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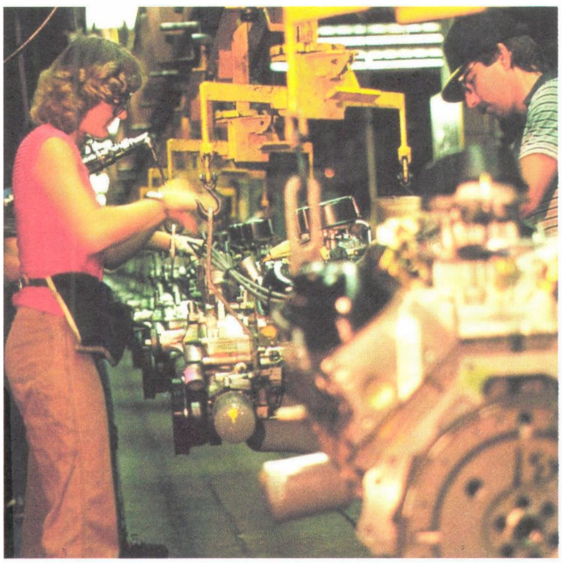
A State of the Environment Fact Sheet

Environmental implications of the automobile

More than 12 million cars now traverse Canada's roads — one for nearly every two Canadians

The automobile[1] has probably done more to shape the character of 20th-century Canada than any other piece of technology. It has given us mobility and independence. It has given us the convenience of going where we want to, when we want to, and of doing so in comfort. It has liberated the average person from the limitations of time and place, opening up new opportunities and offering new experiences. More significantly, it is one of the pivotal elements of our economy. No wonder, then, that Canadians have made the car such a central fixture of their lives.

But the automobile also affects the environment in many ways. Cars and their associated infrastructure use resources, consume energy, and emit pollutants on a substantial scale. They are a source of noise and congestion and a leading cause of accidental deaths. They have also radically reshaped the landscape — directly through the building of expressways, roads, and other infrastructure, and indirectly through effects on settlement patterns.



Industry, Science and Technology Canada

Workers on an automobile parts assembly line

The automobile's impact has been all the greater because of its success. More than 12 million cars now traverse Canada's roads — one for nearly every two Canadians, one of the highest ratios of car ownership in the world. Each of these cars travels, on average, more than 16 000 km per year, a total of some 200 billion kilometres, or more than 1 000 times the distance between the Earth and the sun.

Because it is so tightly woven into the fabric of Canadian life, the car presents a special kind of environmental dilemma. On the one hand, there is the need to eliminate or reduce the environmental stresses associated with it. On the other, there is the desire to preserve the advantages it has given us. Reconciling these objectives presents a considerable challenge.

As Figure 1 shows, the automobile is part of a complex web of interactions. To determine its place in a sustainable environment, we must examine its impacts and devise solutions that effectively respond to this entire range of interactions.

The car and the economy

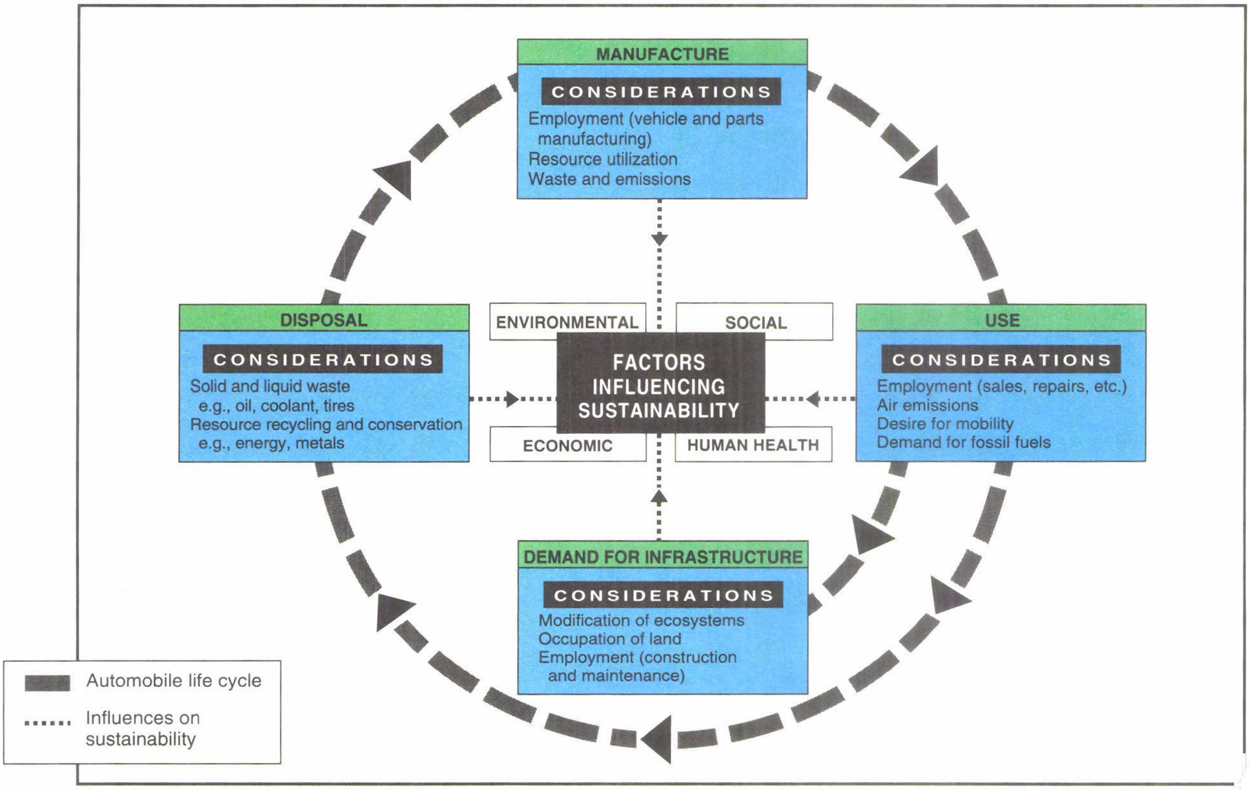
In Canada, the demand for automobiles and associated products and services has stimulated activity in virtually every sector of the economy, contributing to a standard of living that is one of the highest in the world.

