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# Total cost of ownership analysis for alternative gasoline and gasoline hybrid electric vehicle in Thailand

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*Abstract: Nowadays, the gasoline hybrid electric vehicles (HEV) is promote for energy saving that are becoming more popular and more common in Thailand. The purpose of this study is to compare total cost of ownership (TCO) for the typical newly bought between HEVs and ICEVs (internal combustion engine vehicles) in Thailand. The TCO model used life cycle costing as a calculating tool in order to compare the cost of ownership between three HEVs and three ICEVs equivalent vehicle in Thailand 2017. The results from the application of the TCO model to the vehicle sample found that TCO of ICEVs could be about 5% cheaper than HEVs for 5 years life time analysis.*

**Keywords:** Life cycle cost, Hybrid electric vehicles (HEV), Consumer choice model.

## I. BACKGROUND

Nowadays, the gasoline hybrid electric vehicles (HEVs) are becoming more popular and more common in Thailand. Basically, a hybrid vehicle is one that uses two or more engines. An electric motor and a conventional engine are combined for driving. Mitropoulos et al. (2017), Hagman et al. (2016), Goedecke et al. (2007) and Al-Alawi et al.(2013) considered alternative vehicle technologies, including engine and fuel options. In Thailand 2017, there are 3 HEVs brands: Honda Accord (2 sub models), Toyota Camry (2 sub models), Nissan X-Trail (3 sub models) which are available for selling within under 2 Million Thai Baht (60,000 US Dollar). In this paper, the researcher explored a consumer total cost of ownership (TCO) model to investigate the possible accord between purchase price and the TCO of ICEVs and HEVs.

## II. METHODS

The TOC model used life cycle costing theory as a tool for calculating and compared the cost of ownership between three HEVs and three ICEVs equivalent vehicle in Thailand 2017. All prices and costs had been converted from Thai Baht (THB) to US Dollar (\$US) with an exchange rate of 1\$US to 33.278 TH as of August 3rd, 2017 (Bangkok Bank, 2017). In this study, the vehicles in the sample were compared with the top grade equivalent model of ICEV and HEV of each brand: the Honda Accord 2.4EL and Honda Accord Hybrid Tech, Toyota Camry 2.5G and Toyota Camry 2.5HV Premium , Nissan X-Trail 2.0V 4WD and Nissan X-Trail 2.0V4WD Hybrid.

The proposed model provides a structure breakdown of cost (SBC) of vehicle such as purchase cost, insurance cost, tax cost, operating cost, energy cost, maintenance cost, and asset sale cost that can be applied to the asset is shown in fig. 1 (Vorarat,2017)

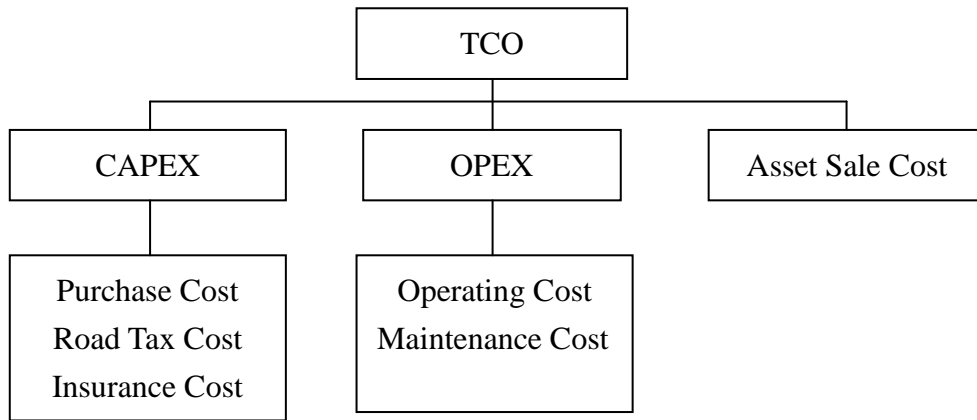


Fig. 1: TCO of vehicle components

In this case the TCO of vehicle has three major components that are shown in Fig.1. The total cost of ownership of vehicle is given by

$$TCO_{veh} = CAPEX + \sum_{i=1}^{NL} \left[ \frac{[OC_{veh,i} + MC_{veh,i}]}{(1+r)^i} \right] - \frac{AS}{(1+r)^{NL}} \quad (1)$$

