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REPORT

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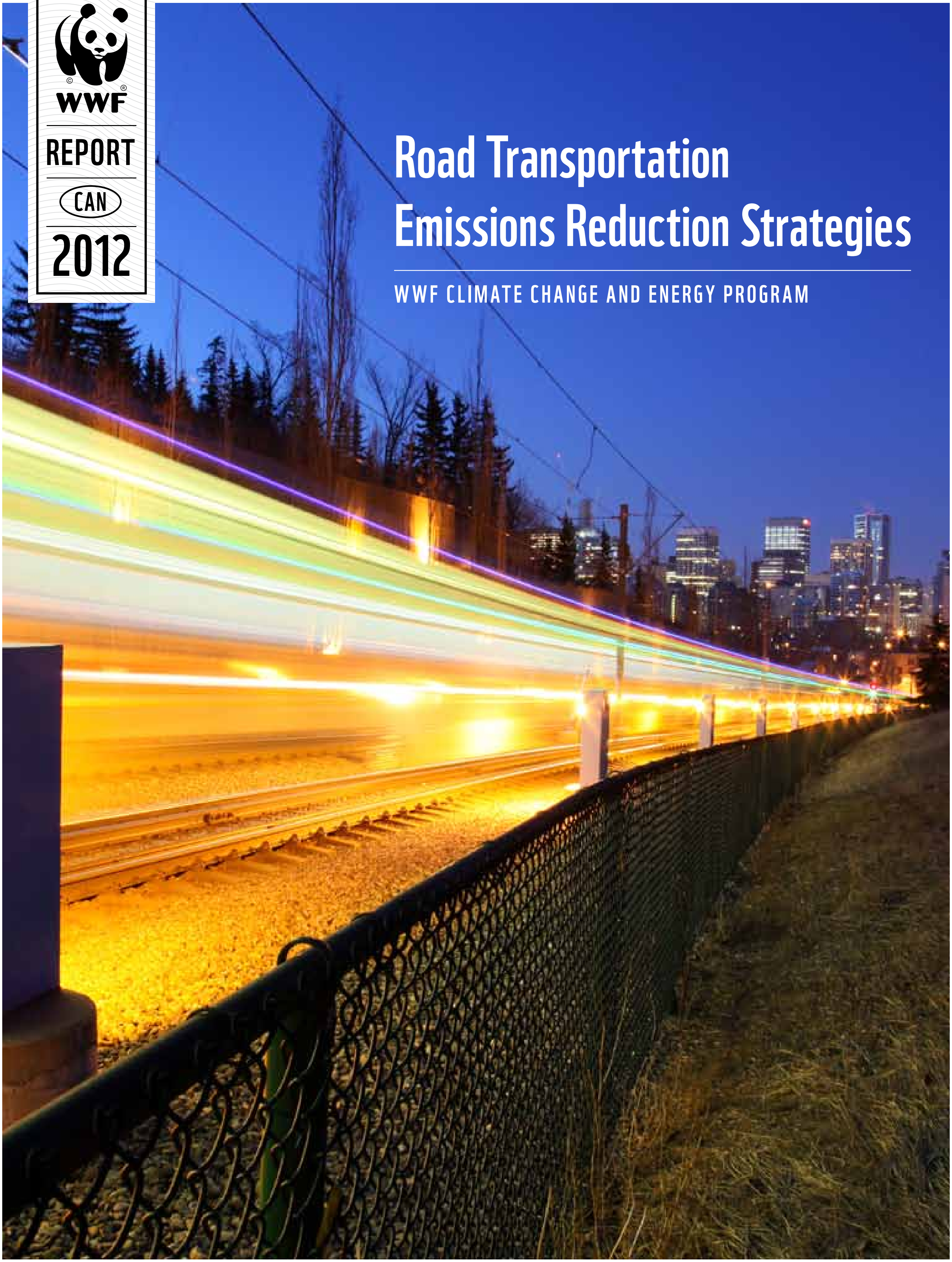
2012

Road Transportation Emissions Reduction Strategies

WWF CLIMATE CHANGE AND ENERGY PROGRAM



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WWF-Canada would like to recognize the McLean Foundation and the Ontario Trillium Foundation for their generous support of our sustainable transportation work. The Ontario Trillium Foundation is an agency of the Government of Ontario. Front cover photo © Michael Buckley / WWF-Canada