With the economic boom that followed the Second World War, car ownership rose dramatically. More people could afford to live and work in widely separated areas, and low-density suburbs

1 In this fact sheet, the term "automobiles" is used synonymously with "passenger cars," a group that includes both personal-use passenger cars and fleet vehicles. In contrast, "motor vehicles" is defined to include both passenger cars and light-duty trucks and vans.

CANADA'S GREEN PLAN

Figure 1
The automobile and sustainability



began to spring up at the edges of large cities and nearby towns. For the suburbanites, car ownership was not only a convenience but often a necessity.

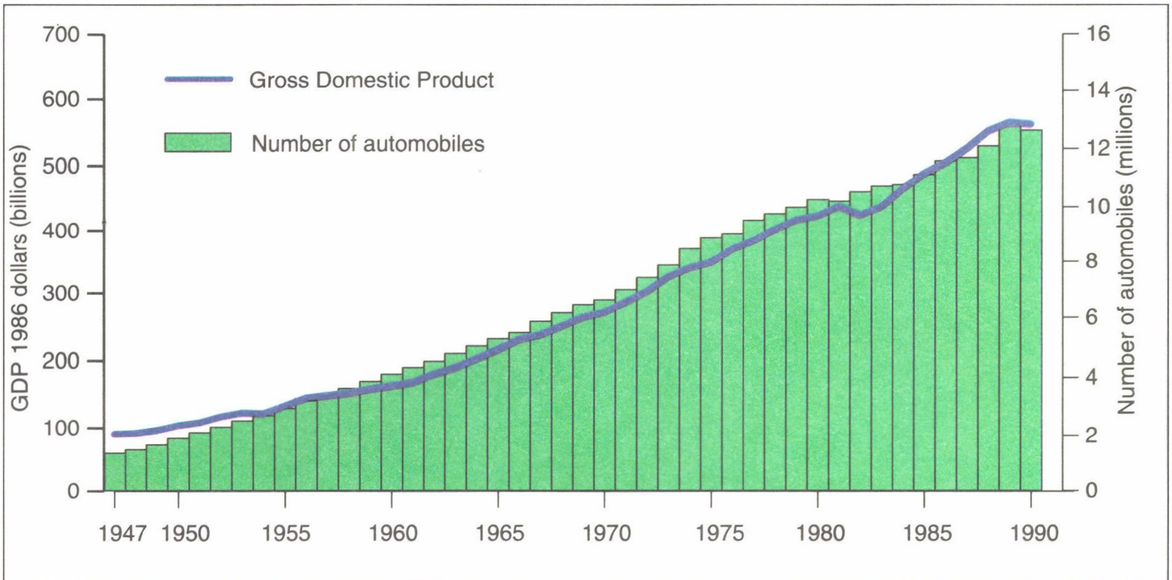
More cars and expansive development increased the demand for motor vehicle infrastructure, such as roads, bridges, and parking lots. More service outlets, dealerships, gas stations, autoparts stores, and other car-related services became necessary. Motels, restaurants, and retail businesses along well-travelled routes also began to benefit. Both directly and indirectly, the automobile had become an important influence on Canada's economic activity, employment opportunities, and development patterns.

In general, the fortunes of the motor vehicle industry have been a good indicator of those of the economy as a whole. In good economic times, car production increases; in bad times, it declines (Figure 2). And as the automobile industry goes, so go the many other industries, such as mining, manufacturing, and retail sales, that depend on it. In 1988, for example, the motor vehicle manufacturing industry used more than $30 billion worth of materials, indirectly stimulating demand in sectors such as energy and mineral resources (Statistics Canada 1988*a*).

