

Economic Assessment of Compressed Natural Gas for Diesel Vehicle in Thailand

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Abstract: In the present work, the economical aspects of compressed natural gas (CNG) as fuel for diesel vehicles were studied. There are 2 main technologies i.e dedicated retrofit and diesel dual fuel (DDF). Dedicated retrofit and diesel dual fuel were considered in technical and economic that composes with infrastructure and conversion investment cost. According to the economic study, the research was mainly concerned the use of compressed natural gas for diesel vehicle in Thailand by focusing on 10 wheels, 6 wheels and 4 wheels both dedicated retrofit and diesel dual fuel. The expected results explain the suitable pathway of compressed natural gas in the case of dedicated retrofit and diesel dual fuel in order to reduce the import diesel oil for Thailand. From the economic analysis based on the same diesel oil saving rate, the investment and operating costs of diesel dual fuel NGV is significantly lower than those of dedicated NGV, particularly for the 4 wheels vehicle.

Keywords: Compressed Natural Gas (CNG), Dedicated Retrofit, Diesel Dual Fuel (DDF), Conversion Investment Cost, Natural Gas (NG)

Introduction

Thailand has been encountering energy crisis from increasing of energy price. This is due to the limitation of our domestic energy resources especially fossil fuels and the increasing of our energy demand every year, therefore, Thailand need to import large amount of energy for activities especially in transportation sector that consumes energy in high level. From the forecast of Energy Policy and Planning Office (EPPO), Ministry of Energy, Royal Thai Government, found that oil demand in transportation sector increases rapidly particularly diesel oil.

Currently, one of the most promising alternative fuel in Thailand is Compressed Natural Gas (CNG), which can be used in the vehicle instead of the diesel oil. In order to use CNG as the fuel, the engine in the vehicle must be modified from the typical one to the gas engine. There are two main technologies related to this modification: Dedicated NGV and Duel Fuel NGV. The advantage of dedicated NGV is the high diesel oil saving rate, but this type of NGV can use only natural gas as the fuel; therefore, the number of gas station along the public road plays the important role. In contrast, duel fuel NGV can simultaneously use both natural gas and diesel oil as the fuel, however, the diesel oil saving rate is lower than dedicated NGV. Diesel dual fuel engines are based upon diesel technology. The main fuel is natural gas but they are designed to start operate with diesel as a 'pilot' ignition source. As the vehicle begins to move to full load performance, the substitute ratio of natural gas can be up to 80%. This makes DDF valuable in circumstances where the use of natural gas is desired for environment or economics reasons [1]. According to the review of the performance testing, ECOS-DDF system performed almost equal to diesel performance in terms of break torque, net break power and break specific fuel consumption (BSFC) [2]. The substitute ratio of natural gas replaces the diesel oil was about 80% in these tests. The emission results of the test engine that used ECOS-DDF system in the chassis dynamometer shows attractive reduction of PM about 70% while 40% for NO_x, about 90% for CO and about 35% of THC against the stock diesel operations.

For the dedicated engine, this engine is Otto cycle that is operated only on natural gas. It has a compression ratio designed to take advantage of the 130 octane number of natural gas. Dedicated have been designed to take into consideration the combustion characteristics of the fuel so that the engine is environmental friendly [1]. Nissan Diesel motor Co, Ltd developed CNG engine for heavy duty garbage truck was modified a 12.503 liter intercooled and turbocharged in-line 6 cylinder heavy duty diesel engine [3]. The full-load performance of the developed engine was comparable with the diesel engine and the CNG engine for heavy-duty buses.

In the present work, both technologies were economically compared in terms of the investment and operating costs (costs of engine modification, dedicated engine, gas station, and the natural gas transportation) in order to determine the suitable technology for application in Thailand.

Methodology

Analysis of the economic aspect of the compressed natural gas program in Thailand

The economic aspect of Thailand natural gas vehicle was investigated in term of the cost of diesel oil that can substitute by natural gas in the case of 10 wheels, 6 wheels and 4 wheels of both dedicated retrofit and diesel dual fuel (DDF).