The definitions of symbols used in above equations are given below:

$TCO_{veh}$  is Total cost of ownership of vehicle

CAPEX is Capital expenditure

$OC_{veh}$  is Operation cost of vehicle

$MC_{veh}$  is Maintenance cost of vehicle

$r$  is Discount rate

$NL$  is Lifetime of vehicle in years

$AS$  is Asset sale

### Capital Expenditure (CAPEX)

The initial capital costs can be divided into sub categories of costs: Purchase price and all associated costs.

### Operating Expenditure (OPEX)

This category includes the cost of operating and maintaining of the vehicle for life cycle time.

The conditions for the TCO analysis are length of ownership 5 years and annual kilometers driven 20,000 km.

Operating cost of vehicle can be divided into sub categories of cost:

#### Road tax cost

Road tax cost in Thailand can be calculated by using the size of the combustion chamber in an engine (CC) of vehicle. The CC of an engine varies from few hundreds 700 cc or 0.7 L) to few liters (3000 CC or 3 L). The formulas of road tax cost are (The Act on Road Tax Rate B.E. 2522) 1 – 600 CC size is 0.5THB per CC, 601 - 1799 CC is 1.5THB per CC and 1800 CC up is 4THB per CC. Then after 5 years of life vehicle it can be discount following Year 6 discount 10 %, Year 7 discount 20 %, Year 8 discount 30 %, Year 9 discount 40 % and



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Year 10 up discount 50% off. For example, in this study the Honda Accord 2.4EL that has 2,356 CC of the combustion chamber then the rode tax rate for first year to fifth year is  $(600CC \times 0.5THB) + (1,800-600CC \times 1.5THB) + (2,356-1800 \times 4THB) = 4,324 THB$ . The data of CC of sample vehicle that is shown in table 2.

**Insurance cost**

Type of vehicle Insurance in Thailand. Vehicle owners in Thailand have the option to get the following types of car insurance:

**First class insurance**

First class insurance is the most comprehensive type of car insurance in Thailand. It typically covers the vehicle, the driver’s life, costs associated with injury to the driver and passengers, and third-party liability and property damage.

**Second class insurance**

Second class car insurance covers collision damage and repairs to any vehicle involved in an accident, as well as theft and fire.

**Third class insurance**

Third class insurance covers third-party property damage and medical expenses for the driver and passengers, even bail bond.

**3Plus Insurance**

This type of car insurance has the same coverage as third class insurance, with additional coverage for damage to own car but only when there’s a collision with another motor vehicle, and the identity of other party is known. It offers no coverage in the event of an accident where there’s no other party involved, or the identity of the other party is unknown.

**2Plus Insurance**

This type of insurance is similar to 3+ insurance coverage, but including fire and theft coverage. Insurance cost in this study is used the first class insurance for calculating in the TCO model for 5 years. The insurance cost is covered sum insured 90% of market price. (Honda insurance, 2017)

**Energy Cost or Fuel Cost**

In this study, the gasohol 91 E10 (fuel mix 10% ethanol and 90% petrol) is used for calculating in the TCO model that shown in Table 1. The fuel consumption is collected form specification of each vehicle model that is shown in Table 2.

**Table 1: The Fuel cost of Thailand (Thai retail oil prices, 2017).**

5-Aug-17	PTT	BCP	Shell	Esso	Chevron	IRPC	PTG	Susco
Retail Prices in Bangkok & Vicinities Unit: US\$/Litre								
Gasohol 95-E10	0.815	0.815	-	0.815	0.815	0.815	0.815	0.815
Gasohol 95-E20	0.725	0.725	0.725	0.725	0.725	-	0.725	0.725
Gasohol 95-E85	0.599	0.599	-	-	-	-	-	0.599
Gasohol 91-E10	0.792	0.792	0.792	0.792	0.792	0.792	0.792	0.792
ULG 95RON	1.014	-	-	1.028	1.028	-	1.029	1.014
Diesel HSD,0.005%S	0.756	0.756	0.756	0.756	0.756	0.756	0.756	0.756
Diesel Premium	0.847	0.847	0.847	0.847	0.847	-	-	-



