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1. The Need for Fuel Consumption Data

The world oil crisis of the 1970's triggered significant changes in energy policy in Canada. Although it is a net exporter of energy, Canada did not escape the effects of rapidly rising world oil prices and concerns about supply interruptions. By 1980, imports of foreign oil totaled 425,000 barrels a day, or one quarter of total Canadian oil consumption.

The Canadian government began a series of programs to deal with the situation, culminating with the introduction in 1980 of the comprehensive National Energy Program. A major goal of this program is for Canada to ultimately become independent of the world oil market. In order to finance the necessary exploration and development of new sources of oil, Canadian oil and natural gas prices were scheduled to rise rapidly in the 1981 to 1986 period. Major programs were also implemented in each energy use sector to substitute more abundant energy sources, such as natural gas and electricity, and to conserve existing supplies of oil.

The transportation sector is the largest consumer of petroleum products. Transportation accounts for three out of every five barrels of oil consumed, with nearly four-fifths of this consumed by road motor vehicles. Consequently, energy conservation measures for automobiles have been a top priority. Among the actions which the government has taken are: (1) the establishment of new car fuel consumption standards, with the goal of reducing automobile fuel consumption by 40 percent by 1990; (2) the publication of The Consumption Guide and The Car Economy Book, intended to aid consumers in buying, driving and maintaining their cars to save energy; (3) the legislation of lower speed limits, which have now been implemented in all provinces.

The evaluation of such programs, and the development of future government policy in the transportation energy field, require basic data about on-the-road fuel consumption by motor vehicles driven in Canadian conditions. Until the advent of the Fuel Consumption Survey, the existing information was incomplete, insufficiently detailed, or out-of-date. Information on fuel sales by petroleum companies, for example, does not indicate how fuel use is split between cars and trucks or between personal and commercial vehicles. Statistics on vehicle registrations and new cars sales indicate the size of the vehicle fleet, but give little detail on its composition and how the fleet is being used. Information on the technological and environmental factors affecting fuel consumption have come only from laboratory experiments where operating conditions are closely controlled.

2. Development of the Fuel Consumption Survey

In mid-1977, Transport Canada approached Statistics Canada with a proposal to conduct a survey measuring actual, on-the-road fuel consumption of motor vehicles in Canada. The request came to the Special Surveys Division, the organization in Statistics Canada that manages surveys of a "special" nature providing data not produced as part

of the national program of statistical series. Drawing on specialists from various areas in Statistics Canada, the Division organized a multi-disciplinary project team, consisting of a project manager, survey methodologist, data processing expert, and a specialist in data collection procedures. The team's work was overseen by a steering committee formed of senior personnel from the various divisions represented on the team. Transport Canada funded the work on a cost-recovery basis, and provided both project team and steering committee representatives.

Working closely with officials of Transport Canada, Statistics Canada developed detailed survey objectives and data requirements, identified operational problems that would have to be overcome, and laid out a strategy for the implementation of an ongoing survey by 1979. Because this was the first time such a survey had been attempted, Transport Canada and Statistics Canada agreed to limit it initially to passenger cars operated for personal use.

Among the major objectives identified during discussions was the need to monitor both seasonal changes and long-term trends in fuel consumption and vehicle use. Another was to measure improvements in the fuel efficiency of new cars under actual operating conditions. The relationship between fuel consumption and vehicle characteristics (e.g., weight, number of cylinders and type of transmission), how the vehicle was maintained (e.g., tune-ups and maintenance of correct tire pressure), and how it was used (e.g., commuting versus long distance travel) were also of interest.

Deciding how to obtain an efficient and representative sample of vehicles was an important part of the feasibility study. Statistics Canada first considered using a household survey, selected by area sampling, to construct a sampling frame for vehicles. However, such an approach would have been expensive and time consuming. The emphasis on new model year vehicles would have required a large sample of households to obtain enough new cars. An alternate possibility was to use motor vehicle registration files for sampling. The project team visited each of the ten provincial motor vehicle agencies to discuss access to their files, the accuracy, completeness and currency of their files, and the costs to Statistics Canada to obtain the files. Based on these visits, it was concluded that the registration files could be a good frame of motor vehicles. In addition to the lower costs, the files contained vehicle data that would be useful in the sample design. The potential of the files as a source of statistics on vehicles not directly included in the survey was another factor in their favour.