Projection the economic aspect of Thailand natural gas vehicle program in the future

Following PTT Public Company Limited plan on NGV expansion during year 2006-2010, the future economic aspect of Thailand natural gas vehicle was studied.

Results and Discussion

Analysis of the economic aspect of the compressed natural gas program in Thailand

According to the information from PTT Public Company Limited, Thailand has refueling stations about 65 stations [4] that can separate to types, number of refueling stations and average investment cost include maintenance cost as shown in Table 1 [4].

Table 1 Types of refueling stations and amount of fuel services from 65 refueling stations

Type	Number	Total average refueling investment cost (million baht)	Total all average maintenance cost (million baht/year)
Conventional	13	2,334	11
Mother	6	906	16
Daughter	46	874	38
Total	65	4,114	65

From 65 refueling stations, the average amount of fuel services in each type of refueling stations and total average amount of fuel services is shown in table 2[4]

Table 2 Total average amount of fuel services per day

Type	Number	Average amount of fuel services (ton/day)	Total average amount of fuel services (ton/day)	Total average amount of fuel services (kilograms/day)
Conventional	13	975	1,807	1,807,000
Mother	6	96		
Daughter	46	736		

The information of PTT Public Company Limited on investment cost of conversion diesel vehicles to DDF and dedicated retrofit in shown in table 3 [5].

Table 3 Average investment cost of dedicated retrofit and DDF

Type	Investment cost (Thousand baht)	Average investment cost (Thousand baht)
Van/ 4 Wheels (DDF)	36-50	43
Truck/Bus		
- DDF	125-200	162.5
- Dedicated (Dedicated Retrofit)	460-600	530

PTT Public Company Limited reported in January 31, 2006. Thailand has total natural gas vehicle 10,780 cars by separate to gasoline substitute 9,929 cars and diesel substitute 851 cars [4]. From 65 refueling stations have total all average amount of fuel services 1,807 ton/day (1,807,000 kg/day) that substitute diesel oil amount 142,620 liter/day. The amount of diesel oil substitute at 142,620 liter/day can calculate capacity of dedicated retrofit and diesel dual fuel (DDF) by focusing on 10 wheels, 6 wheels and 4 wheels as shown in Table 4 by using some assumptions; 1. Dedicated retrofits of 10 wheels, 6 wheels and 4 wheels have fuel capacity at 200 liters, 100 liters and 75 liters respectively. 2. Diesel oil substitute of DDF of 10 wheels, 6 wheels and 4 wheels have average diesel oil substituted about 27% depend on engine status, traffic condition and conversion technology especially fine adjust. 3. Assumption ratio compare between NGV and diesel oil is NGV 1 kilogram equal to diesel oil 1 liter

Table 4 Capacity of dedicated retrofit and DDF

Type	Capacity (Cars/day)		
	10 Wheels	6 Wheels	4 Wheels
Dedicated Retrofit	713	1,426	1,901
DDF	977	1,954	2,971

The data's in Table 1 and Table 4 were investigated the relation between investment cost of diesel oil that substitute by natural gas and using assumption cost of diesel oil is 30 baht/liter as shown in Figs. 1-3 .