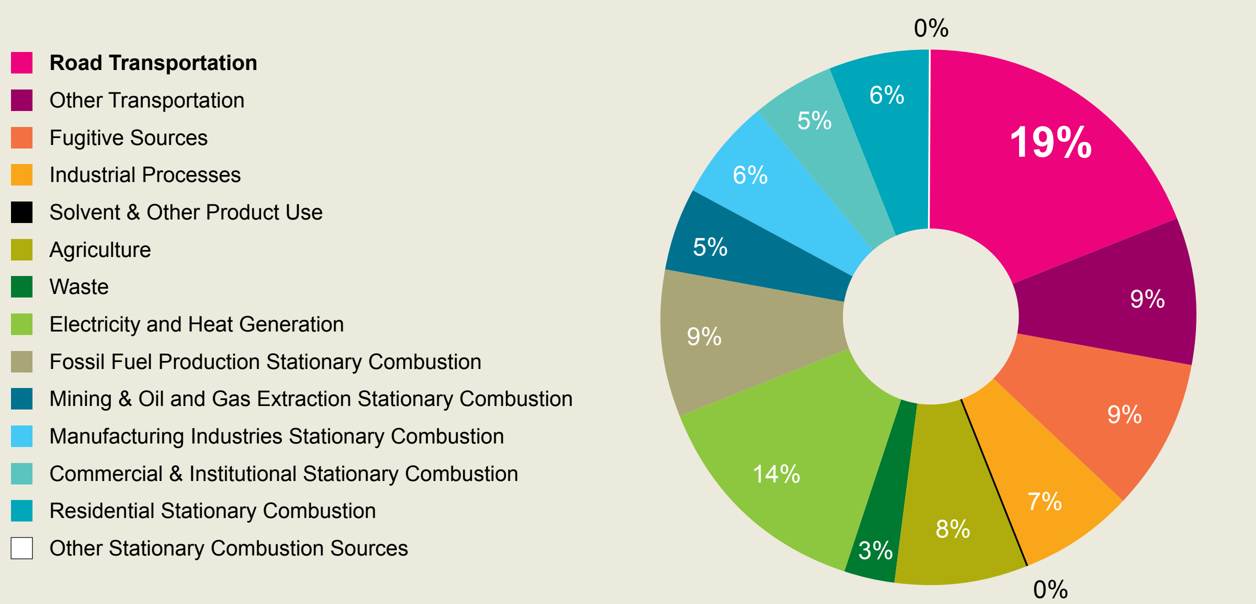
Ontario Trillium Foundation
Fondation Trillium de l'Ontario

Published in August 2012 • WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

INTRODUCTION

Road transportation is the single-most significant contributor to carbon emissions in Canada, accounting for 19 per cent of the country's total greenhouse gas (GHG) emissions (Figure 1). Additionally, road transport emissions have increased by 35 per cent since 1990, second only to GHG emissions growth from the Canadian oil sands industry.

Figure 1. Canadian GHG emissions breakdown by sector[1]



All possible and potential solutions to energy-related climate change issues can be categorized under the following strategies:

- Avoiding unnecessary energy consumption
- Reducing the energy intensity of energy-consuming activities
- Replacing high-carbon sources of energy with non-fossil fuel sources

For example, for the road transportation sector, actions can be categorized as follows:

- *Avoid* using personal vehicles, choosing instead other modes of transportation, such as walking, or biking.
- *Reduce* GHG emissions per passenger kilometre travelled by using more fuel-efficient vehicles or cleaner fuels.
- *Replace* internal-combustion engines powered by fossil fuels with zero-tailpipe emissions vehicles, such as electric vehicles.

Any effective strategy to reduce GHG emissions from the road transportation sector must include efforts to encourage private automobile users to avoid using their personal vehicles

The current dominance of private vehicles in passenger transportation confirms that any effective strategy to reduce GHG emissions from the road transportation sector must include efforts to encourage private automobile users to avoid using their personal vehicles and choose other modes of transportation such as walking, biking, or transit.

No single sustainable transportation initiative will achieve the necessary emissions reductions. For example, transportation needs in dense urban areas could be met with good urban design, investments in public transit, and modal shifts to active transportation. In less dense areas, it may be neither economically feasible nor desirable to invest only in a public transit network, as transit networks running under minimum utilization levels emit more CO_2 per passenger than a single-occupancy private automobile.[2] Understanding the opportunities and limitations of various emissions reduction strategies is key to identifying the optimal strategic mix of interventions.

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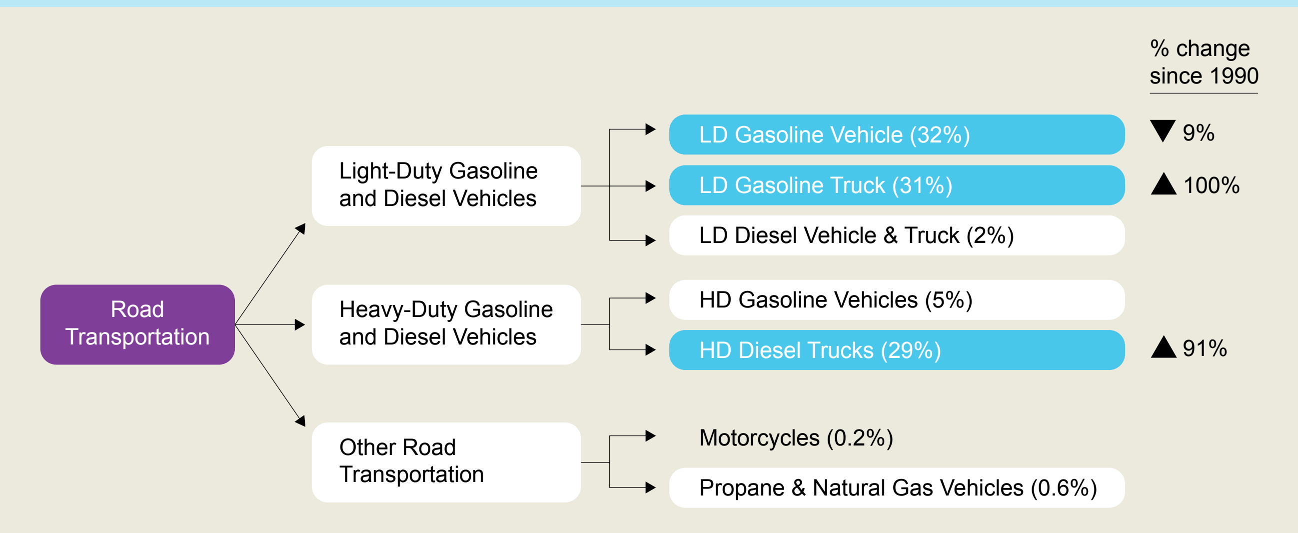
ROAD TRANSPORTATION

