CLIMATE CHANGE AND TRANSPORTATION:
ALTERNATIVE TECHNOLOGIES FOR PASSENGER VEHICLES

Passenger Vehicles and Transportation Sector Emissions

The transportation sector continues to be a significant contributor of greenhouse gas (GHG) emissions in Canada. In 2003, it is estimated that transportation related emissions accounted for 26 per cent of all GHG emissions in Canada. Passenger car (27.8%) and passenger light truck (22%) emissions combined represent over 49 per cent of transportation sector GHG emissions. In Alberta, the most recent information available (2003) indicates that the transportation sector accounted for 14 per cent of the total GHG emissions in the province, and that 37.5 per cent of transportation sector emissions resulted from passenger cars and light trucks.

Trends Influencing Passenger Vehicle Emissions

While some degree of regional variability does occur in regard to passenger vehicle emissions, particular trends continue to manifest across Canada. The net result of these trends is continuing growth in passenger vehicle GHG emissions, from 150,000 kT in 1990 to 190,000 kT in 2003.

- *The passenger vehicle population in Canada continues to grow*. Over the period 1990-2004 the number of passenger vehicles (gasoline and diesel automobiles and light trucks) in Canada increased from 14.7 million to 18 million.

- *The distance travelled annually has been increasing*. The total distance travelled in Canada has risen from 247,402 million kilometres in 1996 to 286,271.2 million kilometres in 2003. This trend of increased mobility is projected to continue.

- *The impact of the changing mix of vehicles*. Over the past decade, North American sales of light-duty gasoline trucks, vans, and four-wheel drive vehicles have been increasing at a much faster rate than automobile sales. In Canada over the period 1990-2003 the population of passenger light trucks increased by 48.2 per cent while the number of cars being driven *declined*. The net effect has been an increase in total fuel consumption. Light trucks and vans tend to travel longer distances than cars and station wagons, 18,100 km and 15,800 km respectively in 2002.
  Source: Canada's Greenhouse Gas Inventory, 2003 Emissions and Removals with Trends and Transportation in Canada 2003.

Reducing Emissions from Passenger Vehicles

There are two broad strategies for reducing emissions from passenger vehicles, change the manner in which we engage in transportation activities, and change the very nature of transportation. The first strategy involves behaviour modification. Individuals alter their transportation habits and make less GHG intensive transportation choices and practices. The second strategy involves both incremental and extensive changes to vehicles and transportation infrastructure, and the development of new technology to be implemented over the short, medium, and longer-terms. Given the current trends in passenger vehicle numbers, use, and preferences, technological innovation and advancement in vehicle design and propulsion systems will be necessary for reducing emissions from passenger vehicles.

Modifications to Current Vehicle Design and Engineering

In passenger vehicle applications, internal combustion engines convert the heat released by the combustion of fuel into mechanical energy to drive the wheels. Due to limitations in engine design, friction and heat loss reduce the overall efficiency of this process. As a result, numerous strategies are under development for improving the efficiency of internal combustion engines, including the following:

- running the engine at the lowest speed at which the required power can be generated
- increasing combustion speed, to improve the combustion process and increase efficiency
- increasing the compression and/or expansion ratios of the engine to improve efficiency
- using design features that minimize engine size
- incorporating design features that minimize throttling losses and friction, improving engine efficiency
- reducing engine friction and parasitic losses (efficiency losses to accessories such as air conditioning)
- reducing heat loss to the coolant
- recapturing and using exhaust heat energy.

Fuel economy can be increased through vehicle weight reduction and drag reduction. Weight reduction measures generally involve the use of alternative materials in the design of the vehicle and its components, which includes minimizing engine size. Measures to reduce drag include designing more aerodynamic vehicles and minimizing friction between vehicles and the road surface. Together, reducing weight and drag may be achieved through the following:

- using aluminum bodies
- using high-strength steel bodies
- using lightweight engine components
- other materials substitution

- using lower rolling-resistance tires
- incorporating vehicle design changes
- improving the aerodynamics of passenger vehicle design
- reducing the brake drag (on most vehicles there is some contact between brake pads/shoes and the braking surface when the brakes are not applied).

The technology for most of these measures is currently available. High costs prevent these vehicle improvements from being implemented.

