

Potential Consumer Assessment on the Usage of Diesel-CNG Dual Fuel Vehicle in Malaysia

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ABSTRACT

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A Diesel-CNG dual fuel vehicle is a modified diesel vehicle that is capable of running two fuels. It may have future potential in Malaysia because of its promising cleaner exhaust emissions and lower fuel cost. Thus, a study on its prospective implementation was executed based on three objectives. First is to evaluate potential consumer acceptance of Diesel-CNG Dual Fuel application in Malaysia. Second is to analyse the public awareness on Diesel-CNG Dual Fuel vehicles, and third is to estimate economic gains of using the Diesel-CNG Dual Fuel vehicle. This study focused on consumers that are using light and medium duty diesel vehicles in Malaysia. A quantitative method was applied to obtain the data in the study. A survey was conducted and the set of questionnaires were circulated through two methods, personal interviews and an online response medium. All data from the survey was analysed based on the sampling size obtained from Transport Statistics Malaysia. The survey result shows a total of 63% respondents are interested in installing the DDF system to their vehicle in order to lower their fuel cost and help in conserving the environment. In addition, 70% respondents stated that the main cause that preventing them from installing the DDF system is lack of NGV stations and shop services. Level of awareness on Diesel-CNG Dual Fuel vehicle in Malaysia is still low with only 40% of the respondents know the existence of this system. However, they have shown that their awareness on the current environmental issues is very high.

Keywords:

Dual fuel, natural gas vehicle, survey, potential savings

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1. Introduction

The Transport sector is responsible for the emission of more than a quarter of carbon dioxide (CO₂) emissions from human activity all over the world, as well as considerable shares of methane (CH₄), and nitrous oxide (N₂O) emissions, and is thereby one of the largest single contributors to global climate change [1-5]. Among the group of ASEAN countries, Malaysia is the second largest per capita greenhouse gas emitter [6-8]. Even though Malaysia shares only 0.3 percent of global

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greenhouse gas emission, the raising trend of GHG emission must be controlled. Standards and regulations are being introduced under The National Automotive Policy (NAP) of Malaysia review [9-10]. One of the policies is to transform Malaysia into a regional hub for energy-efficient vehicles (EEV). EEVs are fuel-efficient vehicles as stated in NAP 2014 and may include conventional fuel cars, electric cars, hybrid cars and other alternative fuel vehicles.

One of the solutions to support the policy is the utilization of a gaseous fuel as a fractional supplement for liquid Diesel fuel. These engines are known as dual fuel combustion engines. A Diesel-CNG Dual Fuel (DDF) vehicle is a base diesel vehicle fitted with a dual fuel conversion kit to empower utilization of clean burning alternative fuel like compressed natural gas. In Malaysia, such vehicle is still under research and development [11-13]. The objective of this work is to conduct a study on consumer acceptance of Diesel-CNG Dual Fuel application in Malaysia by determining the level of awareness and understanding on various factors in the issue related to the impact assessment of Diesel-CNG Dual Fuel vehicle in Malaysia. Through this study, the future potential of Diesel-CNG Dual Fuel vehicles in Malaysia can be known. From data survey interpretations, transportation statistics and assumption on fuel consumption rate, the acceptance by Malaysian in future can be analyzed.

2. Methodology

This research was divided into two phases. Phase 1 focused on the research method through survey to know the dependency on the data, consumer acceptance and awareness. Phase 2 conducted projection studies involving Return Investment (ROI) to approximate the values of fuel economy.

2.1 Selection of Respondents

The target respondents were the light and medium duty vehicle users. The respondents selected based on their capabilities to understand the questionnaire given with sufficient comprehension and the ability to provide reliable answer. The determination of sample size and the population in this research are

- I. Sampling – the sampling refers to the potential Diesel-CNG Dual Fuel vehicle consumers.
- II. Population – the population in this research is the target respondents who use the diesel vehicle in Malaysia.

