Transportation fuels outlook

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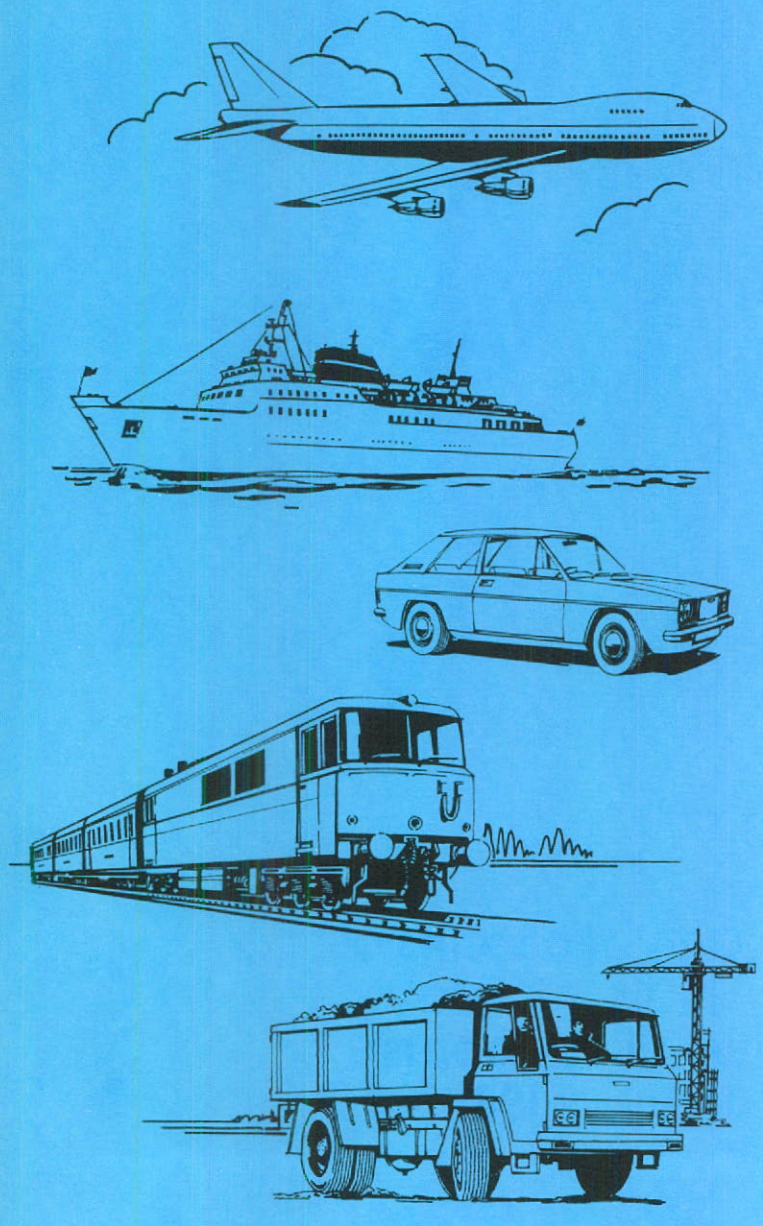


Transportation fuels outlook

No other area of energy demand has a closer relationship with the oil industry than transportation. Almost every facet of major transportation — road, rail, air and marine — is dependent in some way on product refined from crude oil.

Declining oil supplies and higher prices are placing new emphasis on fuel efficiency in car and aircraft design and on possible developments in alternative automotive fuels. Although driving habits may change, there seems to be no practical substitute for automobile travel in a suburbanized society in the foreseeable future.

This briefing paper, prepared as an information service by Shell Canada, provides current demand projections for transportation fuels in Canada to 1990 and beyond. These forecasts have been developed by Shell Canada and are based in large measure on assumptions of economic growth, population trends and disposable income, all of which affect the long-term growth potential for new vehicle sales.

Conversion Factors

1 petajoule = 10^{15} joules = 1,000 trillion joules

1 joule = 0.00095 British Thermal Unit
A B.T.U. is the amount of heat required to raise one pound of water one degree Fahrenheit