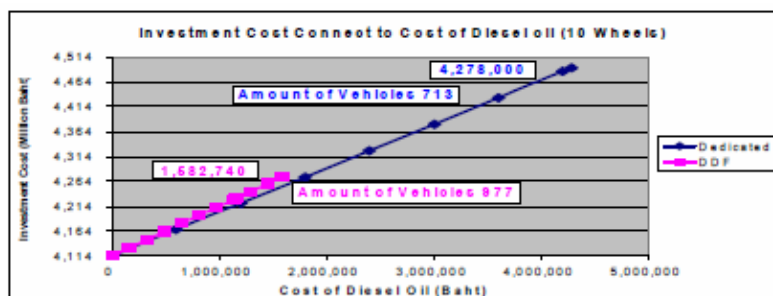


Fig. 1 Investment cost connect to cost diesel oil 10 wheels in 2005

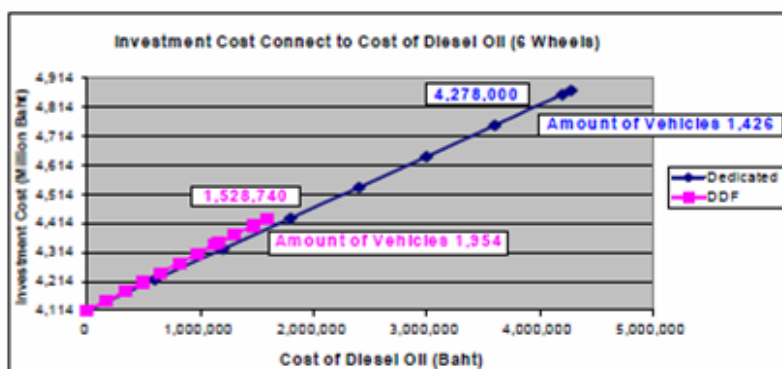


Fig. 2 Investment cost connect to cost of diesel oil for 6 wheels in 2005

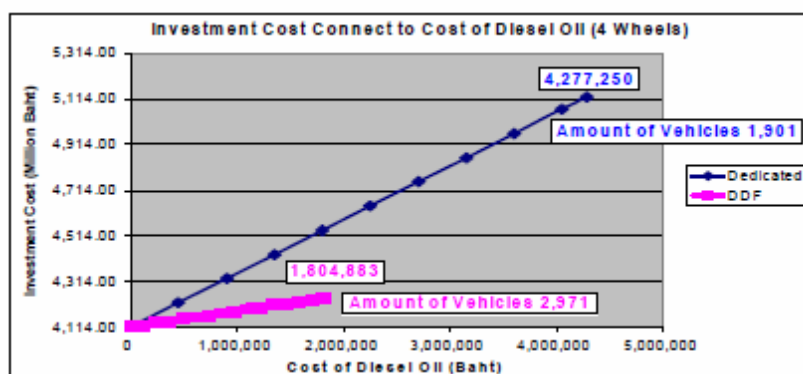


Fig.3 Investment cost connect to cost of diesel oil for 4 wheels in 2005

Projection the economic aspect of Thailand natural gas vehicle program in the future

Following PTT Public Company Limited plan on NGV expansion, in the year 2010 Thailand will have 740 refueling stations [6] as shown in Table 5 and amount of fuels services at 365 million standard cubic feet per day (MMscfd) that separate to diesel oil substitute during year 2006 to 2010 as shown in Table 6 [6].

Table 5 Target refueling station expansion of PTT Public Company Limited during year 2006 to 2010

Part	2006	2007	2008	2009	2010
Bangkok/surrounding/Central	114	190	260	300	355
East	22	30	40	50	60
North East	10	20	54	104	114
West/South	10	15	24	79	99
North	4	15	42	87	112
Total refueling stations	160	270	420	620	740

Table 6 Diesel oil substitute during year 2006 to 2010

Year	Station	Diesel oil substitute (Million liter/day)
2006	160	0.9
2007	270	2.2
2008	420	3.8
2009	620	5.6
2010	740	7.6

The target expansion of refueling stations in Table 5 and amount of diesel oil substitute in Table 6 were investigated in term of investment cost connect to cost of diesel oil substitute in the case of 10 wheels, 6 wheels and 4 wheels of both dedicated retrofit and DDF. The ratio of refueling station in 2005 was use to calculate ratio of refueling station in each types during year 2006 to 2010. The relation between investment cost and cost of diesel oil that substitute by natural gas in year 2010 as shown in Figs. 4-6

