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Life cycle cost analysis of alternative vehicles and fuels in Thailand

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Abstract

High crude oil prices and pollution problems have drawn attention to alternative vehicle technologies and fuels for the transportation sector. The question is: What are the benefits/costs of these technologies for society? To answer this question in a quantitative way, a web-based model (http://vehiclesandfuels.memebot.com) has been developed to calculate the societal life cycle costs, the consumer life cycle costs and the tax for different vehicle technologies. By comparing these costs it is possible to draw conclusions about the social benefit and the related tax structure. The model should help to guide decisions toward optimality, which refers to maximum social benefit. The model was applied to the case of Thailand. The life cycle cost of 13 different alternative vehicle technologies in Thailand have been calculated and the tax structure analyzed.

Keywords: Alternative vehicles and fuels; Life cycle cost; Thailand

1. Introduction

Today almost all energy in the transportation sector originates from crude oil. Several problems related to the use of crude oil for transportation such as: air pollution, greenhouse gas emissions and high expenses due to crude oil and petroleum imports. In the last few years great efforts (political and scientific) have been undertaken to replace or reduce the usage of crude oil with alternative fuels and vehicle technologies. Argentina, Brazil and Pakistan have successfully increased the number of natural gas vehicles. In Brazil, ethanol from cassava is widely used as a fuel. But in almost all other countries crude oil is the only primary energy source for the transportation sector. Because of unforeseable difficulties, alternative vehicle/fuel technologies have not yet entered the market. This especially applies for the fuel cell technology, which was expected to be available much earlier. The date at which it is expected that fuel cell vehicles will enter the market is frequently postponed. It is a common belief of the public that the fuel cell technology will be the ultimate solution for the transportation sector, but there are still several problems concerning technical issues, infrastructure and costs Hammerschlag Mazza, 2004. Other technologies developed much faster than expected. Hybrid vehicles for example, which were expected to be very expensive to produce, are already available (Toyota Prius and Honda Civic Greene et al., 2004). One major disadvantage of fuel cell systems is the low efficiency of hydrogen production. Due to this, several studies have suggested developing hybrid vehicles rather than fuel cell vehicles. Weiss et al., (2000) found that in 2020 the total system energy consumption of a diesel/electric hybrid vehicle could be 25% lower than the total system energy consumption of a hydrogen fuel cell vehicle. Another future alternative could be the battery electric vehicle, which has a high potential to increase energy efficiency and reduce pollutant emissions (Delucchi et al., 2000).

Hydrogen could be a clean energy source but until the technology is commercially available other opportunities have to be considered as well. Maybe a less radical

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change in technology is the first step to reduce the use of crude oil and improve air quality. Transition technologies like natural gas vehicles (NGV) or hybrid vehicles can link conventional fuels with future preferred fuels. A natural gas vehicle for example can use gasoline or natural gas as fuel. Due to the low pollutant emissions, a broad usage of natural gas vehicles could improve the urban air quality significantly (Hekkert Marko, 2005; Abbott, 2004). Innovations in conventional technology can be an option as well: A diesel/electric hybrid vehicle with particle trap for example has a high fuel efficiency and, due to the filter system, low pollution emissions. The advantage of the diesel hybrid option is that there is no need to build an expensive natural gas or hydrogen infrastructure.

This paper addresses the question of how to determine the advantage/disadvantage of different technologies from an objective perspective. Which technology provides transportation at the least cost? There one has to distinguish between the consumer cost and the societal cost, which includes the external cost such as the damages through pollution.

1.1. Scope of the work

In the online encyclopedia of the Victoria Transport Policy Institute there is a description of several specific techniques used for transportation economic evaluations (TDM Encyclopedia, 2005). Ogden, (2004) calculated the social life cycle costs for different alternative vehicle technologies in the United States of America. Daedalus, (March 2002) studied cost-benefits of different gasoline and diesel fuel specifications in Thailand.

The focus of the present study is on the comparison of vehicle technologies which are available at present or will be available in the near future. The life cycle cost methodology has been chosen to determine and quantify the cost of each vehicle technology.