Between 1986 and 1990, about 1.9 million motor vehicles and $35 billion worth of motor vehicles and parts were produced each year (ISTC 1991). The value of these goods was equal to over 6% of Canada's Gross Domestic Product and accounted for more than a quarter of the nation's exports (Statistics Canada 1990*b*, 1990*f*). In 1990, 572 000 people — roughly one out of every 20 working Canadians — were employed in jobs directly linked to motor vehicles. They earned approximately $16 billion in gross wages (Statistics Canada 1990*e*).

Retail sales of motor vehicles, parts, and associated services make up the largest proportion of Canadian retail activity — 35% in 1988 (Statistics Canada 1988*b*). Hotel, restaurant, and other retail businesses associated with domestic automobile travel amounted to $9.1 billion, or 64% of domestic travel spending, in 1990 (Statistics Canada 1990*c*).

Figure 2
The relationship between Gross Domestic Product and number of automobiles



Source: Statistics Canada (1990*a*, 1990*b*).

The car and the environment

Most Canadians are aware of the high-profile environmental concerns associated with automobiles, such as the consumption of fossil fuels and the subsequent air pollution that accompanies their use. While these are legitimate concerns, a number of less obvious but equally significant environmental stresses occur during the car's life cycle. These impacts are related not only to its use but also to its manufacture, demand for infrastructure, and disposal. Understanding the full spectrum of these impacts is an important first step towards minimizing the negative environmental effects of the car.

Motor vehicle manufacture

The transformation of raw resources and energy into motor vehicles gives rise to a variety of environmental consequences. The most important of these are the depletion of nonrenewable resources (including metals and energy) and the environmental stresses associated with the production and use of these resources.

Use of nonrenewable materials. In 1989, the average motor vehicle weighed 1 428 kg, 77% of which was metal (Table 1). It can therefore be estimated that more than 2 billion kilograms of metal could be used in the manufacture of the 1.9 million motor vehicles produced each year in Canada. While much of this metal is recovered or recycled when the vehicle is taken out of service, it is neither cost-effective nor technologically possible to recover all of the metal used in motor vehicle manufacture. Furthermore, because the number of

Table 1
Weights and types of materials utilized in the construction of an average motor vehicle,[a] 1989

Material	Weight (kg)
Plain carbon steel	643.6
High-strength steel	106.4
Stainless steel	14.1
Other steel	21.4
Iron	208.6
Plastics/composites	102.0
Fluids/lubricants	81.6
Rubber	61.1
Aluminum	70.7
Glass	38.6
Copper	22.5
Zinc	9.1
Other materials	47.5
Total	1 427.7

[a] Includes cars, vans, and station wagons.
Source: Government of Canada (1991).

vehicles being produced is growing, more metal is needed for the manufacture of new vehicles than can be obtained from old ones. Consequently, some depletion of nonrenewable resources is inevitable.

In addition, the extraction, smelting, and refining of these metals can give rise to a number of other concerns, such as land disturbances, leaching of metals from mine tailings, acid mine and saline drainage, runoff of milling effluent containing toxic reagents used to extract minerals from the ore, and release of nitrogen oxides (NO_x), volatile organic compounds (VOCs), sulphur dioxide (SO_2), carbon dioxide (CO_2), carbon monoxide (CO), particulates, and other pollutants (Government of Canada 1991).

Consumption of energy. As much as 20% of all the energy consumed throughout the life of a vehicle goes into its manufacture (Matsumoto 1984). It has been estimated that between 66 and 105 gigajoules of energy are needed to produce a motor vehicle, depending on the proportion of recycled materials used. This is equivalent to the energy contained in between 2 000 and 3 100 L of gasoline, or the amount of fuel consumed by 16 000 to 26 000 km of driving. Production of the 1.9 million motor vehicles made in Canada in 1989 would thus have consumed between 1.8% and 2.9% of Canada's end-use energy demand, or the energy used by the final consumer (Tien *et al.* 1975; Government of Canada 1991).

An amount of energy equivalent to between 2 000 and 3 100 L of gasoline is required to manufacture an automobile

The environmental stresses that may result from using this energy depend on its source. Fossil fuels, for example, emit SO_2, CO_2, NO_x, CO, and particulates, while nuclear power plants generate toxic radioactive wastes, which are often difficult to dispose of. Hydroelectric energy may cause ecological disruption through flooding. Regardless of origin, electric power requires the construction and maintenance of transmission lines and associated rights-of-way.

Canada's largest urban centres and accompanying automobile infrastructure are often built on prime agricultural land

Infrastructure and land use

The infrastructure required by the increasing numbers of vehicles on Canada's roads today can be linked to a variety of environmental effects, including the occupation of productive land and the alteration of ecosystems.

