Economic and Environmental Benefits of Using Hybrid Taxies in Dubai-UAE

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ABSTRACT

Transpiration in general and cars in particular contribute significantly to energy resource depletion and environmental pollution. The use of advanced power systems in cars can significantly reduce fuel consumption and CO_2 emissions. Hybrid Electric Vehicles (HEV) falls into this category offering the benefits of lower fuel consumption and lower emissions. HEVs have been around for a few decades but failed to gain popularity on wide scale. The main barrier for this is economic due to the high upfront cost of a HEV compared to the standard internal combustion (IC) the only counterpart which tends to translate into a long pay-back period. The economics become even worse in countries in which fuel is subsidized, e.g. the case of the UAE. TaxisTaxis are a prime candidate to benefit from the use of HEVs due to the high operational duty cycles and long distances travelled. This study looks at the economic and environmental benefits of using HEV taxies in Dubai-UAE in place or the current gasoline powered fleet. The results are promising with a pay-pack period of less than 1 year and a net taxi operator annual direct saving of 2613 AED (712 USD) and 4301 AED (1172 USD) for the 1st and subsequent years, respectively. As the gasoline price is subsidized in the UAE, the Dubai government stands to save 12997 AED (3541USD) per taxi for a total of around 104 million AED (approximately 28.3 million USD). The use of hybrid taxis would also result in an annual CO_2 emissions reduction of around 13.7 tons/taxi (approximately 30% reduction compared to the current gasoline CI) which translates to more than 109 thousand tons of CO_2 per year given the current size of taxi fleet in Dubai. The results clearly show that using hybrid taxies in Dubai has both significant economic and environmental benefits.

KEYWORDS: hybrid vehicles, sustainable transport, CO_2 emissions, UAE

1. INTRODUCTION

The topic of sustainability has gained significance in the past few decades. The issue is being tackled at both the national and international levels, e.g. Kyoto. Still there is no international consensus as to the best way to tackle this and thus each country is proposing and implementing its own steps as dictated by its local conditions, that is policy, economics and available resources. According to the U.S. Energy Information Administration's 2011 data, the United Arab Emirates (UAE) is ranked as the number 1 country in terms of CO_2 emissions per capita (aie, 2013a). In fact at 47.7 Metric ton of CO_2 per capita, the UAE is more than 10 times the world average which stands at 4.7 Metric ton of CO_2 per capita. As a developing oil-rich country, the UAE is facing specific issues when it comes to the environment and sustainable practices. These issues have been identified by the 2011-2013 UAE federal government strategic plan which lays down the guidelines and priorities the UAE needs to

follow in order to address these issues (UAE cabinet, 2013). In fact, the concept of Sustainability is highly emphasized in the UAE Vision 2021 (Vision 2021). This strategy identified "Sustainable Transportation" as a major sector that needs to be addressed in the quest for a more sustainable living style. The UAE is a young and wealthy country; the UAE federation was formed in 1971. The main source of income the UAE is oil in which the UAE is ranked as the world's 4th exporter, 7th producer and 8th in proven oil reserved (aie, 2013b). The public transportation infrastructure in the UAE is not well developed and most people tend to rely on private cars or taxis for their daily transportation.

Since 2008 the UAE government has recognized this issue and has since taken steps to reduce the country's CO_2 emissions and ecological footprint. Initiatives like MASDAR City in Abu Dhabi and Sk. Mohammad Bin Rashid Solar Park in Dubai are designed to help achieve such reductions. On the transportation front specifically, the UAE in general and the emirate of Dubai in particular have taken steps to expand and improve the use of public transportation in a bid to reduce CO_2 emissions. Plans are underway for a federal railroad system linking all seven emirates in the UAE federation to each other as well as to surrounding countries. Dubai metro, which became operational in 2009, is designed to improve public transportation within Dubai and help reduce traffic congestion. The start of the metro operations was also accompanied by a significant increase in the bus transport system in order to act as a feeder system for the metro. Still the metro has limited coverage and does not link Dubai to the surrounding emirates, the federal railroad system is initially designed for transporting cargo rather than passengers between the emirates. This will lead people to continue to rely on private cars and taxis for a significant part of their daily travel. There are currently around 8000 taxies and close to 470,000 private cars in Dubai (2011 Statistical Yearbook – Emirate of Dubai; 2013). Around 85% of the Dubai taxis are mid-sized cares (mainly Toyota Camry) while the rest are minivans designed for families and special need passengers.

