ENERGY CONSUMPTION INDICATORS AND BENCHMARKS FOR VEHICLES

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ABSTRACT

The Energy Efficiency Office (EEO) of the Electrical and Mechanical Services Department (EMSD) has recently completed a study on the development of energy consumption indicators and benchmarks for private offices, commercial outlets, private cars and light goods vehicles. This paper presented the findings of the study on vehicles, in particular, private cars.

The study provided insight into various factors affecting fuel consumption in Hong Kong. An interactive benchmarking software tool has also been developed to facilitate vehicle owners and drivers to compare the fuel consumption of their vehicles with others in Hong Kong and to identify ways to save fuel.

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BACKGROUND

Since its establishment in 1994, the Energy Efficiency Office (EEO) of the Electrical and Mechanical Services Department has been spearheading the promotion of energy efficiency and conservation programmes in Hong Kong. In order to enable better understanding of energy consumption patterns and to provide the government with the necessary information base for the formulation and evaluation of energy efficiency policies, EEO has been maintaining the Hong Kong Energy End-use Database which captures energy end-use data in all sectors in Hong Kong. The database is compiled using data from various statistical sources, surveys and estimations. It is updated on a year-on-year basis, and currently contains data up to the year 2000.

In order to acquire further in-depth information about energy consumption levels, the use of energy-efficient equipment, user awareness and practices, etc., the EEO commissioned a consultant in late 2000 to develop energy consumption indicators and benchmarks for major energy-consuming groups in Hong Kong. The results of the study enable users and operators to benchmark their own performance with others, identify areas for improvement, and set targets for energy saving. This is the first energy benchmarking exercise in Hong Kong that we are aware of.

The study focussed on four important energy-consuming groups selected from the commercial and transport sectors, which together accounted for 68% of Hong Kong's total energy consumption. The four groups selected are:

Commercial Sector
- Private Offices
- Commercial Outlets

Transport Sector
- Private Cars
- Light Goods Vehicles

This paper focussed on the results of the private car study. In Hong Kong, private cars account for about one-third of total end-use energy consumption of the passenger segment in the transport sector. They also represent the biggest numbers among the registered vehicles.

METHODOLOGY

In the study, all the selected groups were divided into sub-groups to ensure that data within each sub-group were sufficiently homogeneous, i.e. the survey subjects within the sub-groups should have reasonably similar energy consumption patterns. Otherwise the benchmarking process may not faithfully capture the characteristics of subjects which have/have not some particularly energy intensive activities. Specifically, private cars were divided into the following sub-groups according to the engine sizes:

- Engine size ≤ 1500 c.c.
- Engine size 1501 to 2000 c.c.
- Engine size 2001 to 2500 c.c.
- Engine size 2501 to 3000 c.c.
- Engine size > 3000 c.c.

Survey for the study was conducted in the form of intercept interviews undertaken at petrol stations. Questionnaires were set out to capture the vehicle details, trip making information and user awareness information. A mail-back form was used to collect information on the fuelling records of two consecutive full-tank refuelling, and on the distance travelled in between. The forecourt surveys were conducted in September 2001 and January 2002 to obtain data for hot and cold temperature conditions. A third sample was taken in the interim period in November 2001 for mild weather using mail-back forms from respondents recruited in the September survey.

The data collected were used to develop the ***primary*** and ***secondary*** indicators. Primary indicators are the common transport end-use intensity indicators of litre/100 km and litre/person-km. Secondary indicators are parameters which have major impact on the primary indicators, e.g. engine size, temperature, vehicle age, body type, transmission type, etc.

Regression analysis was performed to develop a regression model relating the primary indicators with the secondary indicators. In order to simplify the model, only those secondary indicators contributing high explanatory power were retained in the regression equation. Several tests were undertaken to check whether it was possible to produce a single regression equation for the whole of Hong Kong. However, as the traffic conditions in the urban areas in Hong Kong and Kowloon differed significantly from that in the sub-urban districts in the New Territories, the analysis yielded unsatisfactory results and three regression equations were therefore developed to represent each of the three regions.

Using the regression models, the benchmark percentiles for each sub-group were then computed. The regression models and the benchmarks were used for setting of improvement targets for individual users as well as for the whole sub-group.

KEY FINDINGS

A total of 5,936 valid fuel consumption results and 6,842 awareness data were obtained from the survey. The annual average fuel consumption is summarised in table 1.

Engine Size	Annual Average Fuel Consumption (litre/100km)			
	Hong Kong Island	Kowloon	New Territories	Hong Kong SAR Average
≤ 1500 c.c.	10.7	10.4	9.6	10.0
1501 to 2000 c.c.	12.2	12.0	10.8	11.3
2001 to 2500 c.c.	13.5	13.4	11.9	12.5
2501 to 3000 c.c.	15.2	15.2	13.3	14.1
> 3000 c.c.	17.7	17.9	15.3	16.3

Table 1 Annual Average Fuel Consumption in Hong Kong

The survey data were used to develop the multiple variable linear regression models for the fuel consumption for cars based in Hong Kong, Kowloon and New Territories. The resulting equations are as follows:

$Y = 1.78 + 0.00303\ X_1 + 0.168\ X_2 + 1.28\ X_3 + 0.105\ X_4$ ... *Hong Kong Island*