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Table 2: Vehicle descriptions (Honda, Toyota and Nissan,2017)

	Honda Accord 2.4EL	Honda Accord Hybrid Tech	Toyota Camry 2.5G	Toyota Camry 2.5HV Premium	Nissan X-Trail 2.0V 4WD	Nissan X-Trail 2.0V4WD Hybrid
Purchasing Price	\$ 49,132	\$55,562	\$48,050	\$55,562	\$41,829	\$44,173
Fuel type	Petrol	Petrol	Petrol	Petrol	Petrol	Petrol
		Electricity		Electricity		Electricity
Size of the combustion chamber (CC)	2,356	1,993	2,494	2,494	1,997	1,997
Horsepower(PS)	174	215	181	205	144	179
Fuel consumption (km/l)	14.98	20.92	13.1	18.59	13.39	16.7

#### ***Maintenance cost***

In general, the maintenance cost of vehicle can be divided into two categories: routine and non-routine maintenance. The most of new vehicles come with warranties that cover any breakdown from manufacture such as air condition, pump and engine during the first three years or 100,000 km of ownership. The routine maintenance or service cost such as oil engine and filter is determined by the service manufacturer center of vehicle. The condition base maintenance such as battery and tire changes are to be considered in TCO model for five years.

#### ***The Asset Sale Cost***

The asset sale cost is the resell price of the vehicle after a life time. This study uses five years lifetime of sample vehicle for calculating. The asset sale of vehicle in this study collects and estimates the data from second hand vehicle market on the website. The depreciation rate is the difference between the purchase price and the resell price in the end of fifth year.

### **III. RESULTS**

Table 3 shows that the cost of ownership (TCO) between three HEVs vehicles: Honda Accord Hybrid Tech, Toyota Camry 2.5 HV and Nissan X-Trail Hybrid (HEV group) and three ICEVs vehicles such as Honda Accord 2.4EL, Toyota Camry 2.5G and Nissan X-Trail 2.0V 4 WD (ICEV group) equivalent vehicle in Thailand 2017 market for five year life. The HEV group has lower OPEX than ICEV group but have higher CAPEX, depreciation and TCO than HEV group. The Honda Accord Hybrid has the lowest OPEX but has the highest CAPEX of the vehicles in the sample. The Honda Accord 2.4 EL has the lowest TCO but the highest maintenance cost of the vehicles in the sample. The Toyota Camry 2.5 HV has the highest TCO of the vehicles in the sample. The difference between the TCO of ICEV group and HEV group, the results show that Honda 2.4EL has lower TCO than Honda Hybrid about 5.3 % and Camry 2.5G has lower TCO than Toyota Camry 2.5HV about 4.8% and the last model Nissan X-trail 2.0 has lower TCO than the Nissan X-trail 2.0 Hybrid about 1.5%. The results in Fig. 2 show that the depreciation cost is the major part in TCO and when compare between HEV and ICEV in the same brand, the depreciation costs of HEV are more than ICEV vehicle about



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4-6% except Nisan is 2% differential.

Table 3: Total cost of ownership computation results (Honda, Toyota and Nissan service, 2017)