In the UAE the selling price (SP) of gasoline fuel is subsidized and fixed; currently stands at 1.72 AED/liter for RON 95 unleaded gasoline (0.47 USD/liter; 1 USD=3.67 AED). An important issue to note is that while the UAE is rich in oil, 94% of this oil is concentrated in the emirate of Abu Dhabi. Abu Dhabi is also the only emirate in the UAE with an oil refinery. Each emirate is responsible for its internal affairs including energy and electricity supplies. Because of this the emirate of Dubai actually has to import most of the fuel used in its power stations and transportation system, this includes natural gas, gasoline and diesel. Dubai buys gasoline from the open international market at international market prices but sells it at the pump at the UAE-wide fixed price of 1.72 AED/liter. Dubai buys the gasoline mainly from the Asia-Pacific fuel market. Figure 1 shows the variation in the Singapore MOPS95 petrol over the past two years (Australian Institute of Petroleum, 2013). This figure shows that the wholesale price of gasoline RON 95 ranged between 60-88 cents/liter over the past two years. The average price over the past 12 months was 73.8 cents/liter (2.71 AED/liter). These numbers do not include transportation, insurance, distribution to petrol stations and operating costs of the petrol stations. Once all of these costs are added, it is estimate that cost at the pump (CP) is around 3.18 AED/liter (86.6 cents/liter). This means that each liter is subsidized to the tune of 1.46 AED/liter (almost 45% subsidy). This results in a huge burden on the Dubai government budget. It is estimated that Dubai government pays around 1 Billion AED (272.5 million USD) annually as fuel subsidies.
Based on the above it is expected that the use of HEVs in taxies in Dubai would result in direct economic savings to the taxi operators as well as indirect savings to the Dubai government due to savings in subsidies. The use of HEVs is also expected to produce a reduction in CO_2 emissions from the taxis. This study is aimed at quantifying the potential economic and CO_2 savings should the Dubai taxi fleet be converted to HEVs.

2. METHODOLOGY

Studying the performance and emissions of HEVs is not an easy undertaking. Some researchers used an experimental method to study the performance and impact of HEVs (Fontaras et al. 2008, Alvarez and Weilenmann 2012). Others studied HEVs using transport carbon-emission models (Thomas 2009, Brand et al. 2012, Johansson and Ahman 2002) but this methodology requires a model that has been validated using local relevant data, something that is not available for the UAE. The majority relied on

literature reviews and data collection from publically available data from reputable sources (Nanaki and Koroneos 2013, Haan et al. 2007, Berggren and Magnusson 2012, Ng 2011). Thus this study will be based on data collected from a range of sources in order to estimate the amount of fuel savings and CO_2 emission reduction.