$Y = 3.55 + 0.00323\ X_1 + 0.0950\ X_2 + 1.09\ X_3$ ... *Kowloon*

$Y = 3.60 + 0.00244\ X_1 + 0.0709\ X_2 + 1.22\ X_3 + 0.147\ X_4 - 0.596\ X_5 + 0.699\ X_6$ ... *New Territories*

where Y = Fuel consumption (litre/100 km)
K = constant
X_1 = Engine Size (c.c.)
X_2 = Mean monthly temperature (°C)
X_3 = Body type (0 = saloon, 1 = all other types)
X_4 = Vehicle age (years)
X_5 = Transmission (0 = automatic, 1 = manual)
X_6 = Wheels driven (0 = 2-wheel drive, 1 = 4-wheel drive)

The above equations show that fuel consumption is mainly affected by engine size, temperature, vehicle body type and vehicle age. Furthermore, in the New Territories, the fuel consumption is also affected by the transmission type and the factor of whether the car is 2-wheel or 4-wheel driven. This is as expected due to the generally higher speed of travelling under the less congested roads of the New Territories.

The study also observed that there had been a growing number of large engine size vehicles (e.g. four-wheel drive vehicles and multi-purpose vans) running on the road. Table 2 shows the comparison of engine size proportion of the newer cars in comparison to the existing private car fleet. There has been a significant drop in the proportion of smaller engine size cars while the proportion of larger engine size cars, particularly those over 3,000 c.c., is growing.

Engine Size Sub-group	**% of Vehicles in Sub-group**	
	Whole fleet	**New fleet (2000 or after)**
≦1500 cc	31%	24%
1501 – 2000 cc	30%	30%
2001 – 2500 cc	18%	19%
2501 – 3000 cc	10%	11%
3001 – 4000 cc	7%	11%
> 4000 cc	4%	5%

Table 2 Growth in Private Car Engine Size

Another similar set of statistics is the proportion of saloon cars. In the existing fleet, saloon cars account for 84% of the overall private car fleet. But for the new fleet, the proportion of saloon car has dropped to just 67%. On the other hand, the number of station waggons has increased in proportion from 10.2% to 27.2%. Clearly, these larger cars as well as larger engine cars both lead to increase in the overall fuel consumption. The study estimated that if measures can be put in place to control the number of such vehicles, there is a potential to reduce overall fuel consumption by 4%.

BENCHMARKING SOFTWARE TOOL

In order to provide the general public with a means to determine the fuel consumption level of their cars and to benchmark it with other cars, a benchmarking software tool has been developed which makes use of the models developed in the study. The regression equations were used to compile the benchmark percentiles by normalising the survey data using the regression coefficients.

The users only need to input simple data like the engine size, vehicle type, vehicle age, distance travelled, fuel consumed between two fuel intakes, etc. The tool will then calculate the fuel consumption rate of the vehicle and give a benchmark value representing how efficient the vehicle is compared with similar types of vehicles in Hong Kong. Users will also be advised of some fuel saving tips as well as hints on buying a fuel-efficient vehicle.

The benchmarking software tool is available from the EMSD website http://www.emsd.gov.hk for public use.

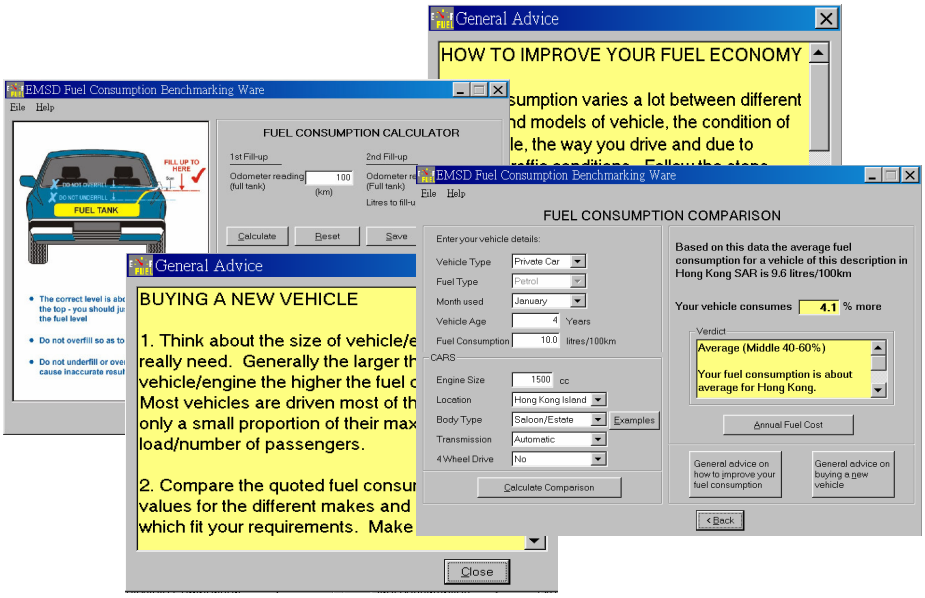

Figure 1 Fuel Consumption Benchmarking Software Tool

CONCLUSION

This study is the first step in establishing energy consumption indicators database. The indicators and benchmarks developed enable vehicle owners and drivers as well as fleet managers to benchmark the fuel consumption of their vehicles with other similar vehicles in Hong Kong and to identify areas for improvement in fuel efficiency. It is hoped that the exercise will raise public awareness in fuel efficiency and to encourage active public participation in taking positive steps to reduce fuel consumption. The Energy Efficiency Office will continue to extend such study to other vehicle groups in the future.

References

1. Hong Kong Energy End Use Data (1989 – 1999), Electrical & Mechanical Services Department, December 2001.