	Honda Accord 2.4EL	Honda Accord Hybrid Tech	Toyota Camry 2.5G	Toyota Camry 2.5HV Premium	Nissan X-Trail 2.0V 4WD	Nissan X-Trail 2.0V4WD Hybrid
<b>CAPEX</b>	\$ 49,132	\$ 55,562	\$ 48,050	\$ 55,562	\$ 41,829	\$ 44,173
<b>Asset Sale</b>	\$ 25,542	\$ 28,547	\$ 22,537	\$ 27,045	\$ 16,527	\$ 17,429
<b>Depreciation</b>	\$ 23,589	\$ 27,015	\$ 25,512	\$ 28,517	\$ 25,302	\$ 26,744
<b>OPEX</b>	\$ 14,365	\$ 12,966	\$ 14,814	\$ 13,739	\$ 14,432	\$ 13,581
<b>Operating Cost</b>	\$ 11,449	\$ 10,110	\$ 12,146	\$ 10,886	\$ 11,716	\$ 10,688
<i>Fuel Cost</i>	\$ 5,292	\$ 3,789	\$ 6,051	\$ 4,264	\$ 5,920	\$ 4,747
<i>Insurance</i>	\$ 5,507	\$ 5,890	\$ 5,362	\$ 5,890	\$ 5,362	\$ 5,507
<i>Road Tax</i>	\$ 650	\$ 432	\$ 733	\$ 733	\$ 434	\$ 434
<b>Maintenance Cost</b>	\$ 2,916	\$ 2,855	\$ 2,668	\$ 2,852	\$ 2,716	\$ 2,893
<b>TCO</b>	\$ 37,954	\$ 39,981	\$ 40,326	\$ 42,256	\$ 39,734	\$ 40,325
<b>TCO per month</b>	\$ 632.57	\$ 666.34	\$ 672.10	\$ 704.27	\$ 662.23	\$ 672.09
<b>TCO per km</b>	\$ 0.380	\$ 0.400	\$ 0.403	\$ 0.423	\$ 0.397	\$ 0.403

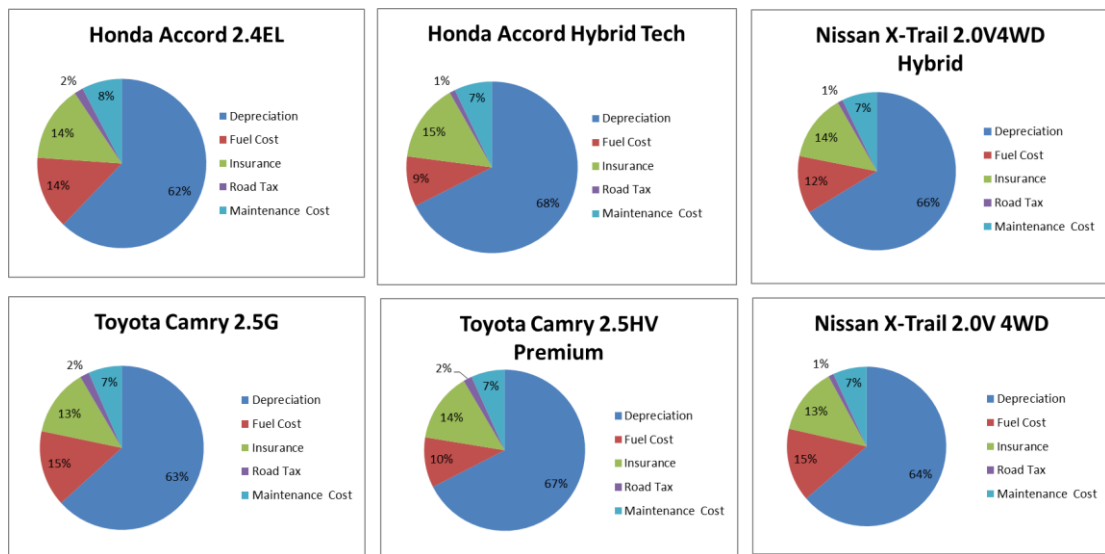


Fig.2: Total cost of ownership for the typical newly of HEVs and ICEVs vehicle in Thailand

#### IV. CONCLUSION

The purpose of this study is to use life cycle costing as a tool for calculating and comparing the cost of ownership between three HEVs and three ICEVs equivalent vehicle in Thailand 2017. The difficulty of TCO model is the available data, such as the failure rate of the HEV vehicles (non-routine maintenance), the price of HEV battery after 5-10 year, the fuel cost and the depreciation in the future. The factors that affect TCO between HEV and ICEV are depreciation and insurance cost. The HEV vehicle like Honda Accord Hybrid has lower fuel cost than Honda Accord 2.4EL about 28% but has the highest depreciation and insurance cost. Then the vehicle buyers should be considering these two factors for making decision buy a new vehicle in Thailand rather



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than considering only the fuel cost.

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