Overall, there are about 879 000 km of highways in Canada (Statistics Canada 1991). In urban areas, up to 42% of the land in downtown cores and 18% of the land in greater metropolitan areas may be occupied by motor vehicle infrastructure, including roads, rights-of-way, bridges, garages, retail outlets, and parking lots (Simpson-Lewis *et al.* 1979). In Toronto, 2% of the city's area is devoted specifically to parking (Macpherson 1988).

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Automobile infrastructure

Much of this land was once prime agricultural land. Urban development patterns, while beginning to change, are still often characterized by the demand for low population density suburbs and are based on the assumption that cars will be the primary mode of transportation. As most of Canada's largest urban centres — the Windsor–Quebec City corridor, for example, or British Columbia's Lower Fraser Valley — have typically developed in productive agricultural areas, motor vehicle infrastructure usually consumes some of the country's best farmland. The most recent data available show that, between 1981 and 1986, 55 200 ha of rural land near 70 Canadian cities was urbanized. Of this, 59% was prime agricultural land (Government of Canada 1991).

Roads and supporting services for vehicles affect the environment in numerous other ways as well. Road salt, leaked motor oil, and particulate emissions, for example, wash off road surfaces and concentrate in ditches and storm sewers. The extent of the contamination of water and land by these routes has not yet been determined. In addition, highway construction may alter traditional drainage patterns, and soil erosion and landslides may occur more frequently around roads and bridges. Roads may also divide otherwise undisturbed lands, interfering with the movements of wildlife and altering habitats.

The demand for fossil fuels

In 1990, transportation accounted for 29% of Canada's end-use energy demand. Retail sales of gasoline for motor vehicles accounted for 54% of this, or 16% of end-use energy demand (Statistics Canada 1990*d*). Although fuel consumption per vehicle has declined in recent years, a number of concerns remain. These include dependence on a nonrenewable energy source, the environmental damage that accompanies the exploration, extraction, refining, storage, delivery, and disposal of fossil fuels, and the pollution produced by combustion.

Consumption of energy resources. In 1988, the average personal-use passenger car was driven 6% farther but consumed 22% less fuel than its 1980 counterpart. The average fuel consumption of all in-use automobiles decreased from 16.5 to 12.0 L/100 km between 1980 and 1988 (Statistics Canada 1991). For new cars, the average consumption decreased from 10.2 to 8.1 L/100 km over the same period (Transport Canada 1991). Reduced engine size and vehicle weight have both contributed to improved fuel efficiency.

Energy production and delivery. About 35% of the crude oil that enters Canadian refineries is turned into motor gasoline. The processing and handling of these substances can result in such environmentally damaging events as oil and gas spills. Between 1985 and 1990, an average of 7.9 million litres of motor gasoline and 16.2 million litres of crude oil per year were reported to have been spilled in Canada during extraction, transportation, refining, storage, and delivery (NATES 1992). It is suspected that unreported events, such as the dumping of contaminated ballast from tankers and runoff from roads and sewers, may release even greater amounts (OECD 1991). Furthermore, leaking gasoline from underground storage tanks has recently begun to emerge as a significant contributor to the contamination of soil and water. A single litre of gasoline can make up to 1 million litres of water unfit for human consumption (Kruss *et al.* 1991).

In 1987, crude oil refineries collectively discharged, on a daily basis, 1 080 kg of oil and grease, 4 039 kg of suspended solids, 77 kg of phenols, 21 kg of sulphide, and 726 kg of ammonia nitrogen. However, a general downward trend in refinery discharges has been apparent. Between 1972 and 1987, discharges of oil and grease were reduced by 87%, suspended solids by 81%, phenols by 96%, sulphides by 99.5%, and ammonia nitrogen by 93%. In 1987, refineries were, on average, in compliance with monthly emission standards 94% of the time and with daily standards more than 99% of the time (Losier 1990).

In 1990, retail sales of motor gasoline accounted for 16% of Canada's end-use energy demand

VOCs, which contribute to the formation of ground-level ozone, are commonly released into the air when gasoline is transferred between facilities and vehicles are refuelled. In 1985, these processes contributed an estimated 6% of the human-released VOCs in Canada (Government of Canada 1991).

Fossil fuel combustion. Emissions from fossil fuel combustion can lead to a number of environmental and human health problems (Table 2). In the past 20 years, factors such as improved fuel efficiency, the increased use of emission control devices, and stricter new car emission control standards have contributed to a decline in per-vehicle emissions of some common pollutants. A new car today emits only 24% of the NO_x, 4% of the VOCs, and 4% of the CO of a new car in the early 1970s (Motor Vehicle Manufacturers' Association 1991). Between 1985 and 1990, total emissions of NO_x from automobiles decreased from 352 000 to 248 283 t, VOC emissions decreased from 412 700 to 340 838 t, and CO emissions decreased from 4.0 to 2.7 million tonnes (Kosteltz and Deslauriers 1990; unpublished data, Environment Canada, Pollution Data Analysis Division).