1 litre = 0.220 gallon = 0.0063 barrel

Transportation Energy Demand

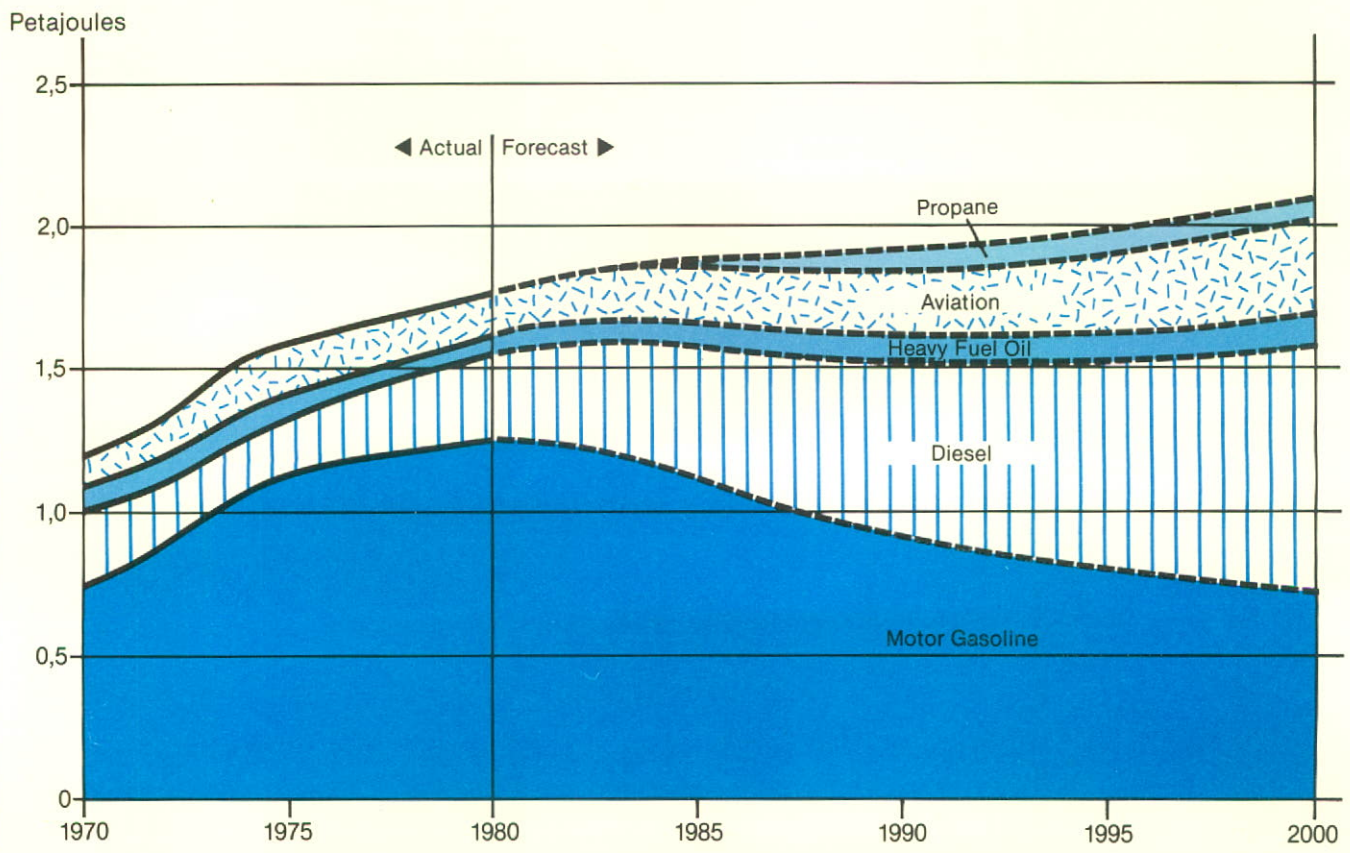
Just over 150 years ago most people could not conceive of a world in which the horse was not the primary form of transportation. Then along came the steamship, steam locomotive, internal combustion engine and jet propulsion.

Transportation in the 20th century has evolved rapidly and in step with gigantic developments in oil discoveries and refining methods. But gasoline shortages and sudden price increases in the 1970s turned attention to conservation and more efficient utilization of non-renewable fossil fuels.

Growth in transportation energy demand during the 1970s averaged about 4.5 per cent annually. This rate is forecast to level out in the 1980s and remain below one per cent in the 1990s.

This slowdown will reflect an expected easing in over-all growth of total energy demand in Canada, primarily resulting from a decline in motor gasoline requirements beginning in the early 1980s. Nevertheless, transportation's share will remain at slightly more than one-quarter of total demand to the end of the century. Industrial, commercial and residential sectors make up the balance of energy demand.

Projected Shares of Transportation Fuel



Diesel Penetration

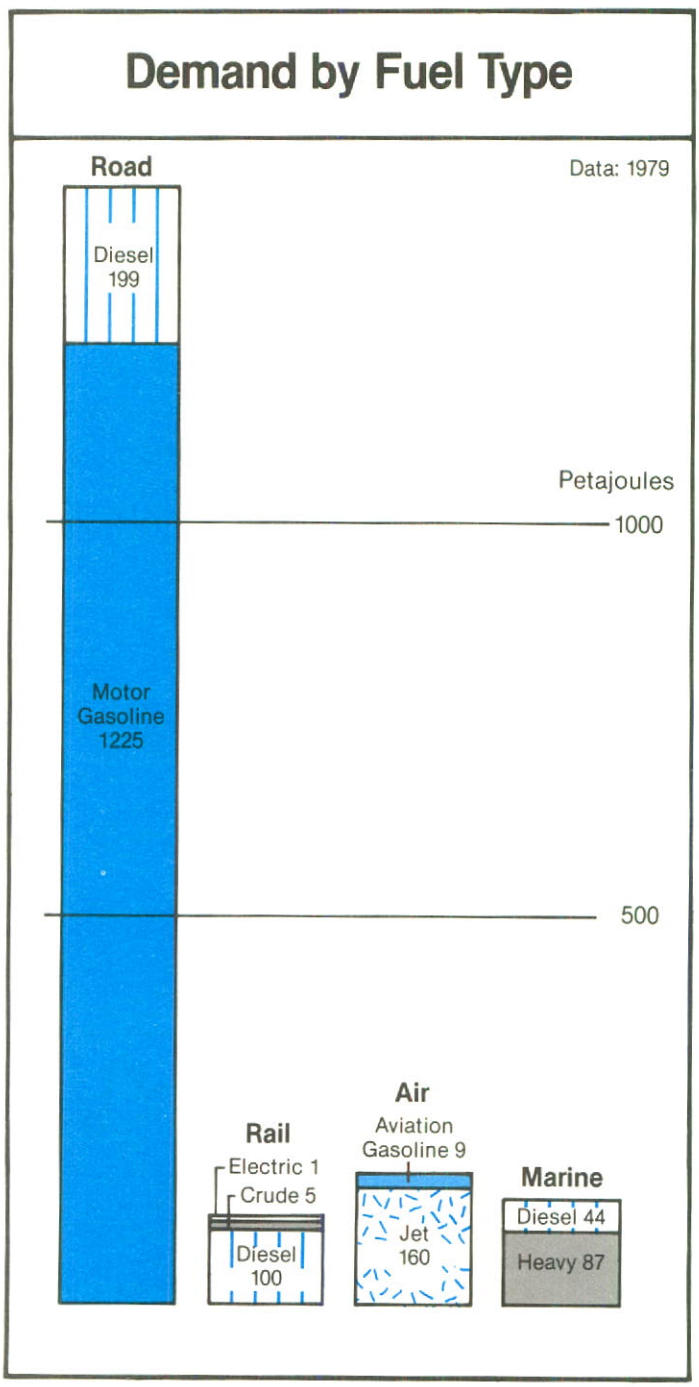
Motor gasoline in absolute volumes is expected to peak in the early 1980s and then decline sharply, falling to slightly more than one-third of total transportation energy demand by the year 2000 from almost three-quarters in 1979. This assumes that diesel engines will penetrate the new vehicle market by 10 per cent in both car and light truck sales by 1990.

