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Greenhouse gas emissions from Thailand's transport sector: Trends and mitigation options

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ABSTRACT

Rapid growth of population and economy during the past two decades has resulted in continuing growth of transport's oil demand and greenhouse gas (GHG) emissions. The objectives of this study are to examine pattern and growth in energy demand as well as related GHG emissions from the transport sector and to analyze potential pathways of energy demand and GHG emissions reduction from this sector of the measures being set by the Thai Government. A set of econometric models has been developed to estimate the historical trend of energy demand and GHG emissions in the transport sector during 1989–2007 and to forecast future trends to 2030. Two mitigation option scenarios of fuel switching and energy efficiency options have been designed to analyze pathways of energy consumption and GHG emissions reduction potential in Thailand's transport sector compared with the baseline business-as-usual (BAU) scenario, which assumed to do nothing influences the long-term trends of transport energy demand. It has been found that these two mitigation options can reduce the GHG emissions differently. The fuel-switching option could significantly reduce the amount of GHG emissions in a relatively short time frame, albeit it will be limited by its supply resources, whereas the energy efficiency option is more effective for GHG emissions mitigation in the long term. Therefore, both measures should be implemented simultaneously for both short and long term mitigation effects in order to more effectively achieve GHG emissions reduction target.

1. Introduction

1.1. Thailand's transport sector

Population growth and economic development have caused increasing demand of travel and freight transport in the country. Energy demand and greenhouse gas (GHG) emissions in transport sector have increased dramatically since Thailand began transforming its agrarian-based economy to an industrialized one.

Because of rapid development of transport infrastructure, especially road transport, during the past three decades, nowadays, Thailand heavily relies on energy-inefficient transport modes. Passenger transport, both in urban area and inter-city, is mostly made by private passenger vehicles. The urban passenger transport share by private vehicles, including private cars, pick-up trucks and motorcycles, around 90%, while less than 10% are made by public transport [1,2]. The inter-city transports are made by passenger cars (57%), buses (35%) and small proportion of rail and plane about 7% and 1%, respectively [3]. Additionally, more than 83% of long-distance freight transport around the country is done by trucks [4], which is the highest energy intensity among various transport modes.

Thailand is also one of the high private vehicle ownership developing countries. In 2007, the overall private vehicle ownership is 370 vehicles per thousand persons, which included car and motorcycle ownerships of 126 and 244 vehicles per thousand persons, respectively [5].

Due to the use of these energy-inefficient transport modes, the transport sector consumed large amount of energy every year. In 2007, this sector used 23,615 kilo ton of crude oil equivalent (ktoe), accounting for about 36.4% of the total final energy consumption in Thailand [6]. Presently, the transport sector is the second largest of energy consumed sector.

Since Thailand has few of oil reserves, thus almost of crude oil and petroleum products have to import from oversea. More than 47 billion liters of imported crude oil and petroleum products [7] cost Thailand $US 22.5 billion in 2007, which accounting for 9% of the gross domestic product [8]. About 75.7% of the energy was used in road transport mode, 16.0% in international air transport,

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Nomenclature

D	dummy variable
F	fuel consumption
G	gross domestic product per capita
P	average crude oil price
MBE	mean bias error of estimation
$RMSE$	root mean square error of estimation
R^2	coefficient of determination
X	independent variable
Y	dependent variable
n	number of data set
$\hat{y}_i$	estimated value i
y_i	observed value i
$\bar{y}$	mean of observed values
a	y-intercept of regression equation
b,c,d	regression coefficient
ε	error term

Subscripts

f	type of fuel
m	transport mode
t	year

6.6% in oversea water transport, and little was used in more energy efficiency transport modes, such as rail (0.4%) and inland water transport (0.4%) [6]. Moreover, this sector was also the second largest greenhouse gas (GHG) emissions of the total GHG emissions from energy sector. It emitted about 54.6 million ton of CO_2 equivalent in 2007 [6].