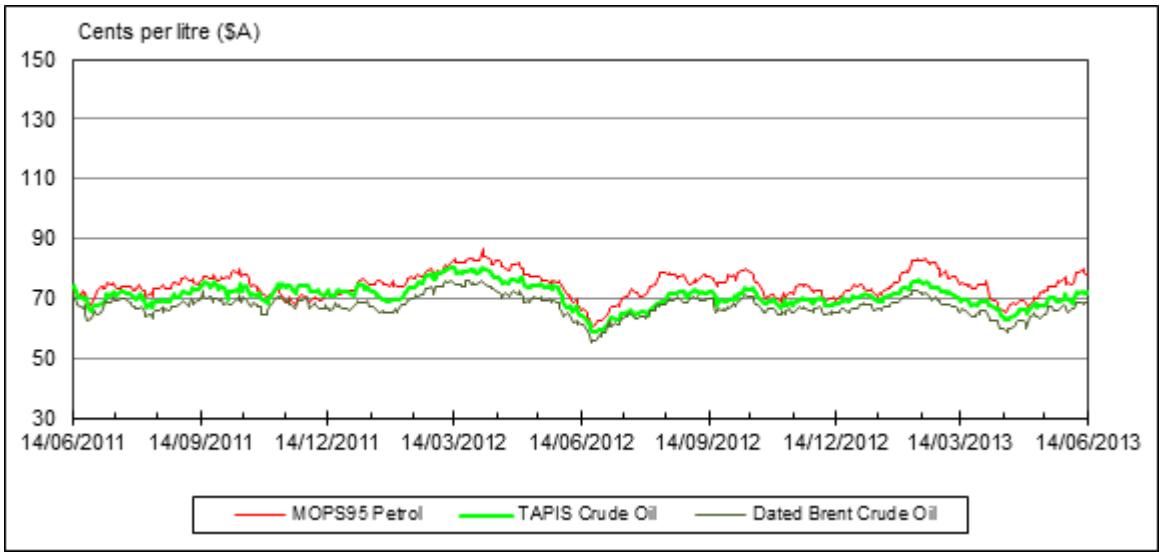

Figure 1. Comparison of Singapore petrol price (MOPS95 petrol) with crude oil prices (http://www.aip.com.au/pricing/facts/Weekly_Petrol_Prices_Report.htm)

The first step was to collect data regarding the number of taxies in Dubai and the distances travelled. This information was provided by special request from the Dubai Statistics Centre (Dubai Statistics Centre 2013). The 1st four columns in Table 1 show the raw data for the biggest taxi operator in Dubai, Dubai Taxi Corporation (DTC). The rest of the columns in Table 1 show the calculated average daily values per taxi. The total distance travelled seems to have a cyclic pattern with the peak in Q1 (winter) and minimum in Q3 (summer). This is expected as Dubai is fast becoming a tourist destination frequented by visitors from all over the world. Most of the visitors come to Dubai during the winter time when the temperatures are more temperate. This explains the rise in the distances travelled by taxis as the demand from tourists' increases during that season. On the other hand, the high temperature and humidity during summer significantly impacts the number of tourists visiting Dubai. In order to avoid these seasonal variations the results will be averaged across the different seasons.

The next step is to get estimates of the fuel consumption as CO_2 emissions (CO_2E) of the taxies for their gasoline only and hybrid versions. Toyota Camry is the most widely used vehicle as a taxi in Dubai. Cars of the same category but from other manufacturers are also used to a lesser extent, e.g. Nissan Altima and Ford Fusion. Table 2 shows the city driving fuel consumption (CFC) and CO_2 emissions for these three car models (both gasoline only and hybrid); data obtained from the 2013 US Department of Energy fuel economy datafile and converted to SI units (U.S. Department of Energy 2013). The city fuel economy data was used as it better resembles the duty cycle of a taxi. The data for the hybrid version of the Nissan Altima was not available in the cited datafile. The fuel economy was obtained from the manufacturer's brochure but no CO_2 emissions could be located. Table 2 clearly shows that the hybrid versions of the three models offer different levels of improvements over their gasoline only versions. This could be due to the use of different IC-electric technologies as well as history and the level of experience of the manufacturer in designing and building HEVs. Although the Ford Fusion is more efficient than the Toyota Camry it is also more expensive, about 1000 USD according to the Manufacturer's Suggested Retail Price of both vehicles. To avoid any further complications, all the analysis and results in the following section will be based on the data of the 2013 Toyota Camry.

Table 1. Summary of the quarterly number of taxis, number of trips and distances travelled for taxies operated by Dubai Taxi Corporation (DRC) in Dubai (Dubai Statistical Centre 2013).

Period Quarter	# Taxis	# trips per Q	kms travelled per Q	Average trips/ Taxi/day	Average kms travelled/ Taxi/day	Average kms/trip
2010Q1	3506	7939425		24.82		
2010Q2	3506	7627979		23.84		
2010Q3	3506	7560313		23.63		
2010Q4	3506	8791019		27.48		
2011Q1	3504	8967405	197607237	28.05	618.02	22.04
2011Q2	3504	9045513	189192032	28.29	591.71	20.92
2011Q3	3504	8788215	180531140	27.49	564.62	20.54
2011Q4	3504	9038173	190848074	28.27	596.89	21.12
2012Q1	3504	9918725	217405415	31.02	679.94	21.92
2012Q2	3504	9263955	192609548	28.97	602.39	20.79
2012Q3	3504	9814515	190265412	30.70	595.06	19.39
2012Q4	3504	10482826	211736299	32.79	662.21	20.20
2013Q1	3504		211068292		660.12	

Table 2. Summary of the city driving fuel consumption and emission data for major taxi models used in Dubai (U.S. Department of Energy 2013).