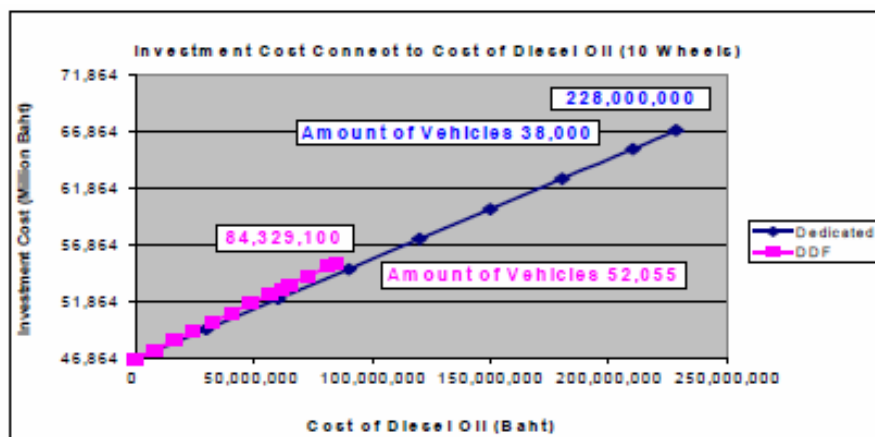


Fig. 4 Investment cost connect to cost of diesel oil for 10 wheels in 2010

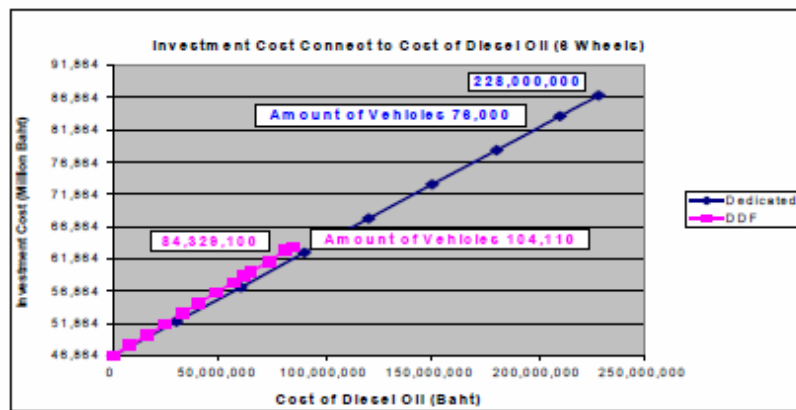


Fig.5 Investment cost connect to cost of diesel oil for 6 wheels in 2010

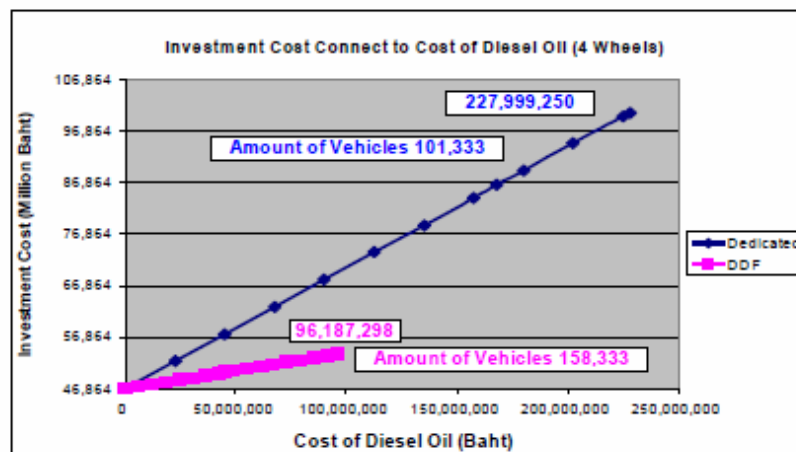


Fig. 6 Investment cost connect to cost of diesel oil for 4 wheels in 2010

Conclusion

The projection of the economic aspect Thailand natural gas vehicle program connect to cost of diesel oil that substitute by natural gas in the case of dedicated retrofit and diesel dual fuel (DDF) by focusing on 10 wheels, 6 wheels and 4 wheels during year 2006 to 2010. The results show that investment cost of dedicated retrofits 10 wheels and 6 wheels are cheaper than DDF at various levels of diesel oil substitute, whereas the investment cost of DDF is cheaper than dedicated retrofit in the case of 4 wheels at many levels of diesel oil substitute.

Acknowledgments

The authors gratefully acknowledge Association Professor Dr.Somchai Chanchaona, and Association Professor Dr.Withaya Yongchareon.

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