As a result, demand for diesel fuel in the transportation sector is forecast to grow at five per cent annually. Its share of total transportation energy, including some growth in the rail and marine segments, is expected to more than double to 40 per cent by the end of the century from about 18 per cent in 1979.

Propane will begin to make a significant appearance as a fuel in the mid-1980s as governments move to encourage its substitution for gasoline in internal combustion engines. It is expected to increase at an annual rate of some 20 per cent through the 1990s and represent about five per cent of total transportation energy by 2000.

Aviation fuel demand has grown rapidly and it is expected to increase its share of total transportation energy to nearly 15 per cent by 2000 from nine per cent in 1979.

Heavy fuel oil for transportation is used mainly in marine services. Its share is not forecast to change much through the remainder of this century.



Sources of Demand

Road transport accounted for approximately four-fifths of total transportation energy demand at the end of the 1970s, overshadowing energy demand by all other forms of transportation. Of this, 85 per cent was for motor gasoline.

Diesel fuel for road, rail and marine uses was the second major source of transportation energy, filling 18 per cent of total demand.

Changing Vehicle Market

During the last two decades, the percentage of households with one or more automobiles increased rapidly. This growth is not likely to continue in the years ahead as saturation levels in the vehicle market are approached.

Car owners as a group will still change old cars for new ones. But the size of this replacement market has been difficult to predict in the short term because of consumer sensitivity to fluctuations in the economy and to changing perceptions of model style and energy supply.

Most of the new fleet, according to vehicle manufacturers in North America, will consist of front-wheel-drive cars with engines mounted crosswise, offering maximum interior space relative to over-all car size and weight. In addition, fuel economy has become an important factor to the buying public.

Though lightweight materials will be used extensively, most economy gains will come from downsizing and more efficient engines. No new propulsion technologies are likely during the 1980s; the present internal combustion (spark-ignited reciprocating) engine will remain the dominant powerplant.

Advances continue to be made in battery design for electric vehicles. But it remains difficult to predict when or if a break-through will occur allowing such vehicles to be cost-competitive with increasingly efficient gasoline/diesel vehicles.

Slower Growth Rates

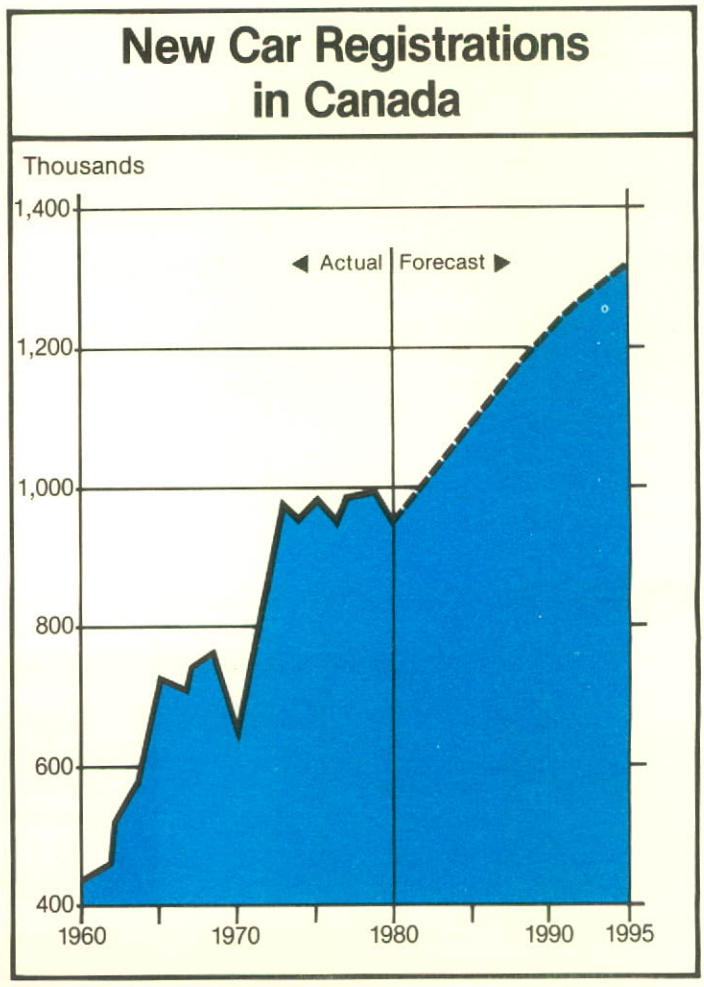
Growth in new vehicle sales in Canada during the 1980s is expected to be trimmed to half the 4.5-per-cent annual rate experienced since 1960. This reflects forecasts of declining birth rates, smaller families, slower growth in multi-vehicle households and rising vehicle ownership and maintenance costs.