Among different modes of road transportation, *light-duty gasoline vehicles, light-duty gasoline trucks,* and *heavy-duty diesel trucks* have the largest share of GHG emissions, with 32, 31, and 29 per cent contribution, respectively. Figure 2 shows the GHG emissions contribution of different modes of road transportation. The arrows beside blue boxes show the percentage increase or decrease in emissions since 1990.

According to Figure 2, emissions from light-duty gasoline vehicles show a 9 per cent decline in actual amount of CO2 equivalent emitted, but these vehicles are still the most significant emissions contributor in the transportation sector. Emissions from light-duty gasoline trucks (e.g., SUVs) have doubled since 1990, and currently account for 31 per cent of road transportation emissions. Over the same period, heavy-duty diesel trucks are responsible for 29 per cent of emissions and show a 91 per cent increase.

Figure 2. Canadian road transportation GHG emissions breakdown by mode of transportation[3]



This report will focus on strategies to reduce emissions from light-duty vehicles. While heavy-duty trucks are an increasing source of GHG emissions in Canada, they require specific policies and considerations to acknowledge the different pressures (e.g., just-in-time delivery, receiver requirements, technology options) that trucking and shipping industries face compared with private commuters.

As such, a separate report is necessary to investigate strategies to reduce emissions from heavy-duty vehicles. **WWF-Canada has chosen to focus on light-duty vehicles at this time because they make up the majority of road transportation emissions (65 per cent).**

Light-duty vehicles make up 65% of road transportation emissions

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GREENHOUSE GAS EMISSIONS REDUCTION STRATEGIES

Three main strategies can be used to tackle road transportation GHG emissions: avoid, reduce, and replace. There are several policies and options available within each strategy.

Policies that help commuters avoid driving their personal vehicles include building up dense urban communities and well-developed transit systems, and transforming neighbourhoods into great places for walking or biking to reduce vehicle kilometres travelled (VKT). Businesses can facilitate working from home, or reducing travel through webinars and teleconferencing. Other policy alternatives such as increasing fuel taxes, road taxes, and parking costs are among the options that indirectly discourage drivers from using their personal vehicles.

Policies that help increase vehicle efficiency and reduce emissions include improving corporate average fuel economy (CAFE) standards and lowering the

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Reducing emissions requires policies that help commuters avoid driving their personal vehicles carbon content of fuels. Additionally, specific programs designed to support replacing inefficient vehicles with more efficient ones and educating drivers on fuel-efficient driving behaviours can help to reduce emissions.

Lastly, substituting fossil fuel combustion engines with zero-tailpipe emissions technologies such as electric and hydrogen fuel cell vehicles can also significantly reduce emissions. Table 1 summarizes some of the discussed tools and options.

Table 1. List of tools and options identified for each strategy

Strategy	Tools and Options
Avoid	Dense urban design and land use planning to support public transit Facilitating modal shift to active transportation Increasing fuel taxes Increasing road taxes and parking costs Facilitating teleconferencing and working from home
Reduce	Improving fuel-efficiency standards Supporting and facilitating carpooling Facilitating modal shift to public transit Switching to cleaner fuels (biodiesel, ethanol, and propane) Supporting vehicle retirement programs that support low-emission transportation replacements Promoting driver education programs
Replace	Supporting zero-tailpipe emissions engines powered by renewable energy

In selecting and implementing sustainable transportation strategies, it will be very important to consider the implications of each alternative. For instance, supporting electric vehicles can potentially reduce carbon emissions and fossil fuel use from transportation; however, this could have an unintended negative consequence for transit development in jurisdictions that use fuel tax revenues to fund transit. In the following section, we look at the benefits and implementation considerations of some of these tools and options.