Consideration of possible data collection methods soon made it clear that accurate measurement of fuel consumption, rather than verbal estimates from respondents, would require the respondent to keep a log of fuel purchases and odometer readings. In addition, the respondent would have to

fill the car's gas tank at least twice during the survey reference period.¹ The frequency of fuel purchases, the required accuracy of consumption estimates and the acceptable level of respondent burden suggested that a one-month reference period for the fuel purchase diary would be the most appropriate. Statistics Canada also proposed to ask respondents to complete a separate questionnaire describing how the vehicle had been used during the month. This Usage Questionnaire would contain questions on commuting patterns, long distance trips, how the car was maintained, and characteristics of the principal driver. As it would be a separate document, the content of this questionnaire could be changed as new aspects of fuel consumption became of interest.

Because of concern over the response rate to the survey, Statistics Canada decided to contact the owner of each vehicle just before the survey reference month in order to explain the survey and to ask for his cooperation in keeping a diary. This telephone survey would also serve to trace vehicles that had changed ownership or that had been scrapped, identify vehicles not in the survey population, and correct erroneous information on the frame. Eligible and cooperating respondents would then be mailed the diary, which they would mail back at the end of the following month. Respondents would also be telephoned a few days into the reference month to answer any questions and to remind them to keep the diary. Respondents who had not mailed back their diaries a week after the reference month would be telephoned to ask them to mail back the information.

Since none of these procedures had been tried before, a period of pilot testing and refinement was required. Between October 1978 and September 1979, Statistics Canada conducted a series of tests to evaluate the sampling and data collection activities. In the fall of 1978, sampling and telephone screening operations were tested in nine provinces (New Brunswick was excluded because it was in the process of converting from a manual to a computer registration system). In addition, fuel purchase diaries were mailed in Nova Scotia to test the rate and quality of response to this part of the survey. The results of these tests were encouraging, and were used to refine the methodology for a full-scale survey carried out in seven provinces during the July-September 1979 quarter. The methodology was further refined during this test, and a regular cycle of data collection, processing and publication began in all ten provinces in the fourth quarter of 1979. Personal use light trucks and vans were added to the survey at the beginning of 1981.

At this time, results have been published in quarterly bulletins covering the last six months of 1979, and all of 1980 and much of 1981. An annual report on the first full year of the survey was released this summer, and microdata tapes are also available.

Publication was delayed for several months by a lengthy re-design of the data processing system. The re-design was completed in May 1983 and bulletins for the remainder of 1981 and 1982 will be published in the coming months. The eventual goal is to publish quarterly results approximately six months after the end of the survey

reference quarter.

3. Some Results from the Survey

Analysis of results from the survey to date has concentrated on a description of the vehicle fleet in operation, the distances travelled, the fuel consumed, and the fuel consumption ratio² (fuel consumed per unit of distance travelled). These variables have been analyzed by vehicle characteristics such as model year, vehicle weight, number of cylinders and type of transmission, as well as by province and quarter.

Analyses involving how the vehicle was used (e.g., commuting, long distance trips), how the vehicle was maintained, and driver characteristics have not been attempted. Response rates to the Usage Questionnaire in its initial version were extremely low, and the questionnaire has been dropped for the time being.

One of the most interesting results is that the vehicle population in use is much younger than previously believed (Table 1). This table also shows the trend to greater use of newer vehicles, with average kilometres per vehicle declining with increasing age. Combining these two distributions, it is evident that a high proportion of vehicle use is accounted for by relatively recent model year vehicles.

Table 2 summarizes the age-distribution of vehicles operated and total kilometres driven. Over 45% of vehicles operated and 50% of total kilometres driven are accounted for by the four most recent model years. About 90% of both vehicles operated and kilometres driven are accounted for by the nine most recent model years.