Total passenger car registrations are projected to grow at an average rate of less than two per cent annually to 1990, down sharply from rates of 4.6 per cent in the 1970s and 4.9 per cent in the 1960s.

One measure of future registrations is the historical relationship between population and number of cars. This ratio (persons per car) has been steadily declining in Canada from a high of 4.3 in 1960 to 2.4 in 1979. It is forecast to be about 2.1 in 1990.

Assuming the Canadian population grows to 26.5 million in 1990 from 24 million in 1980, the resulting passenger car registrations (including gasoline and diesel engines) will be 12.5 million.

North America and Western Europe are relatively more car intensive than other regions. Vehicle saturation in Canada, at about two persons per car in 1990, will be second only to the United States where the ratio is moving to 1.9 persons per car. West Germany at 2.4 and France at 2.5 will closely follow Canada. By comparison, in the late 1970s the Soviet Union and Turkey had persons-per-car ratios of 25 and 60 respectively.



Better Fuel Economy

The advent of higher gasoline prices and stricter automobile emission controls resulted in significant adjustments by the automobile manufacturing industry in the late 1970s. Extensive research was conducted on engine efficiency. Stratified charge, for example, gets better combustion by using a super-rich charge of fuel and air to ignite a leaner mixture. Turbo-chargers to bolster the acceleration performance of smaller engines are becoming available on a growing number of car models. And the popular engine of the mid-1980s will likely have four rather than six or eight cylinders.

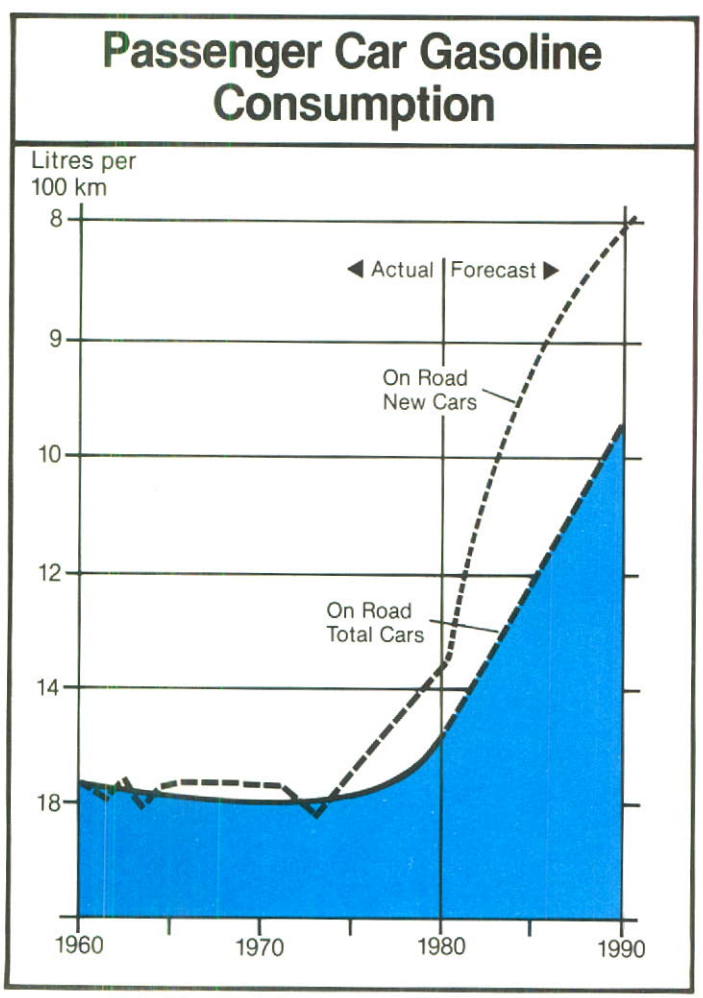
Prodded by consumer demand for fuel economy and by government-imposed pollution and efficiency standards, the average fuel economy of the total automobile fleet has shown an upward trend since 1975, and this is expected to continue through the 1980s.