Make and model	City fuel economy (liter/100 km)			CO_2 emissions (g/km)		
	Gasoline	Hybrid	Reduction %	Gasoline	Hybrid	Reduction %
2013 Toyota Camry	9.41	5.47	41.9%	194	133.5	31.1%
2013 Ford Fusion	10.69	5.00	53.2%	200	147.2	26.4%
2013 Nissan Altima	8.71	7.13	18.1%	178.3	NA	NA

3. RESULTS AND DISCUSSION

In considering the economic viability of using HEV taxis we need to balance the extra investment due to the higher upfront cost of the HEVs compared to its gasoline only counterpart and whether this cost can be recuperated by the operational savings in terms of fuel cost. Since the hybrid version of the Toyota Camry is not available at the UAE, the cost calculations will be based on the manufacturer's suggested retail price in the USA where both versions of the Toyota Camry are sold. The Toyota USA website (Toyota 2013) list the 2013 Camry LE at 22,680 USD and the Hybrid LE ay 26,140 USD. Thus the extra initial cost (EIC) is 3,460 USD (12,698 AED).The manufacturer's city fuel consumption data will also be used to calculate the taxi fuel consumption. Actual fuel consumption is expected to be higher than the manufacturer's data mainly due to two factors:

- Taxis tend to have the A/C on most of the year due to the hot and mostly humid weather in the UAE. This will increase the fuel consumption.
- The high traffic volume in Dubai tends to result in traffic congestion. Thus a taxi in Dubai will spend more time idling in traffic. In such cases the IC engine will continue to run and burn fuel further increasing the actual fuel consumption. The engine of a HEV taxi will be off during such a condition increasing the fuel savings compared to a standard IC engine taxi.

Several attempts were made to get actual fuel consumption data from Dubai taxi operators but were not successful.

Additional service costs would also need to be considered, especially the issue of replacing the battery pack. Toyota offers an 8 years/100,000 miles (160,900 kms) warranty in most 42 states and 10

years/150,000 miles (241,350 kms) warranty in 8 states on the battery pack. Thus the battery pack is expected to regularly last up to around 240,000 kms. Still many Camry user sites regularly report that the battery pack lasts more than 200,000 miles (321,800 kms) and some even more than 300,000 miles (482,700 kms). The data in Table 1 show that the taxi's average travel distance (ATD) is 226,000 kms/year. Thus it will be reasonable to assume that the battery pack would be replaced once every year. No official pricing of the battery pack was found on the Toyota website. A quick search on the web showed that the battery pack replacement cost (BPRC) was around 3,000 USD (11,010 AED), e.g. CarDirect website (CarDirect 2013). This is similar to the price difference between the prices of a new gasoline and hybrid Camry's. The price of replacing the battery packs is lower as the older battery pack is usually traded in when getting a new one thus getting a discount on the full cost of a new battery pack. The battery pack replacement cost could be even lower due to volume discount when buying a large number of battery packs per year, around 4000 battery packs/year based on the current size of the taxi fleet and a 3-year taxi life. Other than the cost of the battery pack, maintenance costs of a hybrid taxi should not be very different from that of a regular taxi. The insurance premium might be slightly higher, due to the higher cost of the taxi. Because of the absence of taxi insurance rate data this part will not be taken into consideration in the subsequent calculations.