2.2 Sample Size

The aim of this type of survey is often to obtain an accurate estimate of a particular figure, such as a mean or a proportion. It is not to compare the figure with another group, but rather, to accurately reflect the real figure in the wider population. Since it is generally impossible to study an entire population (every diesel consumer in this country), this study relied on sampling to acquire a section of the population to perform an experiment or observational study. The increasing demand for research has created a need for an efficient method of determining the sample size needed to be representative of a given population [14]. The formula used for determining sample size using the following formula.

$$S = \frac{X^2 NP (1-P)}{d^2 (N-1) + X^2 P (1-P)} \quad (1)$$

where,

- S = Required sample size
X₂ = The table value of chi-square for 1 degree of freedom at the desired confidence level
(3.841=1.96×1.96)
N = The population size
P = The population proportion (assumed to be .50 since this would provide the maximum sample size)
d = The degree of accuracy expressed as a proportion (0.1)

From the new registered motor vehicles by type of fuel usage data by the Transport Statistics Malaysia [15], assumed that the population for this survey is the total diesel vehicle from year 2012 to 2015. Table 1 below shows the total value for diesel vehicle in the past four years.

Table 1
Number of new diesel vehicle in Malaysia

Year	New Diesel Vehicles
2012	31,912
2013	30,737
2014	27,733
2015	21,597
Total	111, 979

Therefore, the calculation for the required sample size is as follows

$$S = 1.96^2(111, 979)(0.5)(1-0.5) \div 0.1^2(111, 979-1)+1.96^2(0.5)(1-0.5) = 95$$

2.3 Survey Method (Phase 1)

The survey method uses a questionnaire form which was given to the target respondents. The questions made into the questionnaire were chosen based on the objectives of this research and related information required, as adapted from [16]. The questionnaire can be sorted into 3 sections.

Section 1: Awareness of Diesel-CNG Dual Fuel Vehicle

- This section is to investigate how deep the respondents understanding and awareness about issues related to the DDF application in Malaysia.
- It is also to identify the factors that prevent and encourage the respondents in installing Diesel-CNG Dual Fuel system on their vehicle.

Section 2: Suggestion

- This section gives the respondents a chance to give any comment or idea about what is the best actions to take and what is the best incentives to expose the usage of Diesel CNG Dual Fuel vehicle in Malaysia which can help in reducing the pollution of air.

Section 3: Respondents Profile

- This section will consist of general information of respondents and help in giving approximation of which range of group that are interested in the utilization of Diesel-CNG Dual Fuel system.

The surveys were distributed by hand to the target diesel consumers and through online using Google form link. A personal interview was conducted at PUSPAKOM and to the target respondent

on the street. Meanwhile, the Google form responses mostly got from goods vehicle groups at Facebook, shared through WhatsApp and Twitter. This kind of approach has more response than face-to-face method because it is more convenient and people may have extra time to answer the survey carefully.

2.4 Economic Estimation (Phase 2)

The second phase of the study emphasized on the potential savings of Diesel-CNG Dual Fuel system. In this section, the study computed the approximate values between standard diesel vehicle and DDF system. The framework for Return of Investment (ROI) calculation was drawn from previous study [17]. The study measured the DDF fuel consumption using a Toyota Hilux 2.5L year 2006, installed with DDF kit Diesel (B7) and CNG (Petronas). The equipment used were Dynapak chassis dynamometer, Ono Sokki fuel flow meter to measure diesel fuel and Alicat gas flow meter to measure natural gas.

3. Results and Discussion

3.1 Respondent Profile

Table 2 shows the number of respondent participating in the survey through two different approaches. The responses rate is as expected and reliable as it exceeds the sampling size wanted which is more than 95 diesel vehicle owners. The total respondent answering this survey is 154 where 100 is the owner of diesel vehicle and 54 more is the non-diesel vehicle owner.

Table 2

Survey Approach Method

Approach Method	Diesel Vehicle Owner	Non-diesel Vehicle Owner	Total
Personal Interviews	48	0	48
Online	52	54	106

The number of respondent that own a diesel vehicle is 100 out of 154 answering this survey, while the other 54 responses are from other related issues with diesel vehicle. The 100 value of diesel vehicle user exceeds the needed sampling value that has been calculated before which is 95. Hence, this survey can be used to predict based on ratio assumption. Result for questions afterwards will be separated into 2 categories which are diesel vehicle owner, 100 respondents and non-diesel vehicle owner, 54 respondents to provide an accurate and reliable data based on real experience of the diesel vehicle owner itself and the thought of the non-diesel vehicle owner also count in this survey.