Progressive Vehicle Technologies

Reducing GHG emissions from passenger vehicles requires technologies that improve vehicle fuel economy or fuel efficiency. Through improvements in fuel efficiency vehicles will require less fuel, resulting in fewer emissions. Improvements may be achieved through modifications to current vehicle design and engineering in the near term. The outlook for the medium to longer term will involve advanced materials, hybrid technology and/or fuel cells, among other technologies. Of note, there is some indication that progressive technologies may be incorporated into the passenger vehicle market faster than previously anticipated.

In September 1993, the US Government formed a partnership, The Partnership for a New Generation of Vehicles (PNGV), with Chrysler Corporation, Ford Motor Company, and General Motors Corporation, to initiate development of vehicles that would achieve three times the fuel efficiency of conventional ones. By January 1998 the technology selection process was completed, identifying four key areas for further research that would enable the goal of the partnership to be achieved:

- hybrid-electric vehicle drive
- direct-injection engines
- fuel cell technology
- lightweight materials.

This partnership has been succeeded by the FreedomCAR (Cooperative Automotive Research) and Fuel Partnership, initiated in 2003, whose goal is to produce cost-effective, emission-free and petroleum-free cars. This program covers different vehicle systems and different fuels available to achieve these goals. The partnership also includes the Hydrogen Fuel Initiative, which aims to enable industry to decide on the feasibility of the commercial production of fuel cell vehicles by 2015. For the first report on this program (2005), please see:
http://www.nap.edu/openbook/0309097304/html/index.html

1. Hybrid-Electric Vehicle Drive

Hybrid propulsion systems have two power sources onboard a vehicle. The first power source may be a combustion engine, fuel cell, or gas turbine, which convert fuel into usable energy. The second power source is an electric motor that lowers the demand placed on the first power source. Depending on the situation, either or both of the power sources may be in operation. For example, under city driving conditions the electric motor may be sufficient to propel the vehicle, while the combustion engine would operate on the highway, and if a steep incline was encountered both power sources may operate in tandem. The end result is superior fuel economy. Another advantage of hybrid technology is that the energy normally lost during braking can be captured and used to regenerate the electric motor onboard.

The hybrid vehicles and their current availability are listed below:

Vehicle	Date Available
Honda Accord Hybrid	Available
Honda Civic Hybrid	Available
Honda Insight	Available
Ford Escape Hybrid	Available
GMC Sierra / Chevrolet Silverado Hybrid	Available
Toyota Highlander	Available
Lexus RX	Available
Toyota Prius	Available
Nissan Altima	2006 - 07
Dodge Ram	2006 - 07
Lexus GS	2006 - 07
Saturn Vue	2006 - 07
Chevy Malibu	2007
Toyota Camry	2007
GMC Tahoe / Chevrolet Yukon	2007
Dodge Durango	2007
Toyota Sienna Minivan	2007
Porsche Cayenne	2008

2. Direct-Injection Engines

Direct-injection engines exhibit an efficiency advantage over conventional combustion engines by injecting fuel directly into each engine cylinder. Researchers are optimistic about integrating already efficient direct-injection engines into hybrid vehicle applications to achieve further fuel economy improvements.

This technology is widely used in heavy-duty diesel vehicle and equipment applications for 20-40 per cent increased efficiency over traditional diesel engines. Vehicles that offer a direct injection engine include the Volkswagon Beetle, Golf, Jetta, Passat, and Touareg; the Mazda Atenza; the Jeep Liberty, which are rated as the most fuel-efficient vehicles offered in North America in their respective classes (excluding the hybrid vehicles).

3. Fuel Cell Technology

Over the longer term, fuel cell technology could result in zero or near-zero emission vehicles with equivalent range, performance, and refuelling of conventional vehicles. Fuel cells generate electricity via a chemical reaction between hydrogen and oxygen, which is used to power a traction motor that drives the wheels of the vehicle. The hydrogen can be carried onboard as a compressed gas or it may be derived (reformed) from any hydrocarbon fuel, including gasoline, natural gas, methanol, ethanol, or propane. Ongoing research is focussed on reducing fuel cell size, lowering production costs, and developing efficient, compact onboard fuel reformers to provide hydrogen.

4. Lightweight Materials

In addition to changes in vehicle propulsion systems, advanced materials that combine weight savings with increased strength will be integrated into vehicle design and engineering. The aim of FreedomCAR is to develop lightweight materials, and materials processing technologies, that are cost-effective but also functional, durable and safe. Aluminum, steel, plastics, magnesium, and composites (carbon fibre, metal matriceswill likely all be utilized. Current research focuses on vehicle manufacturing methods, design, structural engineering, and increasing the recyclability of new materials. Materials research has been and continues to be a critical component of vehicle engineering.