About 35% of the crude oil that enters Canadian refineries is turned into motor gasoline

Reduced automobile emissions may be contributing to improved urban air quality in some Canadian cities. For example, in Vancouver, Calgary, Toronto, Ottawa, Montreal, and Quebec City, where cars are a major influence on air quality, indicators such as ambient NO_2 and CO decreased by an average of 8.6% and 33%, respectively, between 1980 and 1990 (T. Furmanczyk, personal communication).

In spite of these improvements, the automobile remains a major source of some pollutants. A 1985 survey of national air emissions showed that gasoline-powered cars contributed 18.7% of total

Table 2
Major impacts of common pollutants associated with automobile use on human health and the environment

Emission	Health impacts	Environmental impacts
Nitrogen oxides (NO_x) include nitric oxide (NO) and nitrogen dioxide (NO_2), which is formed from the oxidation of NO.	• NO_2 is a lung irritant at high concentrations. • NO_2 may lead to depression of the immune system, with children and the elderly being at risk.	• NO_2 reacts with water to form nitrate (NO_3^-), a source of acid rain. • NO_2 contributes to the formation of ground-level ozone. • NO_2 is associated with suppressed vegetation growth. • NO_2 contributes to the corrosion of metals and degradation of textiles, rubber, and polyurethane.
Carbon monoxide (CO) is a gas produced through the incomplete combustion of organic materials.	• CO reduces the ability of the blood to carry oxygen, with smokers, persons with heart disease, and those with anemia being especially sensitive.	• CO may contribute to the formation of ground-level ozone by depleting the atmosphere's supply of hydroxyl radical (OH·).
Carbon dioxide (CO_2) is released by the combustion or decay of organic material.		• CO_2 is an important greenhouse gas, contributing to global warming.
Volatile organic compounds (VOCs) are a chemically diverse group of compounds that have at least one carbon atom and are highly volatile.	• Many individual VOCs (e.g., benzene) are known to have or are suspected of having human health effects ranging from carcinogenicity to neurotoxicity.	• VOCs contribute to the formation of ground-level ozone.
Ozone (O_3) is formed from the reaction of NO_x, VOCs, and sunlight.	• Exposure to O_3 is associated with changes in lung function, decreased immune function, and possibly the development of chronic lung disease.	• O_3 reduces agricultural productivity and the growth rate of trees. • Ground-level ozone is a global warming agent.

Source: Modified from Healthy City Office (1991).

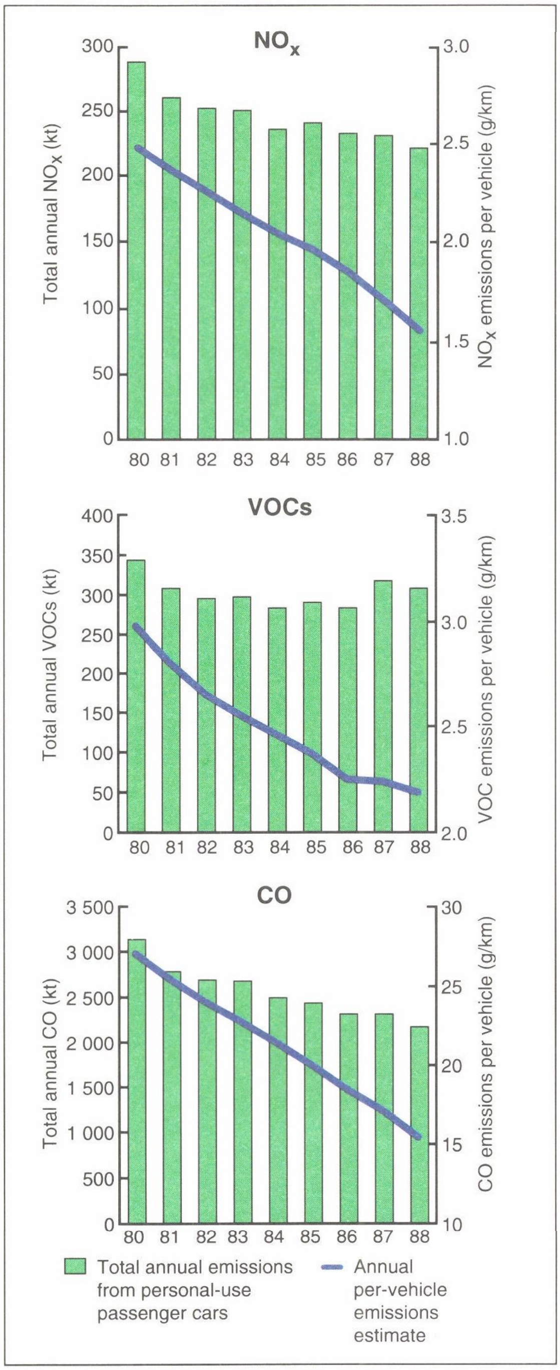
NO_x emissions, 22.9% of total VOC emissions, and 37.1% of total CO emissions (Kosteltz and Deslauriers 1990). Although emissions of these pollutants from the average personal-use passenger car decreased between 1980 and 1988, the total number of kilometres driven increased. As a result, the reduction in overall emissions was less dramatic than might have been expected (Figure 3).