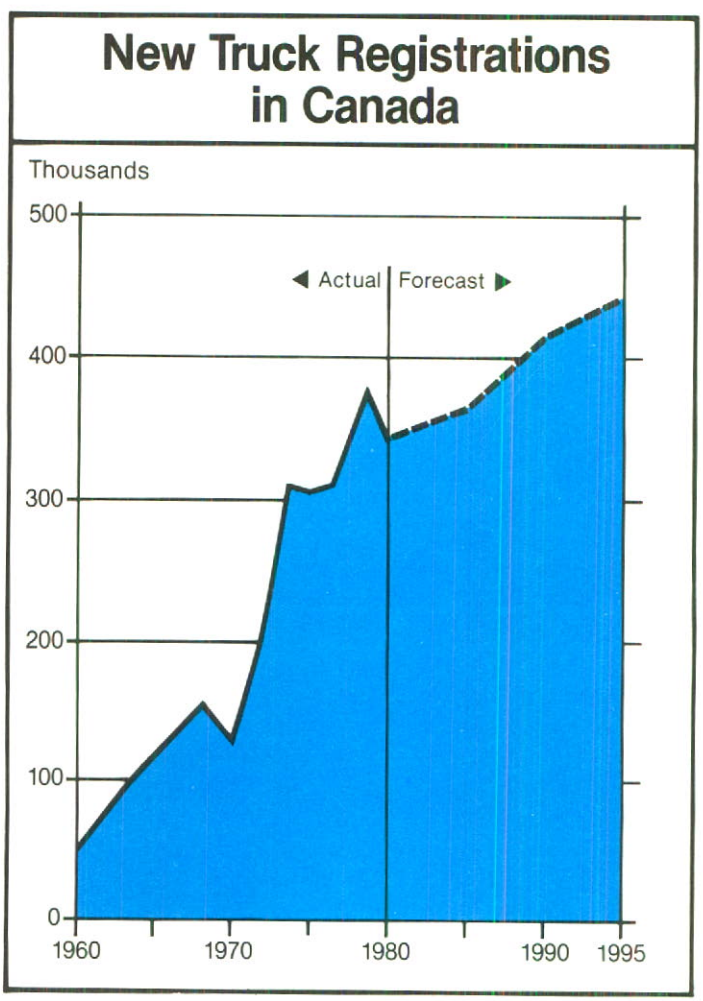
Contributing to these goals will be the sale of a greater percentage of small cars, the use of diesel engines in larger models, improved wind and rolling resistance and front-wheel drive.

Car Mix Changes

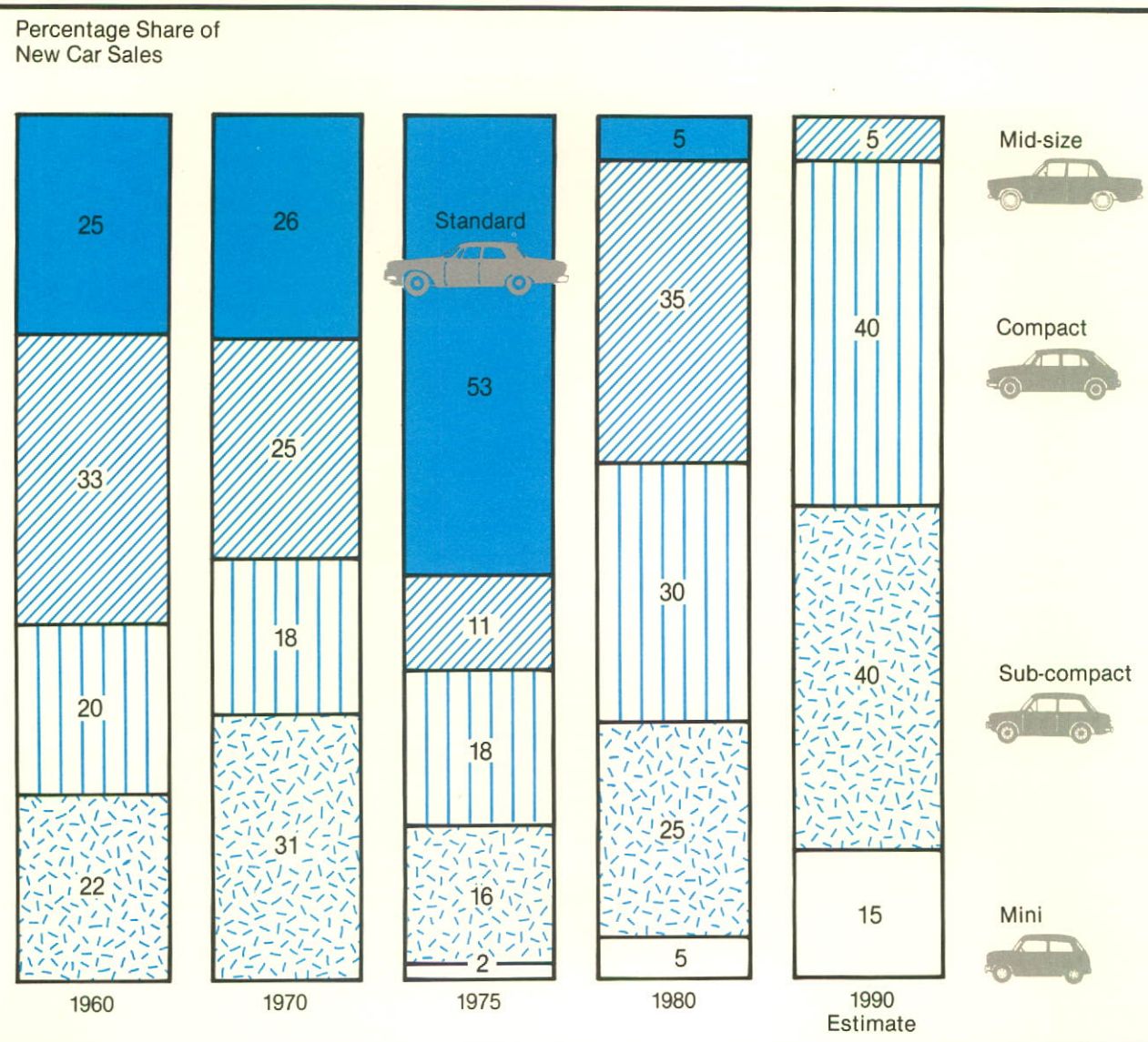
Consumer acceptance of sub-compact cars and downsized large cars is drastically changing the size mix of new cars. In 1980, the standard class (more than 4,000 pounds in weight) dropped to five per cent of the new car market from a high of 53 per cent in 1975. The share of mid-size vehicles (3,500 to 4,000 pounds) rose to 35 per cent from 11 per cent.