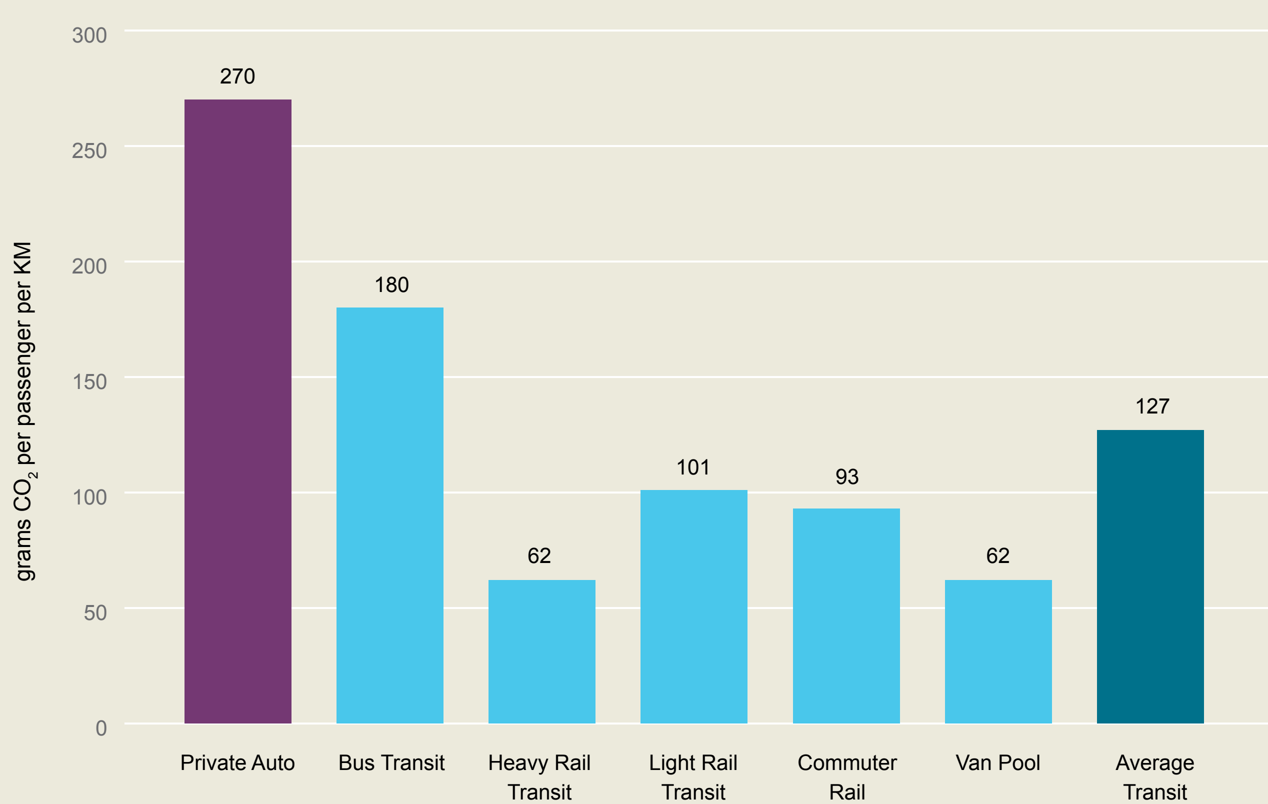
PUBLIC TRANSPORTATION

A well-developed public transportation system reduces GHG emissions by providing a convenient option to reduce unnecessary driving, lowering emissions per passenger kilometre travelled, and supporting more compact urban design and reducing the need for travelling long distances.

Benefits

Public transit GHG emissions per passenger kilometre travelled are still significantly lower than those from driving, even taking into account emissions from required construction, manufacturing, and maintenance. In addition to the direct per kilometre emissions reduction consequences of public transportation, it encourages more compact urban design over the long run, which eventually

Figure 3. U.S. national average for GHG emissions of different modes of transportation[4]



lowers average travelling distance and reduces the number of cars per household. In other words, in areas served by public transportation, even non-transit users drive less because destinations are generally closer together. An analysis conducted by the Natural Resources Defense Council and the Sierra Club confirmed that each new transit mile travelled replaces four to eight miles of private auto travel attributable to changes in land use that might result from transit development.[5]