The occurrence of ground-level ozone, a product of the interaction of NO_x, VOCs, and sunlight, should also be decreasing. However, because of the increased number of vehicles on the road, emissions of NO_x and VOCs still lead to concerns about ground-level ozone, especially in urban centres where automobile use is concentrated. The Lower Fraser Valley, the Windsor–Quebec City corridor, and the Southern Atlantic Region have been identified as problem areas, as they exceed Canada's maximum acceptable ground-level ozone objectives most frequently (Hilborn and Still 1990).

Canadian emissions of CO_2, which contribute to increasing CO_2 levels internationally and concerns of global warming, have decreased on a per-vehicle basis in recent years as average fuel efficiencies have improved. Nevertheless, between 1987 and 1990, total CO_2 emissions from automobiles rose slightly, from 48.4 to 49.0 million tonnes, as a result of the increase in vehicle numbers and use. In 1990, automobiles continued to be among the most important sources of CO_2 in Canada, accounting for almost 11% of our total emissions (Jaques 1992).

Disposal. Large amounts of waste motor oil, containing a diversity of contaminants ranging from PCBs to metals, enter the environment because of improper disposal. Of the estimated

Figure 3
Total annual and per-vehicle emissions of NO_x, VOCs, and CO from personal-use passenger cars, 1980–88



Source: Statistics Canada (1991); unpublished data, Environment Canada, Industrial Programs Branch, Transportation Systems Division.

230 million litres of waste motor oil generated by motor vehicles in 1990, approximately 50% was rerefined and 34% was used as fuel to power incinerators and furnaces. The remaining 16% — over 36 million litres — is believed to have been disposed of in ways that allow environmental contamination, including dumping in landfills and sewers and use as a dust suppressant (unpublished data, Environment Canada, Office of Waste Management).

Driving and maintenance habits

Technical improvements in fuel efficiency and emission controls can be offset by the driving and maintenance habits of automobile owners. A Vancouver study, for example, showed that passenger cars made up 98.4% of downtown rush-hour traffic but carried only 62.6% of the commuters (B.C. Transit 1990) — an inefficient use of transportation energy when compared with the use of public transit vehicles (Table 3). In addition, traffic congestion reduces fuel efficiency and increases pollution, as engines not running at maximum efficiency tend to consume more fuel and release proportionately more emissions. It has been estimated that a 16-km trip taken in light traffic and requiring 11 minutes would produce 2 g of VOCs; the same trip in heavy traffic and requiring 30 minutes would generate 7 g — a 250% increase (Go Green 1990).

Car maintenance also influences fuel efficiency and emissions. New vehicle emission standards for NO_x, VOCs, and CO assume a properly maintained vehicle. Unfortunately, many vehicles do not receive regular maintenance or may no longer have functioning emission control devices. Inadequate maintenance may result in emission levels 2–10 times higher, per car, than might be expected (B.C. Ministry of Solicitor General 1991). As a result, a relatively small number of vehicles may account for an unusually large proportion of emissions. One recent study suggested that nearly 50% of total emissions may be produced by only about 10% of all vehicles — mostly those that are older and poorly maintained (Ontario Round Table on Environment and Economy 1991). Vehicle emissions may often be lowered by simple repairs, such as replacing the air filter or spark plugs, resetting the engine timing, or adjusting the carburetor, measures that may also increase fuel efficiency and improve driving performance.

Inadequate maintenance may result in emission levels 2–10 times higher, per car, than might be expected

Table 3
A comparison of energy use by transportation mode

Transportation mode	Fuel or electricity use (L/100 km)	Number of commuters	Energy use (MJ/person-km)
Automobile	15	1	4.74
		6	0.79
	10	1	3.16
		4	0.79
	7	1	2.21
		4	0.55
Van	20	15	0.42
	10	7	0.45
Diesel bus	56	40	0.52
Subway	2.61 kWh/km	75 (per car)	0.13
GO Rail	761	810	0.35

MJ = megajoule
Source: Modified from Healthy City Office (1991).