The first goal was to develop a model to calculate the consumer life cycle cost, the societal life cycle cost and tax.

The second goal was to apply the model to the case of Thailand. The cost–benefit of different near-term alternative vehicle technologies and the tax structure in Thailand has been analyzed.

Due to time and resource limitations, not all direct, indirect and long-term economic, social and environmental impacts are included in the cost calculations. Nevertheless, it should be possible to point out major tendencies and make a step towards societal benefit optimization. One problem of a life cycle cost calculation is that it can become invalid in a relatively short period of time when important parameters change. Therefore the calculation model for this study was programmed in HTML and PERL to facilitate recalculation. It is available freely on the Internet at the following URL: (http://vehiclesandfuels.memebot.com).

2. Methodology: description of the model and calculation of societal and consumer life cycle cost

In the following section the basic methodology of the societal life cycle cost calculation will be described. On the website (see http://vehiclesandfuels.memebot.com) the calculation is demonstrated for a diesel vehicle.

The societal life cycle cost is the sum of:

1. the vehicle initial cost without tax,
2. the operation cost (fuel cost) without tax,
3. The external costs (pollution damage).

An example of societal life cycle cost is shown in Fig. 1a. The societal life cycle cost does not include taxes because it is assumed that the collected taxes are used for the benefit of society. The external costs are based on the indirect and long-term economic, social and environmental impacts.

The consumer cost is the sum of

1. the vehicle initial cost including tax and
2. the operation costs (fuel cost) including tax.

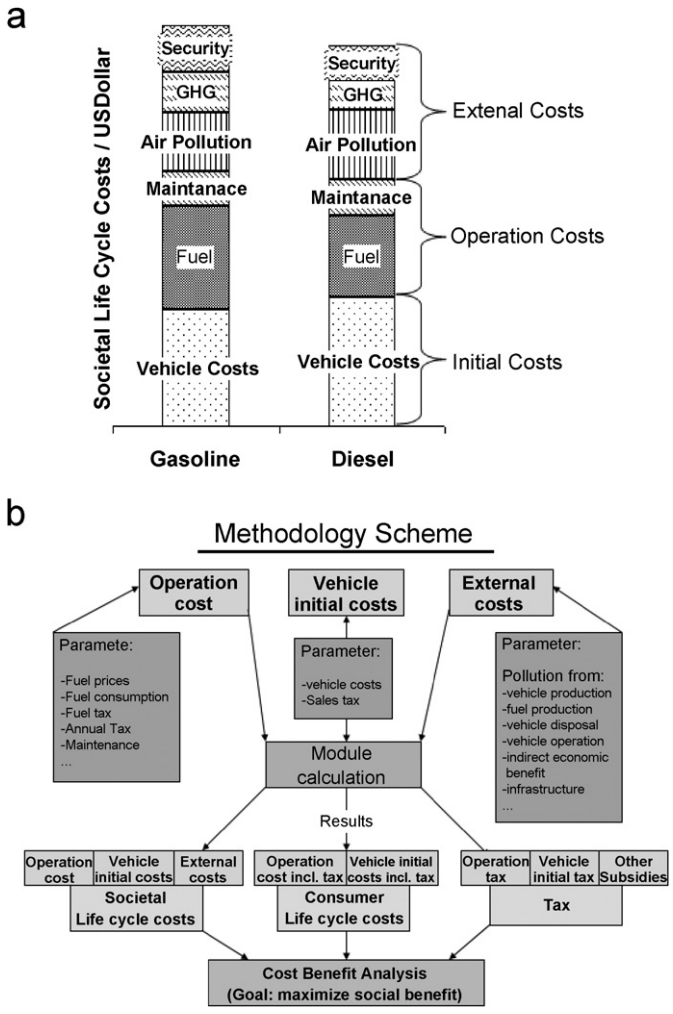

Fig. 1. (a) Example of societal life cycle cost: The sum of initial cost, operation costs and external costs. (b) Scheme for the life cycle cost calculation with cost–benefit-analysis.