The age of respondents was needed because it is easy to analyze majority of diesel vehicle user related to which range of age group. Based on the data, respondent that own a diesel vehicle between range 41 till 50 is the major respondent in this study, while for the non-diesel vehicle owner which are the user in government organizations, the user of public transportation, the user of forwarding services and not related shows the highest value of respondent is the age between 17 till 30. The respondent gender is presented in Figure 1.

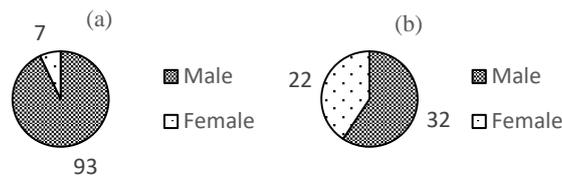


Fig. 1. Respondent gender (a) Diesel vehicle owner, (b) Non-diesel vehicle owner

The respondent’s living state has been categorized into 15 options which include 14 states around Malaysia and one option for other countries. This question continues to the next question if the respondent pick other countries, the options given are limited to Indonesia, Thailand, Singapore and Philippines only because it was believed that this survey will only reached that listed countries. The highest feedback is from Johor for diesel vehicle user respondent. This is due to hands on survey by personal interviews that were conducted mostly in Batu Pahat and Kluang area. For the non-diesel vehicle owner, mostly respondent are from Selangor and also including one respondent from other country which is Indonesia.

3.2 Respondent Answers

Table 3 shows a part of the survey result of closed-ended questions with positive answers. Half of the diesel owner already knew about the existence of the Diesel-CNG Dual Fuel vehicle before the survey. Most of the respondent were unaware of the high percentage of road tax incentive given by the Malaysian government on the use of diesel green engine with CNG. More than half of the respondent are interested installing the Diesel-CNG Dual Fuel System on their existing/future vehicle.

Table 3

Closed-Ended Questions with Yes Answer

Question	Group	Frequency	%
Before getting this survey, do you know the existence of Diesel-CNG Dual Fuel Vehicle?	Diesel Owner	52/100	52%
	Non-diesel Owner	9/54	17%
	Total	61/154	40%
Are you aware that using Dual Fuel Engine will get 50% - 62% reduction of road tax from the prevailing rates?	Diesel Owner	25/100	25%
	Non-diesel Owner	17/54	31%
	Total	42/154	27%
Are you interested in installing Diesel-CNG Dual Fuel system to your vehicle?	Diesel Owner	63/100	63%
	Non-diesel Owner	30/54	56%
	Total	93/154	60%

On an opened-ended question of “How do you know about Diesel-CNG Dual Fuel vehicle?”, most respondent know about the dual fuel system through media social such as internet, newspaper and articles. The second source is hearing from other people about this engine existence and the least one is because of their job background. For example, one of the respondent has automotive background and the other respondent was once a mechanical student and currently work as a bus driver for part time job. Mostly for others who do not own diesel vehicle leave the answer blank because this question is not compulsory. 41 out of 54 respondents have no idea about Diesel-CNG Dual Fuel Engine until they completed this survey. The other 13 respondents may have accidently seen one in real life experiences or go through media social. Interestingly, one of the respondent works as a marine engine technician but do not own any diesel vehicle.

On a multiple-choice question of “What are the factors that encourage you to install Diesel-CNG Dual Fuel system for your vehicle?”, the answers showed that almost all diesel vehicle users want to lower their fuel cost through this engine modification. As we know, CNG is cheaper than diesel thus people prefer to switch to something more affordable. Second largest value of voting is the reducing air pollution factor. This shows that people concern about welfare of the environment and aware about the effect of unwanted exhaust emissions. Among the factors, the non-diesel vehicle owner respondent picked almost the same value for the 3 factors which are lower fuel cost, eco-friendly and help reduce air pollution. This indicates that respondents are affected by rising of fuel price and pollution around them. In addition, there is one respondent added one factor that encourage him or her to install Diesel-CNG Dual Fuel system which is better engine power output.