Automobile air conditioners

Approximately 60% of the cars and light-duty trucks sold in Canada are equipped with air conditioners that contain chlorofluorocarbons, or CFCs, which contribute to stratospheric ozone depletion and global warming. Even well-maintained motor vehicle air conditioners leak CFCs during their normal functioning, and additional CFCs are usually released when air conditioners are serviced. Furthermore, old air conditioners release whatever CFCs they still contain when crushed at auto wreckers. In 1991, motor vehicles accounted for 23% of Canada's CFC consumption (unpublished data, Environment Canada, Commercial Chemicals Branch).

Disposal

Once automobiles, or any of their components, wear out, the issue of their disposal must be contended with. A great deal of material goes into the manufacture of a car, making discarded vehicles and components a significant source of metals, plastics, and rubber. Although some materials in scrapped cars are recycled, the disposal of others presents problems.

Much material goes into the manufacture of an automobile, making discarded vehicles and components a significant source of metals, plastics, and rubber

The disposal of tires illustrates the challenge. An estimated 19.5 million vehicle tires are discarded every year in Canada, about 13 million of which come from passenger vehicles (CCME 1990). However, no process exists for converting old tires into materials suitable for manufacturing new tires, in the way that new metal products, for example, can be made from old.

At present, 62% of discarded tires are landfilled, 18% are recycled or retreaded, 6% are burned in an environmentally acceptable manner as a fuel source, and the remaining 14% are stockpiled (CCME 1990). Although landfilling may not be a desirable method of disposal, stockpiling presents risks such as fires, the emissions from which contaminate adjacent air, land, and water. Such an event occurred in 1990, when 11.5 million discarded tires caught fire at a stockpile site near Hagersville, Ontario.

New technologies may lead to uses for discarded tires and change their status from waste to resource. Researchers are now exploring the incorporation of rubber from waste tires into plastics and asphalt. However, considerably more research will be needed before such uses will be accepted as operationally, economically, and environmentally feasible.

Meeting the challenge

A number of initiatives in Canada are aimed at addressing the multitude of environmental challenges presented by the automobile. Collectively, and in the long term, these actions will help to reduce the amount of environmental stress associated with automobiles.

Manufacturing

Manufacturing is a much cleaner process than it was a few decades ago, but many improvements can still be made through improved operat-

Ron Johnson

Burning tires at Hagersville

ing procedures, use of lower-risk materials, new technologies, emission controls, waste minimization, and energy conservation. The Canadian Motor Vehicle Manufacturers' Association, in cooperation with the Ontario and federal governments, now has a major program — the Automotive Pollution Prevention Program — to develop and implement strategies for pollution reduction in the industry. As a component of the Great Lakes Pollution Prevention Initiative, the program's first activities will focus on reducing the use and release of toxic substances in manufacturing.

Recycling

About 75% of the materials in scrap vehicles can be recycled (Siuru 1991). In fact, automobile recycling already contributes significantly to national production levels of some materials. The salvage of platinum from old catalytic converters, for instance, accounts for one-third of domestic platinum production. In addition to extending the life span of nonrenewable resources, metal recycling requires 50–74% less energy for production and releases 86% less air pollutants, 76% less water contaminants, and 97% less solid waste than metal production from ores (Government of Canada 1991).

Most metallic components, such as engine blocks, starting motors, and generators, can be and are reused or recycled, but nonmetallic items, such as plastics, fluids, and rubber, are more difficult to contend with. Car manufacturers are now intensifying their research on recycling, and especially on ways of dealing with nonmetallic components. In North America, one of the most recent initiatives has been the formation of the Vehicle Recycling Partnership to coordinate the research activities of the major automobile manufacturers and to establish recycling guidelines.

An important concept that has been receiving increasing attention is "design for recycling." The idea is that recyclability should be designed into the car from the beginning by selecting materials that can be recycled and by making the car easier to dismantle. Many manufacturers, for example, now label plastic components with standard codes to make it easier to sort them by chemical composition when they are recycled.

To encourage the recycling of certain other components, some provinces place a fee on their purchase. A few, for example, charge tire fees, with the objective of funding research into environmentally acceptable methods of disposal. In British Columbia, a similar system has been set up to facilitate the collection and recycling of lead-acid batteries, thus preventing them from being landfilled or burned. Such fees can help to reduce the landfilling of waste, particularly toxic items such as batteries.

Inspection and maintenance programs

Inspection and maintenance programs are aimed at reducing in-use vehicle emissions and are designed to detect vehicles with excessive emission levels. The Greater Vancouver Regional District's program, possibly the most comprehensive in North America, consists of an annual visual inspection of emission control devices and the measurement of tailpipe emissions. Owners are charged a fee for the inspection, and those whose vehicles do not meet the standards are required to restore them to proper operating condition before being issued registration or re-registration documents. Inspection and maintenance programs are in place or being planned for other regions of Canada.