Turning to seasonal variations, Table 3 shows a peak in vehicle use during the summer quarter. About 33 percent more distance is travelled than in the winter quarter, and about 17 percent more than in the fall quarter. The fuel consumption ratio also changes with the season. On average, vehicles used 17 percent more litres per kilometre during the October to December compared to the April to June quarter. Much of this difference is undoubtedly due to differences in climate, but the spring and summer months also contain a higher proportion of more fuel-efficient highway travel. The exact contribution of these two factors is unknown.

Table 4 shows the improvements that have taken place in the fuel consumption ratio during the past decade. The ratio rose slightly between 1973 and 1975 with the introduction of stiffer pollution standards in those model years, but since then fuel efficiency has steadily improved.

Of all the factors examined, however, vehicle weight has the greatest impact on fuel consumption. Table 5 illustrates its effect: the heaviest cars consume more than twice as much fuel per kilometre as the lightest cars. In fact, the recent improvements in fuel efficiency shown in Table 4 have been achieved primarily by reductions in the average vehicle weight.

Finally, stepwise multiple analysis was used to look at the effect of vehicle characteristics and distance driven on the fuel consumption rate. Table 6 shows a typical result from the third quarter of 1981. The cumulative R square reaffirms the importance of the vehicle weight, but the age of the car and the number of cylinders also enter into the equation. An interesting

finding is the negative coefficient for kilometres travelled. It has been interpreted to mean that vehicles travelling longer distances tend to have better fuel efficiency because a higher proportion of their travel is on the highway. The R-square value for the equation indicates that about 30 percent of the variation in the fuel consumption rate remains unexplained.

4. Future Directions for the Survey

Further development of the survey has been hindered until recently by its financial arrangements. With Transport Canada providing funding only on a year-to-year basis, personnel and other resources could not be permanently assigned to the project. Early in 1983, however, Transport Canada was able to make a three-year commitment to the survey. Hopefully, this will allow for its more orderly development.

One of the first priorities under the new arrangement will be to exploit the potential of the registration files as a source of statistics on motor vehicles. Descriptions of the entire motor fleet will be useful to planners in governments and private industry. To assist in the analysis of these files, Statistics Canada has recently purchased the "VINA" system from R.L. Polk and Company. This is a computer system that both verifies the Vehicle Identification Number and decodes it to give the make, model, weight, engine displacement, and other data. The system will also be useful in conducting the survey. Positive identification of vehicles during the sampling and the automated coding of vehicle data are two potential applications.

A second priority is to expand the coverage of the survey to other categories of vehicles and vehicle use. The major classes not covered by the present survey are commercially-used passenger cars, commercially-used light trucks and vans, and heavy trucks. A study to develop sampling and data collection methods for these vehicles will begin in the second half of 1983.

Several spin-off studies are also possible. A survey on vehicle maintenance has been developed, with field work scheduled for August 1983 and February 1984. Another study involves the oversampling of specific makes and models of vehicles. This would allow comparisons between laboratory measurements of fuel efficiency and measurements made under actual conditions of use.

Finally, there is a need for more information on the relationship between fuel consumption and specific trip characteristics. Very little is known, for example, about how total fuel consumption is split between commuting trips, shopping trips and business/commercial trips. The speed and distance of the trip, the type of roadway used, the weather conditions, and the number of passengers are a few of the other factors affecting fuel use.

Previous surveys, notably the National Driving Survey and the Canadian Travel Survey, have shown the viability of collecting detailed trip data from respondents. Unfortunately, the "fill-refill" method used in the present survey does not permit the measurement of the amount of fuel consumed for an individual trip. In order to do this, a vehicle would have to be equipped with an instrument, similar to an odometer, that accumu-

lates the amount of fuel consumed. Until this happens, surveys of trip making and surveys of fuel consumption will likely continue to develop along separate lines.

5. Conclusion

The past ten years have seen a rapidly developing awareness of the importance of energy in all sectors of the Canadian economy. Although the world oil situation has recently changed as a result of the economic times, the need for reliable data on transportation energy use is an established fact. New fuels, new technologies, and new ways in which Canadians view energy use will all make their effects felt. The Canadian Fuel Consumption Survey will continue to provide important information for the shaping of future energy policy in Canada.