On another multiple-choice question of “What are the possible causes that prevent you to install Diesel-CNG Dual Fuel system for your vehicle?”, it can be observed that almost 70% diesel vehicle owners expressed that lack of NGV shop services is the main cause that prevent them to install Diesel-CNG Dual Fuel system for their vehicle. The second largest value is 46, why most of the respondents did not opt to convert to dual fuel engine is because they cannot afford the installation cost. The other causes mentioned by the respondents also includes engine durability, limited cylinder space and reduce in engine reliability. For non-diesel owner there are fewer answers, mainly is because majority of them do not own any diesel vehicle. Similar to the diesel vehicle owner respondent, they also pick lack of NGV shop services as the main cause of not installing dual fuel engine followed by high installation cost.

Figure 2 and 3 shows the respondent answer on a Likert Scale on two separate questions respectively: (i) Are you affected by the diesel price rise? (ii) What is your first impression of Diesel-CNG Dual Fuel vehicle? From Figure 2, most of the respondent agree and strongly agree that their lifestyle is affected by the fluctuation of diesel price, which indirectly related to the cost of transportation and logistics, especially on the household goods. From Figure 3, most of the respondent that own a diesel vehicle showed somewhat positive impression on the Diesel-CNG Dual Fuel vehicle, whereas non-diesel owners mostly responded neutrally.

3.3 Respondent Opinions

A part of the survey also collected feedback from the respondent regarding any suggestions or opinions towards the awareness of Diesel-CNG Dual Fuel vehicle usage for sustainability of environment can be summarized by categorizing the responses. It consisted of bad, good, neutral and no response. Both sides diesel vehicle owner and non-diesel vehicle owner mostly gave good opinions about this study. Some are being supportive by giving ideas on improvement towards the awareness while the others are giving the problems that might be faced throughout this application. Those problems include

- I. Diesel-CNG Dual Fuel system might affect the engine’s performance and efficiency in a short term.
- II. Not suitable for off road or rural area used (affect the vehicle’s torque or power)
- III. Require a lot of test in order the engine to be successful.
- IV. Difficulties in obtaining gas, as gas pumps decrease may due to high maintenance faced by pump and less profitable sales operation.
- V. Using gas for vehicle needs more black oil hence leading to high maintenance of the vehicle.

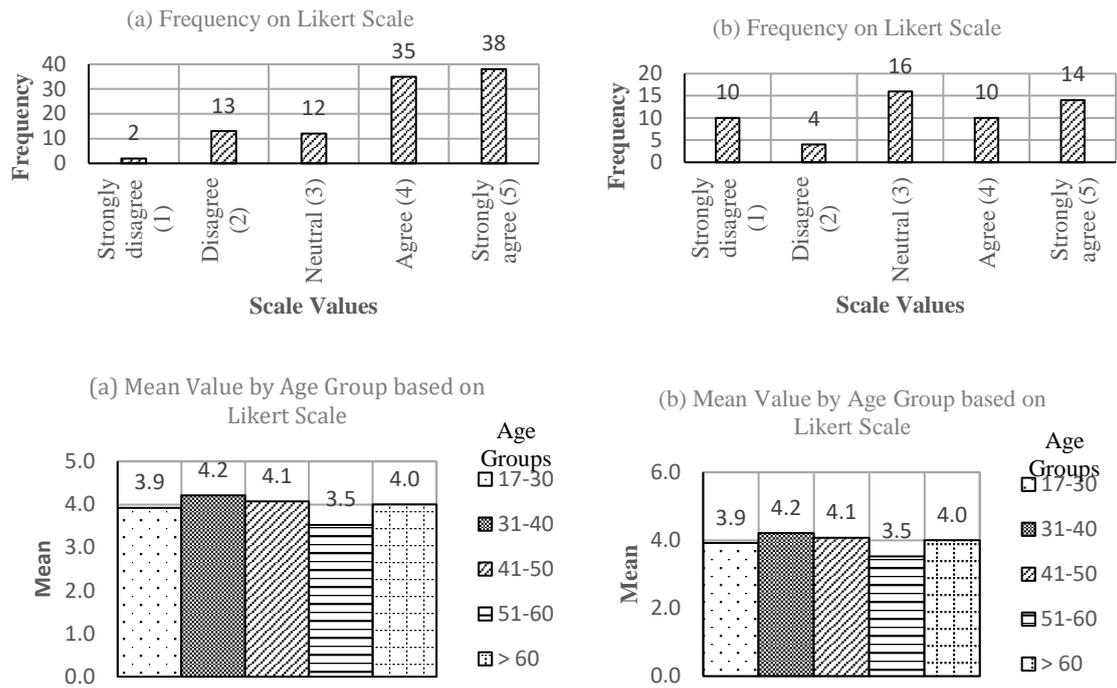


Fig. 2. (a): Diesel vehicle owner, (b) Non-diesel vehicle owner, “Are you affected by the diesel price rise?”