1.2. Policy measures and earlier studies

Because of the dramatic increasing of oil price and environmental concern, both locally and globally, over the past decade, various policy measures to curb energy demand from fossil fuels as well as to mitigate local pollutants and GHG emissions from their utilization in the transport sector have been introduced and analyzed in various countries, especially in emerging developing countries as China and India [9–19]. Among those proposed policy measures, promoting to use alternative technologies for road transport is an approach that often proposed for energy demand reduction and emissions mitigation in short-term to medium-term plans.

The alternative technologies are generally introduced in two options; fuel switching and energy efficiency options. For the fuel switching option, the low-carbon content or carbon–neutral fuels, such as compressed natural gas (CNG) and biofuels, were promoted as alternative fuel substitute for conventional petroleum fuels. On the other hand, the energy efficiency option is to improve the energy efficiency of transport sector by promoting the use of high energy performance vehicles, such as hybrid electric vehicles, plug-in hybrid vehicles and electric vehicles.

In Thailand, the government has been promoting bioethanol and biofuel as alternative transport fuel in the country since 2001 and 2005, respectively. At the end of 2007, annual consumption of gasohol E10 (gasoline blended with 10% of ethanol by volume) in Thailand reached 1300 ktoe, accounting for 24% of the total gasoline consumption, while biodiesel B2 (diesel blended with 2% of biodiesel by volume) has been sold around 540 ktoe [6]. In addition, recently, the higher ethanol blended fuel of E20 and E85 have been promoted in 2008 and all diesel sold in Thailand has been blended with 2% of biodiesel since 2008.

The Thai Government also has promoted the use of high energy efficiency vehicles. Two high energy performance passenger vehicles of hybrid cars and eco-cars have been introduced by using financial incentive measures. The special rate of excise tax and privilege for investment project were adopted to be an incentive for automakers to invest in manufacturing of these energy efficiency vehicles. In addition, other policy measures, such as car labeling, fuel economy or emission standard, and taxation, are also being considered.

Several earlier studies, in Thailand, have estimated energy consumption reduction and/or GHG emissions mitigation in future under different policy scenarios. Results of those studies presented that promotion of alternative technologies in road transport, including promotion of CNG and biofuels as well as improving energy efficiency of vehicles, have potential to reduce energy related GHG emissions around 2–10% of the total GHG emissions in transport sector by 2030 [20–23]. Even though there are many studies assess the reduction potentials in Thailand, but most of them not take into account current policy measures of the Government. Moreover, none of them assess the possible reduction pathway of the policy measures, which is critical importance that should be analyzed.

1.3. Context and objective of this study

In this study, in order to analyze the future trends of energy demand and GHG emissions in Thai transport sector, an econometric model is developed based on historical information to estimate energy consumption and related GHG emissions. Two scenarios have been designed to analyze pathways of energy consumption and GHG emissions reduction in future under the Thai Government's policy measures to promote alternative technologies, including fuel switching and energy efficiency options, compared with the baseline business-as-usual (BAU) scenario. Finally, policy recommendation is given based on comparison of the pathways of energy consumption and GHG emissions reduction of each alternative technology options.

2. Methodology

2.1. Scope of study

In this study, the estimation of GHG emissions is scoped on only fuels consumed in domestic transport modes which include road, rail, water, and air transport. Seven fuel types are used in the transport sector consisting of gasoline, gasohol, diesel, biodiesel, jet kerosene, liquefied petroleum gas (LPG), and compressed natural gas (CNG). The estimation of GHG emissions from combustion of these fuels included both carbon dioxide (CO_2) and non-carbon dioxide (non-CO_2) greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O).

2.2. Data sources

The data for both the dependent and independent variables needed for the fuel demand forecasting models were collected from various official data sources for the years 1989–2007. They are summarized and presented in Table 1.

2.3. Forecasting models of fuel consumption

2.3.1. Model development

In this study, econometric models for each type of fuel were developed to forecast fuel consumption in the transport sector