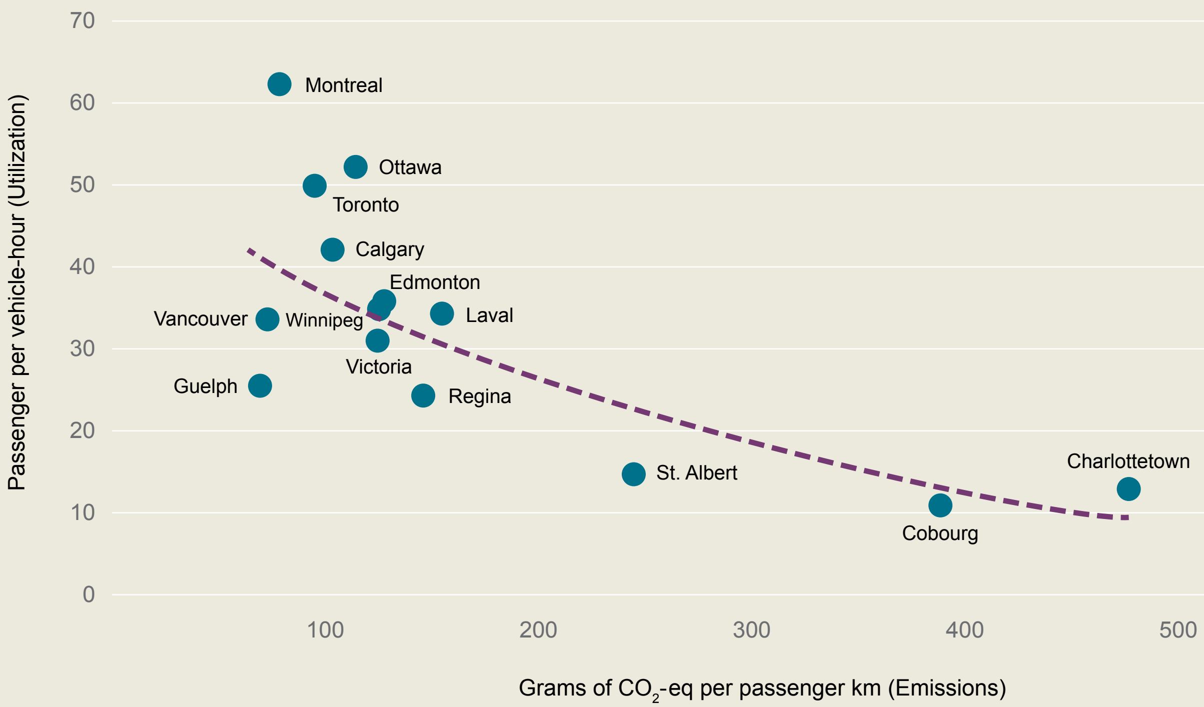
In addition to adding transit routes and increasing ridership, public transportation systems can make logistical changes that can significantly reduce transportation-related emissions from their current fleets. For example, optimizing bus routes and frequency, converting to low-emission buses, or adding routes to existing bus networks can be done quickly without significant planning or infrastructure changes.

Implementation Issues

By encouraging people to avoid using private automobiles, transit could reduce congestion for those who continue to commute by car. Improved traffic operations could reduce fuel consumption per kilometre, but also could have a rebound effect and encourage additional drivers to use their vehicles more often, which would counterbalance some of the VKT reductions.

The number of transit riders greatly impacts GHG emissions savings per passenger per kilometre travelled. When developing transit service as a GHG emissions reduction policy option, communities should ensure that utilization levels are sufficient to realize emissions savings over the alternative of using private automobiles. For example, the average 40-passenger diesel bus must carry a minimum of seven passengers on board at all times to be more efficient than the average single-occupancy vehicle. As illustrated in Figure 4, CO_2 emissions per passenger kilometre travelled on bus transit systems of different Canadian cities increase as utilization (average passenger per vehicle-hour) decreases. These statistics indicate that adding bus routes to underutilized areas may be important as a public service, but may not be justified as a GHG emissions reduction strategy unless designed to drive density or anticipate future demand.

Figure 4. Emissions per passenger kilometre travelled by bus transit systems of different Canadian cities[6]



Note: This graph is an approximation based on Canadian Urban Transit Association's (CUTA's) annual report to illustrate the correlation between ridership and emissions on bus transit systems in Canada.

Finally, adding transit infrastructure can be a lengthy and expensive process that involves consultation, planning, environmental assessments, and fundraising. Installing light rail or subways can take several years to, complete, and transit systems must find funds for projects. Changes to urban form (such as increased density) resulting from new transit systems would occur over a much longer time frame. As such, transit planning needs to happen in partnership with long-term urban planning and needs to be considered alongside funding mechanisms (e.g., road tolls, fuel taxes, vehicle registration taxes). Additionally, when developing plans to meet GHG emissions reduction targets, it is important to remember that these tools can deliver large changes in the long term but limited reductions in the short term.

LAND USE PLANNING

Effective land use planning can shape development patterns that encourage people to drive less.

Land use planning strategies are discussed under the following categories:

- Creating dense and transit-oriented communities
- Facilitating walking and biking
- Focusing dense development on transit stations and corridors

Benefits

A community that is designed to encourage transit ridership, walking, or biking has a huge potential for GHG emissions reductions. Land use planning that increases density can reduce VKT by enabling individuals to walk or use transit between housing, shopping, and employment. Research has shown that doubling density reduces VKT by 20 to 30 per cent.[7]

Recognizing the environmental, economic, and community benefits of density and smart growth, Canadian cities and provinces have begun to include land-use targets in their development plans. For example, compact and complete neighbourhoods in Vancouver are supported by improvements such as new pedestrian and bicycle infrastructure, as well as good transit accessibility. As a result, walking, cycling, and transit use are all on the rise in these areas, while vehicle travel is declining.[8] In Ontario, the 25-year Places to Grow plan addresses sprawl and associated congestion and VKT issues by, among other things, targeting growth to built up areas and promoting transit-supportive densities.[9] This plan is projected to nearly double the increase in sustainable trips by 2031 and significantly slow the projected increase in VKT, congestion, and GHG emissions (compared with growth that would be expected without the Places to Grow plan and targets).[10]

Implementation Issues

The addition of mixed-use and high-density developments are often opposed by homeowners in established single-family neighbourhoods who fear that multi-family housing in their area will negatively affect their property values. Additionally, other constraints such as preservation of old neighbourhoods and heritage spaces in downtown cores can limit the high-density developments.