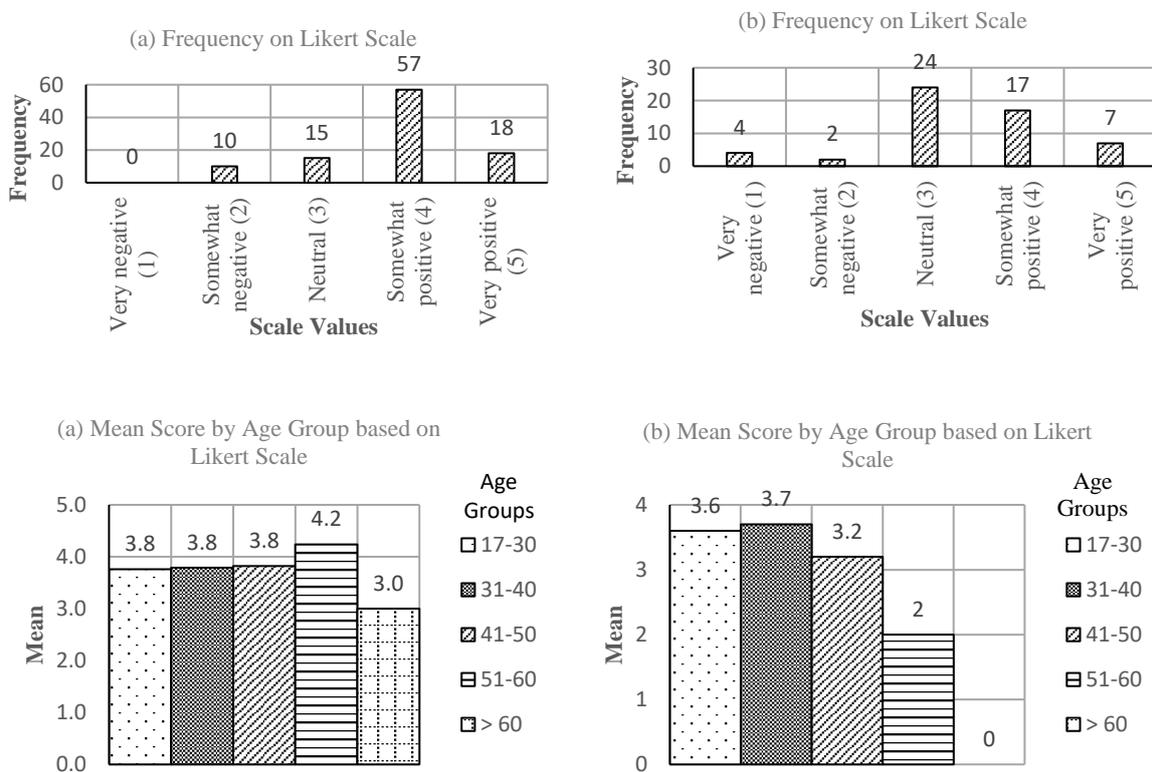


Fig. 3. (a): Diesel vehicle owner, (b) Non-diesel vehicle owner, “What is your first impression of Diesel-CNG Dual Fuel vehicle?”

To resolve the problems listed previously, many suggestions and recommendation were given by respondent in order to broaden the usage of Diesel-CNG Diesel Fuel vehicle to the society. To make the responses clear, the feedbacks obtained will be categorized into 2 groups.

I. Government should give incentives

- a) This can be described that government should make the first move to increase the awareness of Diesel-CNG Dual Fuel vehicle for practicing sustainability of the environment. The first one is to provide facilities such as enlarging the number of NGV stations and develop proper research base for further studies on this concept.
- b) Apart from that, government should promote the usage of Diesel-CNG Dual Fuel vehicle through campaign or seminar. It can be start off with utilization on the public transport or government’s vehicle itself.