Mini cars (less than 2,000 pounds) are projected to increase to 15 per cent of the market by 1990 from two





Growing Trend to Smaller Cars



per cent in 1975, supported by consumer demand for high fuel economy, urban commuter vehicles.

Truck Registrations

Annual growth in truck registrations has historically been related to expansion in gross national expenditures (GNE). The boom in light truck sales during the 1970s, for personal transportation use and recreational vehicles, pushed the ratio of trucks per unit of GNE to 20 in 1979 from 14.5 in 1970. This ratio is nearing its peak as the truck market becomes saturated.

The annual growth rate in truck registrations in Canada, at a record 11.8 per cent during the 1970-79 period, will decrease to about two per cent in 1980-85 and about 2.5 per cent in 1985-90.

Diesel engine-equipped trucks will take an increasing share of the market in the 1980-90 period, moving from five per cent of total sales in 1980 to 26 per cent in 1990. The popularity of the diesel engine in the mid-range trucks for inter-city delivery is due to fuel efficiency, lower maintenance, durability and higher residual value. Heavy trucks, mostly diesel-powered at present, will likely be 100 per cent diesel in 1990.

Impact of Prices

There is an obvious relationship between demand for more fuel-efficient vehicles and rising prices for gasoline. Higher prices also reinforce the trend to greater conservation of available fuel.

Canadian motor gasoline prices have been the lowest among industrialized countries, both in actual

price per litre and in terms of minutes of work required to purchase a litre. The following table shows the comparison for prices in late 1980:

Price per Litre of Motor Gasoline

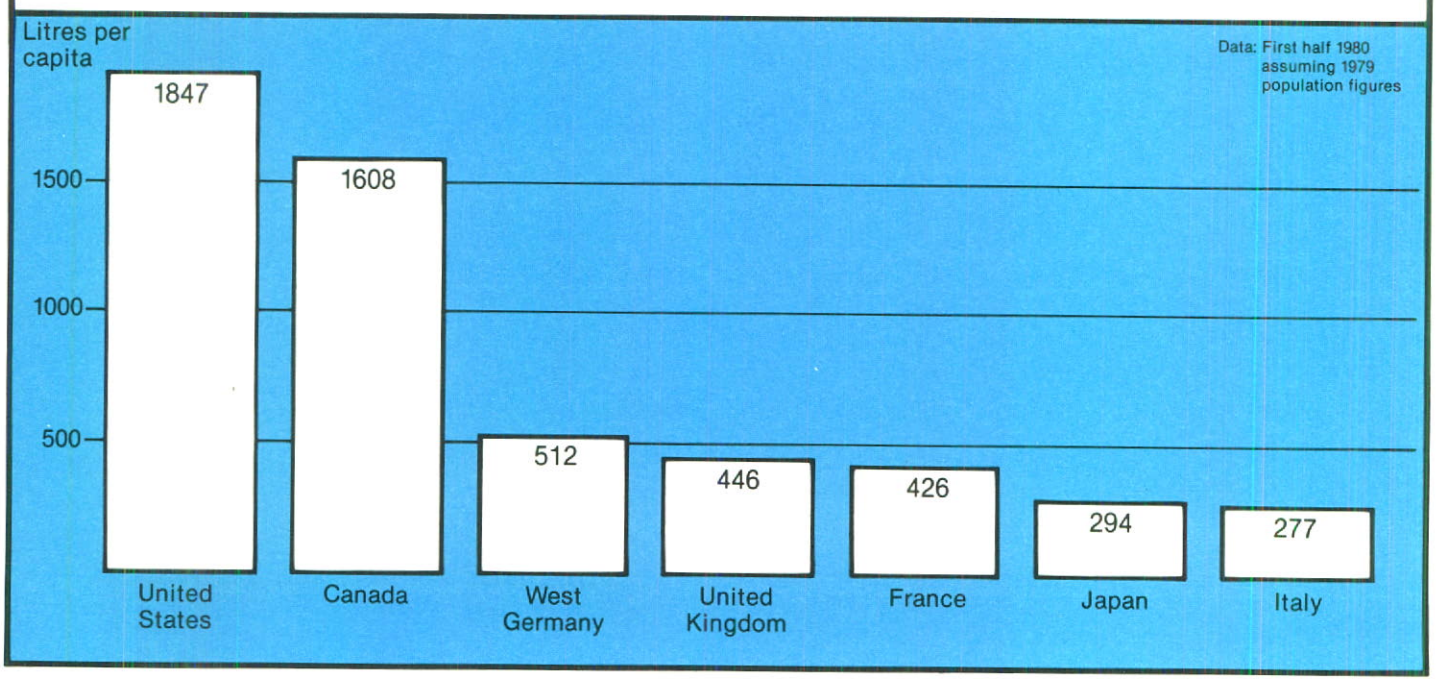
	Canadian cents per litre	Minutes of work per litre
Canada	27	1.9
United States	37	2.7
United Kingdom	76	6.2
W. Germany	78	5.6
Japan	90	6.0
France	90	11.2
Italy	101	9.2

Recent increases in U.S. prices contributed to a decline in consumption per capita, even though gasoline consumption per person in that country was the highest of seven industrialized nations. In Canada, where prices were lower, consumption grew on a per capita basis. Over-all, Canadian consumption was more than three times higher than in countries outside North America (see chart).