PRICING MECHANISMS

According to Harvard University research published in the *Energy Policy* journal,[11] in order to reduce the GHG emissions from personal road transportation, the cost of driving will simply have to increase. Road tolls and congestion charges, parking fees, and fuel taxes are all types of pricing mechanisms that can be used to increase the cost of driving.

The Harvard study showed that taxing gasoline results in the highest reductions in oil demand relative to other transportation policies. As a result of this potential, and the ability to tie the revenue from gasoline taxes to support transit infrastructure, it is the focus here.

Benefits

Increasing fuel taxes adds to driving costs and can potentially decrease VKT. Higher gas prices also encourage travellers to choose more efficient vehicles and indirectly push automakers to manufacture and market more fuel-efficient vehicles.

The effectiveness of an increase in fuel taxes in reducing emissions depends on many factors, such as the level of price increase and public responses to those price changes. Fuel tax advocates believe that higher fuel prices address the source of activity and emissions, while other strategies—such as issuing tax credits for hybrid electric vehicles or EVs—could backfire, because they do not address how the vehicles are being used.

In recent years, federal and provincial fuel taxes have been examined as a potential tool to reduce VKT. Fuel tax increases can be implemented quickly by federal and provincial governments, and have an instant effect on behaviour, such as encouraging commuters to carpool or use alternative modes of transportation. To be most effective, the implementation of fuel taxes, or raising existing taxes, should be visible and permanent in order to signal to drivers that investments in fuel efficiency, or transportation methods that avoid fuel use, will pay off. To support the increased transit demand and volume associated with modal shifts from personal vehicle to public transit, governments should dedicate a percentage of fuel taxes toward transit infrastructure and development.

Currently, federal fuel tax income usually funds municipal infrastructure investments and provincial income tax funds regional municipalities, construction, and road repair projects in that province. Canada Revenue

Agency, on behalf of the federal government, collects taxes on gasoline, diesel and aviation fuelling, as well as the associated GST. The Government of Canada established the Gas Tax Fund and the Public Transit Fund in 2005 as a response to the expressed infrastructure needs of local governments.[12]

Implementation Issues

Vehicle kilometres travelled is not particularly sensitive to the price of fuel alone. According to the 2009 report of the Cascade Policy Institute, while a fuel price shock reduces VKT per capita, the elasticity is low (about 2 per cent in the short run and 6 per cent in the long run).[13] This is consistent with the fact that the 117 per cent increase in fuel prices between July 2004 and July 2008 are reported to have suppressed driving by only about 4.2 per cent.[14]

In addition to low price sensitivity of private commuters, unless the fuel taxes are applied at the federal level, or unless there is regional harmonization, higher taxes in one region may influence residents to travel greater distances to fuel their vehicles with less expensive fueling options in neighbouring regions.

Higher fuel taxes can also harm low-income commuters or small businesses with no transportation alternatives. To avoid this, fuel duties can be accompanied by social policies to support low-income earners, measures to ensure all people have access to decent and affordable alternatives to driving, and planning policies that put walking, cycling, and public transportation at the centre of new developments.

FUEL ECONOMY

Since GHG emissions are directly proportional to the amount of fuel consumed, any improvements in fuel consumption reduce emissions per kilometre proportionately. Improved fuel economy has reduced dependence on oil and reduced carbon dioxide emissions, relative to what they otherwise would have been.

According to the U.S. Department of Transportation, potential GHG emissions reduction benefits of improved fuel economy per vehicle (compared with the baseline projection for conventional gasoline vehicles) in 2030 and beyond range from eight to 30 per cent.[15]

Benefits

According to WWF-Canada's transportation simulation model,[16] new regulated and proposed CAFE standards in Canada have substantial GHG emissions reduction potential by 2020. The potential emissions reduction of newly proposed fuel economy regulations on light-duty vehicles would be 17 Mt of CO_2-equivalent per year by 2020.

Implementation Issues

Improved fuel economy can lead to a rebound effect. That is, lower fuel consumption per VKT may encourage families to buy bigger cars or drive their existing vehicles more often, offsetting a proportion of emissions savings. Some studies suggested that the rebounding effect can offset 10 to 15 per cent of emissions reductions by new fuel economy regulations.[17] Another study suggested that for every 1 per cent reduction in fuel consumption, vehicle use is increased by 0.2 to 0.3 per cent.[18] Moreover, the CAFE standard is the weighted average fuel economy of annual automakers sales. The standard creates extra credits for multi-fuel vehicles such as flex fuel vehicles that, while capable of operating on gasoline or a blend of up to 85 per cent ethanol, seldom use any fuel other than gasoline. This lowers the fleet's average fuel economy, enabling automakers to increase their production of less-fuel-efficient vehicles.

Fuel efficiency can only go so far toward reducing transportation emissions. The ability to continue to increase fuel efficiency in a gas-powered car is likely limited by the cost of developing new technologies and the weight associated with necessary performance and safety materials. In order to further reduce CO_2 emissions and reliance on non-renewable energy, switching to a renewable, non-carbon-emitting transportation fuel will be necessary.