II. Supplier should convince the consumer

- a) To receive an encouraging response and acceptance from society, supplier can give rebate for early stage as trial for people who are interested in installing the Diesel-CNG Dual Fuel system.
- b) As suggested from respondents, support and endorsement from supplier can also attract them to try this new technology approach. Making sure that warranty is not affected and not giving negative effect to engine in a long run.

3.4 Dual Fuel Economy Estimation

Referring to a study made by Ismail *et al.*, [17] in 2016, the potential cost savings of using Diesel-CNG Dual Fuel system were calculated based on several assumptions: (i) The dual fuel system uses 60% of CNG and 40% of diesel; (ii) The DDF fuel price is the total price of 60% CNG and 40% diesel per litre; (iii) The fuel cost was calculated based on the commercial price during that particular study in 2016. With that, the DDF fuel consumption at a constant vehicle speed of 100 km per hour is presented by the table 4 below. From to the table, for every 100 km travelled using DDF, RM2.79 of fuel cost can be saved, that is 26% lower than the fuel cost of using diesel only. As such, for a typical travelling mileage of 30,000 km per year, by using DDF the fuel cost may save RM 837.00 per year. However, it is a known fact that the actual fuel consumption is dependent on variable factors such as: road conditions (road surfaces, road inclination, straight or cornering, etc.), vehicle conditions (engine health, transmission, suspension, handling, tire setup, etc.), weather conditions (temperature and humidity, rain or dry, wind speed and direction, etc.), and driving behaviour (highly subjective to individual experience, styles and mood). Therefore, the actual savings may vary from one case to another.

Table 4

DDF Fuel Consumption at 100 km/h		
For 100 km distance	Diesel	DDF
CNG Quantity (kg)	0	2.5299
Diesel Quantity (kg)	4.4216	2.0016
Total Fuel Quantity (kg)	4.4216	4.5315
CNG Cost (RM)	-	3.11
Diesel Cost (RM)	10.79	4.88
Total Fuel Cost (RM)	10.79	8.00
Fuel Cost Saved (RM)		2.79

Another advantage of using DDF in Malaysia, 62.5% annual road tax savings are given by the government Road Transport Department for each DDF vehicle that uses green diesel engine with

natural gas. Typical engine capacity for pick-up truck segment with its potential road tax reduction is presented as in Table 5 below. Add that to the fuel annual savings estimated earlier, the installation of DDF system to an existing diesel vehicle should give an attractive return of investment.

Table 5

Malaysia annual road tax savings for typical pick-up truck

Engine Capacity	Normal Road Tax (RM)	After Reduction (RM)	Savings (RM)	Savings (%)
2.5 L	835.00	313.00	522.00	62.5
3.0 L	1,640.00	615.00	1,025.00	62.5

4. Conclusions

It was compatible with the objective of this study to survey potential consumer acceptance of Diesel-CNG Dual Fuel application in Malaysia by determining the level of awareness and understanding on various factors in the issue related to the impact assessment of Diesel-CNG Dual Fuel vehicle in Malaysia. In addition, economic impact also has been assessed through projection assumption with the guidance of ROI and Transport Statistics Malaysia data. Overall, this study may conclude that

- I. Diesel fuel consumer positively accept the application of Diesel-CNG Dual Fuel vehicle in Malaysia. The survey result shows a total of 63% respondents are interested in installing the DDF system to their vehicle in order to lower their fuel cost and help in conserving the environment. In addition, 70% stated that main cause that preventing them is lack of NGV pumps and shop services.
- II. Level of awareness on Diesel-CNG Dual Fuel vehicle in Malaysia is still low with 60% of the respondents did not know the existence of this system. However, their awareness on environmental issue is very high. This clearly verifies that potential implementation of Diesel-CNG Dual Fuel vehicle in Malaysia has a big potential as respondents are showing their desire to save the environment.
- III. Respondents did not aware with government incentives on DDF system application. Number of 112 out of 154 respondents have no idea with the reduction of road tax from the prevailing rates for dual fuel vehicle. Perhaps, respondents will intend to try this application after knowing the support provided.
- IV. A huge potential reduction in fuel cost can be obtained with utilization of Diesel-CNG Dual Fuel vehicle. Not including the 62.5% of annual road tax savings, a vehicle can save RM 837.00 per year with 30,000 km travelled distance. The huge saving value shows that consequently, DDF may be able to help reducing the dependency on the diesel import, at the same time reducing part of the transportation cost.

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