Aside from pricing factors, the changing motor vehicle market will influence the gasoline grades sold in future. Assuming that catalytic converters will remain the primary technology to meet legislated emission standards, demand can be expected to grow sharply for unleaded gasoline required with catalytic equipment.

Motor vehicle manufacturers' recommendations on fuel type in 1980 indicate that 84 per cent of the new cars will need unleaded gasoline. By 1985, the market share for unleaded gasoline (both regular and premium) is predicted to double to about 70 per cent from 35 per cent in 1979. Leaded gasoline will decline to 30 per cent of the total market.

Consumption of Motor Gasoline per Capita



Aviation Fuel Growth

Since the introduction of jet aircraft into commercial airline service in 1958, travel by air has become the preferred transportation mode for long-distance inter-city travel. Aviation fuel demand in Canada grew at a high average annual rate of 11.8 per cent between 1965-70 and seven per cent between 1970-75. With recent improvements in fuel efficiency and aircraft scheduling, demand growth eased significantly to an average annual rate of 4.3 per cent between 1975-79.

Most of the increase has been for commercial aircraft. The share for military and government uses decreased to about 10 per cent of the Canadian total in 1979 from 33 per cent in 1960.

Total aviation fuel demand in Canada in 1979 was 4784 million litres, with about 40 per cent of it consumed by major carriers in Canada — Air Canada and CP Air. A substantial total increase from the 1978 demand level of 4247 million litres was attributable to higher pick-up volumes in Canada by U.S. and other foreign carriers due to a favourable Canadian price and some availability problems at refuelling stations abroad.

Efficiency Improvements

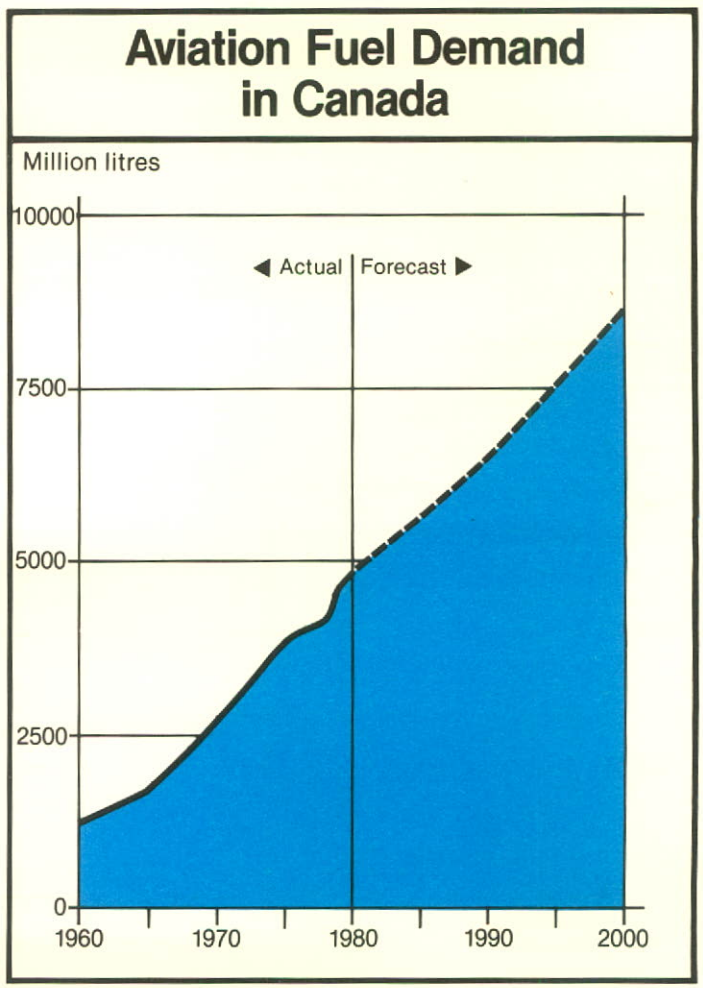
Major fuel efficiency improvements are expected in the 1980s as new wide-body planes, powered by more efficient engines, change the composition of airline fleets. Operational and other technological improvements are also likely to be introduced.

In countries where substantial fuel price increases have occurred since 1973, entire fleets of planes will be replaced sooner than planned. The replacements will have advanced aerodynamic design and engines that will improve energy efficiency up to 20 per cent over previous models.

Replacement of one major fleet in Canada with these aircraft and other new smaller aircraft should achieve an expected nine-per-cent improvement in fuel efficiency by 1989.

Demand Outlook

Future aviation fuel demand in Canada is expected to grow at an average annual rate of about three per cent to the end of the century. Total volume is forecast to reach 6610 million litres in 1990 and 8627 million litres in 2000. The share of jet fuel and aviation gasoline will remain relatively constant during the period — about 95 per cent jet fuel and five per cent aviation gasoline.



Alternate Automotive Fuels

Investigations into alternate automotive fuels have been going on for years. Wider interest recently has been heightened by increasing gasoline costs and uncertainties in international crude oil supplies.

Following is a brief summary of fuels most often discussed as alternatives to gasoline. They include petroleum-based substitutes such as diesel and propane, blends of gasoline and alcohol, hydrogen and battery power. Their assessment is from the consumer perspective of economy, performance, convenience, safety and cleanliness.