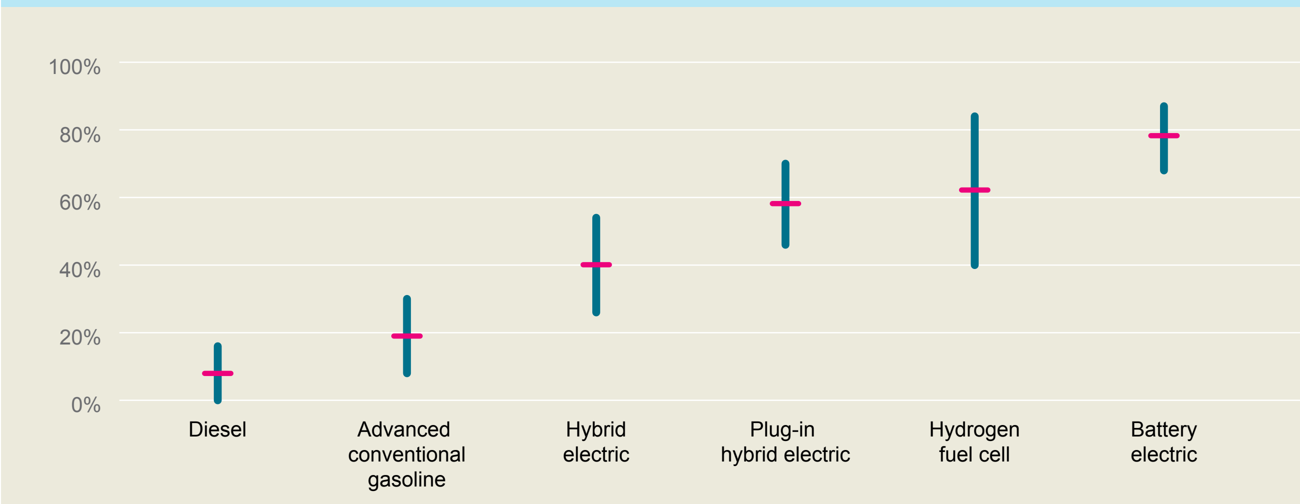
ELECTRIC VEHICLES

According to the U.S. Department of Transportation report to Congress in 2010,[19] potential GHG emissions reduction benefits per vehicle by 2030 range from 8 to 30 per cent for advanced conventional gasoline vehicles; 46 to 70 per cent for plug-in hybrid electric vehicles (PHEVs); and 68 to 87 per cent for battery electric vehicles (BEVs).

Figure 5 illustrates the potential emissions reductions by 2030 from using alternative fuel vehicles in the United States, in addition to the assumed 40 per cent improvement in fuel efficiency of light-duty vehicles in the same period.

Since the actual GHG emissions reduction of electrified transportation depends on the GHG emissions intensity of electricity generation mix, the U.S. Department of Transportation assumes that the United States can reduce its current average GHG intensity from 615 grams of CO_2 per kWh to somewhere between 379 and 606 grams of CO_2 per kWh by 2030. Since Canada's current average GHG emissions intensity of electricity generation mix (180 grams of CO_2 per kWh [20]) is well below the U.S. GHG emissions intensity, emissions reduction potential from electric vehicles is even greater in Canada than in the United States.

Figure 5. Life cycle GHG emissions reduction potential of alternative fuel vehicles by 2030 in the United States comparing to the baseline GHG emissions projection of the U.S. annual energy outlook[21]