Now that all the costs have been identified, the economic analysis part can start. The main interest here is to calculate the operational savings compare to the higher initial cost. The following equations will be used to calculate the annual Direct Operating Cost savings (DOC) and the annual Indirect Subsidy Cost savings (ISC). The DOC will be used to calculate the operator's Pay-Back Period (PBP) while the ISC will be used to calculate savings to Dubai Government Subsidy Savings (DGSS) due to reduced subsidy costs:

$$DCS = SP * ATD * (CFC_{gasoline} - CFC_{hybrid}) / 100 \quad (1)$$

$$ISC = (CP - SP) * ATD * (CFC_{gasoline} - CFC_{hybrid}) / 100 \quad (2)$$

$$PBP_{year\ one} = EIC / DCS \quad (3)$$

$$PBP_{years\ 2+} = BPRC / DCS \quad (4)$$

$$DGSS = No.\ taxies * ISC \quad (5)$$

Based on the data collected in sections 2 & 3, the results from equations 1-5 are as follows:

- Annual Direct Operating Cost savings = 15,311 AED/taxi/year
- Annual Indirect Subsidy Cost savings = 12,997 AED/taxi/year
- Operator' Pay-Back Period (1st year) = 0.83 years ≡ approximately 10 months
- Operator' Pay-Back Period (2nd year and beyond) = 0.72 years ≡ approximately 8.6 months
- Dubai Government Savings = 104 million AED/year

The above results are very informative and encouraging. The less than 1 year PBP is a clear indication that even with the high fuel subsidy, taxi operators can save money by switching to HEVs. Still the net amount of annual direct savings, 2613 AED in the 1st year and 4301 AED in subsequent years, might not be enough to persuade the operators to make the switch; it is human nature to resist change especially if the change is perceived to have some risks associated with it. The main savings come in the form of significant reductions in Dubai government fuel subsidies; around 104 million AED/year. This 10% reduction in the fuel subsidy cost incurred by Dubai government can be achieved by managing 1.7% of the cars registered in Dubai; 8000 taxis compared to 470,000 private cars. Dubai government can use some of these savings to provide incentives to the taxi operators to make the switch. This could be something similar to the 3000 USD UAS federal tax credit offered to operators when they procure a HEV taxi. Such a programme will only last for a few years until the taxi operators feel comfortable using HEVs at which point even a small net annual saving should be an enough incentive to use HEVs taxis. A reduced taxi registration fee is another potential strategy. Another approach will be for Dubai government to require all new taxis to be HEV. This is also a very viable proposal and would insure that the entire current fleet of taxis in Dubai is replaced with HEVs within 3 years, the expected operation life of a taxi in Dubai.

As for the CO_2 emissions savings, they can be calculated using the following equation:

$$\textit{Reduction in } CO_2 \textit{ emissions} = \textit{No. taxis} * \textit{ATD} * (CO_2E \textit{ gasoline} - CO_2E_{\textit{hybrid}}) / 1000 \quad (6)$$

Based on the emission data in Table 2 and other data collected, the annual reduction in CO_2 emissions is calculated to be 13,673 kg of CO_2 per taxi. This translates to approximately 109 million tons of CO_2/year. This would help the CO_2 footprint of Dubai which is in line with the commitment Dubai and the UAE have made to the environmental issue; no CO_2 emissions data is available for Dubai only. Unfortunately there is no way to put a monetary value on this environmental saving. This might change in the future if Carbon taxes or credits are introduced.

4. CONCLUSIONS

The adoption of HEVs has increased around the world mainly for economic motivations. This made the use of HEVs not attractive in countries with low/subsidized fuel costs such as the UAE. Low fuel prices result in long pay-back period considering the higher initial cost of HEVs compared to their IC-only counterparts. The long distances travelled by taxies make them idea candidates to benefit from using HEVs. In this study analysed the potential cost savings both direct (to the taxi operator) and indirect (to the government in the form of reduced subsidy costs) fin Dubai-UAE. The results showed that HEV taxis have a pay-back period of less than 1 year, making them a viable option for the taxi operators. The annual direct savings to the taxi operator was 2613 AED in the 1st year and 4301 AED in subsequent years. The annual indirect savings to Dubai government was around 104 million AED/year in the form of reduced fuel costs subsidies. This is 10% of the total fuel subsidy paid by Dubai government. The use of HEVs is also expected to reduce CO_2 emissions from the transportation sector by around 109 tons/year. Both the financial and environmental benefits are significant especially when considering that replacing current taxies with HEVs is straight forward and carries little risk as shown by the experiences of other countries. With fuel costs expected to continue to increase in the years to come coupled with the continued enhancement in HEV's efficiency and cost reduction both the economic and environmental benefits of HEVs are expected to become even more prominent in the future.

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