with water (3)

27 Colourless gas used as a fuel (7)

29 An established line of travel (5)

31 Circular frame that rotates on a shaft (5)



6 SmartDriver Word Search

Find the hidden words (Answers on page 59)

A	E	P	T	N	O	I	T	S	U	B	M	O	C	S
L	R	O	R	E	T	B	H	H	S	Z	D	Y	M	K
T	E	L	A	R	N	Q	T	M	Y	I	E	A	C	R
E	H	L	N	U	E	V	O	S	E	T	R	F	E	P
R	P	U	S	H	I	G	I	S	U	T	H	H	T	L
N	S	T	P	P	C	N	E	R	D	A	T	A	A	A
A	O	I	O	L	I	L	B	R	O	A	H	U	N	N
T	M	O	R	U	F	S	I	D	E	N	X	X	E	E
I	T	N	T	S	F	V	J	W	Y	T	M	H	E	T
V	A	S	A	G	E	S	U	O	H	N	E	E	R	G
E	T	P	T	R	L	E	M	I	S	S	I	O	N	S
L	O	E	I	L	E	S	E	I	D	O	I	B	G	T
F	L	E	O	S	U	U	W	V	E	H	I	C	L	E
Q	V	D	N	O	F	G	N	I	L	D	I	I	I	X
T	R	A	N	S	M	I	S	S	I	O	N	H	N	R

Alternative
Atmosphere
Biodiesel
Cetane
Combustion
Diesel
Emissions
Environment
Exhaust
Fuel Efficient
Greenhouse
Gas
Hythane®
Idling
Planet
Pollution
Smartdriver
Smog
Speed
Sulphur
Transmission
Transportation
Vehicle
Weather

7 My ideas

Record your own ideas about ways to improve fuel-efficiency or reduce pollution around school buses.

Answer Keys to Activities and Games

1 Alternative Fuels

Biodiesel	Contains fuel produced from waste vegetable oils or animal fats
Natural gas	Engines running on this produce 75-90% less soot than diesel engines
Hythane ®	Blend of compressed natural gas and hydrogen
Propane	Stored as vaporized liquid but burned as a gas
Fuel cell	Converts oxygen and hydrogen into electricity

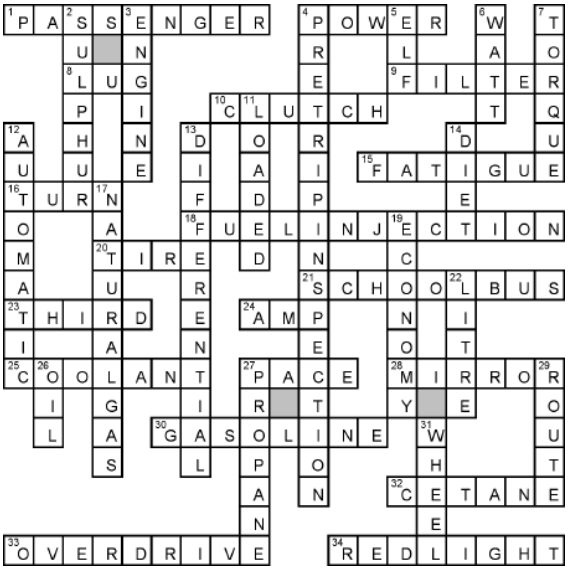
3 Fun time – Not Idling Time!!

1. *School bus driver*
2. *Diesel fuel*
3. *Lubricate*
4. *Alternative fuel*
5. *Horsepower*
6. *Cruise control*

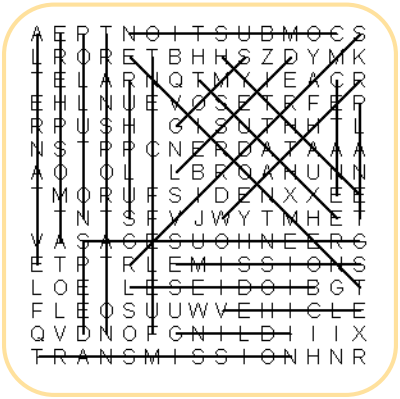
4 How did they get a bus in there?

1. *Busker*
2. *Babushka*
3. *Ambush*
4. *Blunderbuss*
5. *Debussy*
6. *Combustible*
7. *Rhombus*
8. *Syllabus*
9. *Business*
10. *Robust*

5 SmartDriver School Bus Crossword



6 SmartDriver Word Search



For more information on fleet energy-saving opportunities, please write to:

ecoENERGY for Fleets
Office of Energy Efficiency
Natural Resources Canada
580 Booth Street, 18th Floor
Ottawa ON K1A 0E4
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fleetsmart@nrcan.gc.ca
Fleet*Smart* Web site:
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