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Footnotes

¹Measurement of fuel consumption is based on the "fill-refill" method. The respondent fills his tank at the beginning of the process; the total of all subsequent purchases including the amount of fuel needed to re-fill the tank at the last purchase is the amount of fuel consumed.

²The fuel consumption ratio is defined as the weighted average of the fuel consumption rates for individual vehicles, where each vehicle's rate is weighted by the distance driven.

³Estimates for this quarter are based on data for only July and September due to a postal strike which occurred in August 1981. This may account for the Fuel Consumption Ratio being higher in the summer than in the spring.

⁴The dependent variables was ln (Fuel Consumption Rate).

TABLE 1

Vehicles Operated, Kilometres per Vehicle, and Total
Kilometres Driven, by Model Year
(Reference Period October 1980 - September 1981)

<u>Model Year</u>	<u>Vehicles Operated</u>	<u>Kilometres per Vehicle</u>	<u>Total Kilometres Driven (millions)</u>
1980	574,300	20,404	11,718
1979	825,000	18,871	15,568
1978	945,900	15,735	14,884
1977	880,100	16,905	14,878
1976	891,800	17,671	15,759
1975	676,300	15,414	10,425
1974	637,300	12,252	7,808
1973	473,500	12,810	6,066
1972	361,700	12,569	4,547
1971 and previous	789,600	11,224	8,862

TABLE 2

Cumulative Percentages of Vehicles Operated and Total Kilometres
Driven, by Model Year
(Reference Period, October 1980 - September 1981)

<u>Model Year</u>	<u>Cumulative Per Cent Vehicles Operated</u>	<u>Cumulative Per Cent Kilometres Driven</u>
1980	8.1	10.6
1979	19.8	24.7
1978	33.2	38.2
1977	45.7	51.6
1976	58.4	65.9
1975	67.9	75.3
1974	77.0	82.4
1973	83.7	87.9
1972	88.8	92.0
1971 and previous	100.0	100.0

TABLE 3

Total Kilometres Driven and Fuel Consumption Ratio, by Quarter
(Reference Period, October 1980 to September 1981)

	<u>Total Kilometres</u> (millions)	<u>Fuel Consumption Ratio</u>	
		<u>1/(100 km)</u>	<u>MPG</u>
January-March	23,059	17.4	16.2
April-June	30,468	15.1	18.7
July-September ³	30,716	15.5	18.2
October-December	26,273	17.7	16.0

TABLE 4

Fuel Consumption Ratio, by Model Year
(Reference Period, October 1980 to September 1981)

<u>Model Year</u>	<u>Fuel Consumption Ratio</u>	
	<u>1/(100 km)</u>	<u>MPG</u>
1980	12.9	22.0
1979	14.3	19.8
1978	15.2	18.6
1977	16.5	17.1
1976	17.1	16.5
1975	18.7	15.1
1974	18.1	15.6
1973	18.1	15.6
1972	17.5	16.1
1971 and previous	19.6	14.4

TABLE 5

Fuel Consumption Ratio, by Vehicle Weight
(Reference Period, October 1980 to September 1981)

<u>Vehicle Weight</u>	<u>Fuel Consumption Ratio</u>	
	<u>1/(100 km)</u>	<u>MPG</u>
Under 1000 kg	9.7	29.2
1000 to 1271 kg	13.3	21.3
1272 to 1544 kg	15.6	18.1
1545 to 1816 kg	18.1	15.6
1817 kg and over	20.4	13.8

TABLE 6

Stepwise Multiple Regression Analysis of the Fuel Consumption Rate⁴
(Reference Period, July to September 1981)

<u>Independent</u> <u>Variable</u>	<u>Regression</u> <u>Coefficient</u>	<u>Standard</u> <u>Error</u>	<u>Cumulative</u> <u>R-square</u>
ln (weight)	0.646	0.038	57.2
ln (distance)	-0.132	0.008	66.4
ln (age)	0.049	0.007	67.5
ln (cylinders)	0.245	0.033	69.0
Constant Term	-1.578	0.232	

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