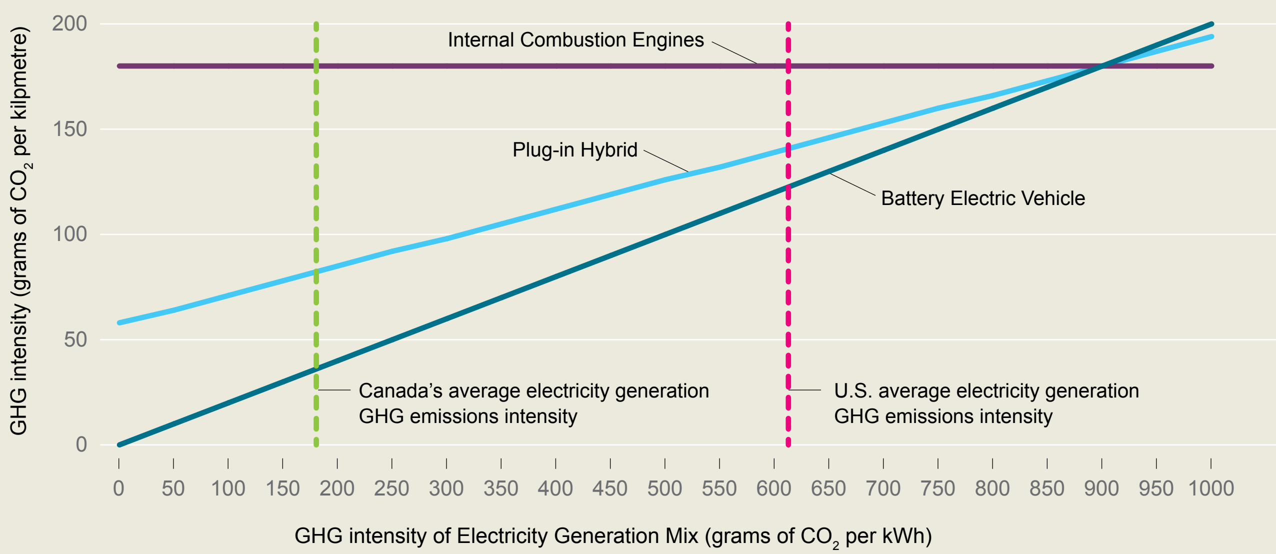


Benefits

WWF-Canada developed an in-house simulation model to estimate the potential contribution of EVs in reducing GHG emissions, taking into account different market penetration scenarios and electricity generation mixes in different provinces.[22] The nature of exponential growth of EV market penetration means that action now is necessary to see significant impact by 2030 and beyond. According to this model, in the aggressive scenario, EVs will be able to save 7 Mt of CO2-equivalent GHG emissions per year by 2025. As stated previously, the potential for EVs to contribute to GHG emissions reduction goals increases as electricity generation moves to renewable energy, so this number will improve as fossil fuels are phased out of provincial grids.

Life cycle GHG emissions assessments of EVs evaluate the emissions associated with manufacturing, usage, and disposal of EVs and compare them with those of conventional vehicles. According to the *Journal of Environmental Science and Technology*,[23] GHG emissions associated with lithium-ion battery materials and production account for only two to five per cent of life cycle emissions from PHEVs. Using the same modelling approach, WWF-Canada produced an interactive model to estimate and compare the potential emissions reductions of BEVs and PHEVs taking into account different electricity generation mixes. As illustrated in Figure 6, an electric vehicle charged in a jurisdiction with no fossil

Figure 6. Comparison of GHG intensity per kilometre travelled by different models of EVs based on different electricity generation intensity



fuel-based electricity generation plant has virtually unlimited potential for GHG emissions reduction, without compromising vehicle performance and safety.

Implementation Issues

Although EVs have been championed as one of the solutions to reduce carbon emissions from transportation, experts agree that EVs are unlikely to be a significant part of the car fleet until well into the 2020s. This is because it will take some time for manufacturers to roll out the full range of models desired by consumers, for consumers to become comfortable with the new technology, for prices to become competitive with internal-combustion engine vehicles through incentives or technological advancements, and for the necessary charging infrastructure to be put in place. A consequence of this transition time is that short-term cuts to transport emissions will have to be achieved by reducing the need to travel, persuading people to leave their cars at home, and making conventional cars greener.

Mass adoption of EVs will eventually lead to a dramatic decrease in fuel consumption. While this reduces emissions, it may affect funding for public transit, as many provinces and municipalities currently fund public transit expansion projects through gasoline taxes. However, this is a long-term consideration, as EVs will not significantly reduce fuel use and therefore not jeopardize public transit investments for at least the next decade.

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CONCLUSION

Road transportation is the greatest contributor to GHG emissions in Canada, and the second-highest growth source of emissions in the country. As such, it must be addressed as part of any successful strategy to significantly reduce Canada's GHG emissions. There is no single comprehensive solution for sustainable mobility; rather, a set of tools and options, deployed in concert, can help Canada reduce its emissions from road transportation. WWF-Canada identified three key strategies to reduce emissions from this sector: avoiding unnecessary vehicle kilometres travelled, reducing the energy intensity per kilometre travelled, and replacing non-emitting new technologies for internal-combustion engines.

Building up dense urban communities and well-developed transit systems, and transforming neighbourhoods into great places for walking or biking are among the options that help commuters avoid using their personal vehicles. Improving CAFE standards, setting low-carbon fuel standards, and promoting programs that educate drivers and retire old vehicles help reduce emissions per kilometre travelled. Lastly, substituting fossil fuel combustion engines with non-emitting new technologies such as EVs charged by renewable sources of electricity can also significantly reduce road transportation emissions. A main finding from this report is that **EVs are an effective GHG emissions reduction option when density does not justify investing in public transit, and in areas where transit infrastructure has not yet been developed.**

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These tactics are all necessary components of a long-term transportation strategy to slash transportation-related GHG emissions. Short-term reductions are necessary to meet Canada's 2020 emissions reduction goal (17 per cent reduction by 2020, based on 2005 levels), and these improvements will come from transit fleet and route improvements, fuel-efficiency standards, and implementing pricing mechanisms. However, to make sure that Canada can meet our long-term emissions reduction goals, we must start planning and investing in the more transformative tactics such as urban planning, electrified public transit infrastructure and networks, and EV infrastructure and uptake.

ENDNOTES

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Road Transportation by the Numbers

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Road transportation is the single-most significant contributor to GHG emissions in Canada, accounting for 19 per cent of total emissions in 2009

35

Road transportation emissions have increased by 35 per cent since 1990, second only to GHG emissions growth from the Canadian oil sands industry

270

The average private automobile emits 270 grams of CO2-equivalent emissions per passenger kilometre travelled

65

Light-duty vehicles make up 65 per cent of road transportation emissions

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