Inspection and maintenance programs are aimed at reducing in-use vehicle emissions

Employer-sponsored initiatives

Some employers have taken steps to reduce the dependence of their employees on automobiles. These include flexible schedules that allow employees to commute during off-peak times or to work longer hours per day but fewer days per week; telecommuting, or communicating with work by phone, fax, or computer, which allows some employees to work out of their homes on a full- or a part-time basis; subsidized parking for employees who carpool, to encourage groups of employees to coordinate their commuting; and satellite offices that enable some employees to work closer to home and reduce commuting distances.

Alternative transportation modes

In areas of high population density, a shift to alternative transit modes can be encouraged by controlling access by cars, improving public transit systems, improving interfaces between cars and public transit (for example, park and ride), and creating and improving facilities for walking and cycling. In low-density suburban developments, where public transit is less practical, car- or van-commuting schemes may be more efficient (Reid 1986). As well as using less energy, alternative modes of transit produce lower emission levels per passenger (Table 4).

Reduction of accidentally released VOCs

The Canadian petroleum industry has installed equipment in the Vancouver and Toronto areas to recover releases of VOCs that occur during the transfer of gasoline between facilities (CPPI 1991*a*). In addition, refineries decreased the amount of butane added to summer gasolines in Canada in 1991 to reduce their volatility and thus minimize VOC releases during refuelling and transfer (CPPI 1991*b*).

CFC replacement in air conditioners

As part of Canada's commitment to phase out CFCs, automobile manufacturers will replace CFC-12 in air conditioners with hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) by the year 2000. HCFCs have considerably less stratospheric ozone-depleting potential than CFCs, while HFCs have virtually no capacity to deplete stratospheric ozone. Both groups of compounds appear to have significantly less impact on global warming than CFC-12. Some automobile manufacturers will voluntarily begin to use HFCs and HCFCs as soon as 1993 but will continue to service vehicles containing CFC-12 until the end of the century. Some also plan to install recycling equipment in authorized service centres to reduce CFC-12 losses during servicing.

Table 4
A comparison of emissions by transportation mode (g/person-100 km)

Transportation mode	NO_x	VOCs	CO
Light rail	43.0	0.2	2.0
Transit bus	95.0	12.0	189.0
Van pool	24.0	22.0	150.0
Car pool	43.0	43.0	311.0
Single-occupant car	128.0	130.0	934.0

Source: Modified from Lowe (1990).

New emission standards

Automobile manufacturers have voluntarily agreed to introduce, in Canada, vehicles that meet the stringent exhaust emission standards being progressively introduced in the United States beginning in 1994. These vehicles will emit 60% less NO_x and 29% less VOCs than are currently allowed. The government is developing comprehensive emission control regulations to be effective in the 1996 time frame.

Alternative fuels

Currently available alternatives to gasoline include propane, natural gas, methanol, ethanol, and oxygenated gasolines (varying mixtures of gasoline and alcohol) such as M85, which is 85% methanol and 15% gasoline. These fuels burn more efficiently than gasoline and thus emit fewer pollutants. Furthermore, ethanol and methanol can be produced from biomass and are therefore renewable. Domestic automobile manufacturers have recently begun to introduce flexible-fuel vehicles that can run on conventional fuel as well as M85 or ethanol.

Electric vehicles or those powered by hydrogen cells may provide a renewable and even cleaner generation of alternatives to gasoline. In fact, with the development of more efficient batteries, some car makers are now preparing to introduce electric cars to the market. Hydrogen fuels are still in the experimental stages and will require additional research before becoming available to consumers.

The car and a sustainable environment

How can we ensure that the automobile is compatible with a sustainable environment? Certainly there is no simple answer. Cars are likely to be a permanent fixture of industrialized and emi-industrialized societies for some time to come.

Nor can we rely exclusively on technology to put the issue to rest. Technological improvements over the last 20 years have already done much to reduce the environmental impact of the individual car, and further improvements can be expected in coming years. But much of the ground gained through technological improvements is being lost as more and more cars crowd the roads. To offset the effect of growing numbers, we shall have to look to other solutions — urban planning initiatives, economic strategies, and education — to lessen our dependence on the automobile. Eventually, these solutions could give us a more varied choice of transportation options in which the car plays a more efficient role.

Whatever the solutions we choose, they must work within an international as well as a national context. Nothing is accomplished if some of the problems, such as those associated with manufacture or disposal, are simply transferred from one country to another, thus solving problems at home but passing on challenges to global neighbours.

With continuing population growth and rising standards of living, the demand for car ownership will continue to increase. Because of that, we are unlikely to find an ultimate solution to the environmental problems associated with the automobile. Instead, we shall always have to confront the task of balancing the demand for cars with our need for a sustainable environment. That means that the issue must constantly be readdressed, with new solutions devised and old solutions reworked as conditions change.

Above all, we have to recognize the complexity of the many issues surrounding the car and look for solutions on a multitude of fronts — technological, social, economic, political, and ecological. Such a holistic approach is our best chance for preserving the benefits of the car while keeping its environmental effects within the limits of sustainability.

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