Diesel: The diesel engine provides superior fuel economy by approximately 20 per cent. Counterbalancing this advantage, diesel-powered vehicles are generally more expensive, noisier and harder to start. While diesels are low in carbon monoxide and unburned hydrocarbons, they also produce soot and nitrogen oxides in high quantities.

Propane: Propane-powered automobiles are appealing for their efficient use of fuel in urban settings, contribution to longer engine life and for low level of exhaust emissions. But they are less powerful than gasoline-powered vehicles, by almost one-third. In addition, the handling and distribution of propane is considerably more dangerous than gasoline.

Gasohol: This is a blend of alcohol and gasoline and requires no engine modifications so long as the alcohol does not exceed 10 per cent. Nonetheless, gasohol behaves as though the carburetor was adjusted to feed proportionately more air, relative to fuel, to the engine. In most cases, this causes hard starting, poor acceleration and an increased tendency to stall. On the positive side, the lean mixture effect contributes to a slight reduction in emissions. Although the alcohol component (commonly ethanol) degrades some plastics found in fuel systems, it also increases the octane rating of gasoline to provide increased resistance to engine knock. Gasohol must be handled with care — if it is contaminated with water, it tends to separate into distinct components of gasoline and ethanol. Ethanol is also more expensive than gasoline and, under present tax policies, gasohol would not be competitive.

Pure alcohol: Methanol has the greatest potential as a pure alcohol fuel, although it requires engine modifications. It can be produced from natural gas, coal or biomass (renewable organic matter such as forest, crop or other waste). Methanol can be burned efficiently and, in very lean mixtures, it is low in nitrogen oxide emissions. The major disadvantage is difficulty with cold starting. In hot weather, it has a greater tendency to develop vapour lock. Methanol degrades many plastics and elastomers in automotive fuel systems and corrodes many common metals. Thus, converting a standard automobile is costly because of the number of parts that must be changed. Methanol is more dangerous than gasoline — its vapours are toxic

Alternate Fuel Characteristics

	Diesel	Propane	Gasohol	Ethanol	Methanol	Hydrogen	Battery
Sources	Crude oil	Crude oil natural gas	Crude oil, corn	Corn, grains	Natural gas, coal, biomass	Natural gas, coal, electrolysis	Hydro heating fuel oil, nuclear
State of development	Commercial	Specialized commercial	Commercial	Prototype	Prototype	Prototype	Prototype
Engine changes required	Different engine	Moderate modifications	No modifications	Moderate	Moderate	Major modifications	Electric motor
Performance versus gasoline	More efficient, hard starting,	Less power	Approximately same as gasoline	Hard starting	Hard starting	Lacking power, limited range	Less power, limited range
Operating costs versus gasoline	Slightly lower	Higher	Slightly higher	Much higher	Much higher	Very high	Higher

and highly flammable. It is also impossible to clean up in the event of a spill because it is soluble in water.

Hydrogen: Hydrogen has been promoted as a fuel of the future because it can be derived from a variety of primary sources of energy. Under ideal conditions, the combustion of hydrogen only produces steam. The fuel tank in a hydrogen-powered automobile would have to be so heavy that it would undermine performance and limit driving range. Also, the tank would be slow and inconvenient to recharge. Moreover, the burning characteristics of hydrogen are significantly different from gasoline, therefore the standard automobile engine is not well-suited to hydrogen as a fuel.

Electric vehicles: Battery technology is developing, but electric vehicles in the foreseeable future will only be practical for urban use because of their low top speed, slow acceleration and limited cruising range. The advantages are silent, emission-free operation and, because of mechanical simplicity, low maintenance requirements. The costs of recharging batteries are expected to be low. Vehicle costs, by contrast, are expected to be high.

Future Prospects

In assessing these alternatives, gasoline is still projected to remain the predominant automotive fuel throughout this century. Prospects for growth of methanol, gasohol and propane are entirely dependent on special incentives that governments may use to promote them.

Electric vehicles could become increasingly competitive as battery technology develops and if the relative price of elecricity falls. They could account for up to five per cent of vehicle production in the 1990s.

Hydrogen has unlikely prospects as an automotive fuel. It has many serious drawbacks. It is more likely to replace gasoline in stationary applications or in jet aircraft, if price becomes competitive.

In Summary

- The transportation sector depends entirely, for its energy, on products of crude oil, principally gasoline and to a lesser extent diesel.
- The gasoline-powered internal combustion engine is likely to remain the major power form in road transportation for the remainder of this century.
- Motorists will demand, and manufacturers will produce, more fuel-efficient and smaller cars in future in response to rising gasoline prices and conservation awareness.
- Total demand for gasoline in Canada will peak in the early 1980s; diesel fuel demand is expected to increase sharply to the end of the century with growing popularity of diesel vehicles.
- No commercial fuel alternatives on a mass scale are yet on the horizon for crude oil-based gasoline and diesel; propane, however, is expected to make a small but visible impact during the next two decades.
- Automotive, aircraft and marine fuel demand will grow at a slower rate than in the last two decades, reflecting more efficient utilization of supply against higher costs.

Further information can be obtained from Shell Canada, Public Affairs Department:

P.O. Box 400, Terminal 'A'
Toronto, Ontario M5W 1E1

P.O. Box 2211
Vancouver, British Columbia V6B 3W4

P.O. Box 100,
Calgary, Alberta T2P 2H5

P.O. Box 6700
Winnipeg, Manitoba R3C 3A8

P.O. Box 430, Station 'B'
Montreal, Quebec H3B 3K2

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