50034

Thailand: Making Transport More Energy Efficient

The World Bank

National Economic And Social Development Board

NESDB

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Abbreviations and Acronyms

ADB	Asian Development Bank
AfD	Groupe Agence Francaise de Developement (French Development Agency)
B	Billion
CDP-INFRA	Country Development Partnership for Infrastructure
cf/d	cubic feet per dag
BCMA	Bus Control Management Authority (proposed)
BITA	Bangkok Integrated Transit Authority (suggested)
BMA	Bangkok Metropolitan Administration
BMCL	Bangkok Metro Company Limited
BMR	Bangkok Metropolitan Region
BMTA	Bangkok Mass Transit Authority
BOB	Bureau of Budget
BRT	Bus Rapid Transit
BTS	Bangkok Transit System
BTSC	Bangkok Transit System Corporation
CAI-Asia	Clean Air Initiative - Asia
CDM	Clean Development Mechanism
CNG	Compressed Natural Gas
CH_4	Methane
DEDE	Department of Alternative Energy Development and Efficiency
DLT	Department of Land Transport
DOH	Department of Highways
EPPO	Energy Policy and Planning Office
ESB	Eastern Seaboard
EU	European Union
EURO	European Emission Standard
GDP	Gross Domestic Product
GHG	Greehouse Gas
GOT	Government of Thailand
GPP	Gross Provincial Product
IEA	International Energy Agency
ICD	Inland Container Pepot
ITS	Intelligent Transportation Systems
IFIs	International Financial Institutions
JBIC	Japan Bank for International Cooperation
ktoe	thousand tonnes of oil equivalent
LPG	Liquified Petroleum Gas
LTA	Land Transport Act
M	Million
MJ	Megajoules
MPG	Miles Per Gallon
MRT	Mass Rapid Transit (rail)
MRTA	Mass Rapid Transit Authority
MVA	Motor Vehicles Act
NESDB	National Economic and Social Development Board
NGOs	Non-governmental organizations
NGV	Natural Gas Vehicle
NMT	Non-motorized transport
NOX	Oxides of Nitrogen
No_2	Nitrogen Dioxide
OTP	Office of Transport and Traffic Policy and Planning
OECD	Organization of Economic Co-operation and Development
pa	per annum
PDMO	Public Debt Management Office, Ministry of Finance
PM	Particulate Matter
PPM	Parts Per Million
PPP	Public Private Partnership
PPP	Purchasing Power Parity
PTT	PTT Public Company Ltd
SEPO	State Enterprise Policy Office, Ministry of Finance
SRT	State Railways of Thailand
TA	Technical Assistance
THB	Thai Baht
TOE	Tonnes of Oil Equivalent
TOR	Terms of Reference
TPES	Total Primary Energy Supply
µg	micrograms
UNFCCC	United Nations Framework Convention on Climate Change
URMAP	Urban Rail Transportation Master Plan (for Bangkok)
USA	United States of America
UTDP	Urban Transport Development Partnership
WRI	World Resources Institute

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The study was conducted under the general guidance of Ian Porter (formerly Country Director for Thailand, World Bank), Arkhom Termpittayapaisith (Deputy Secretary General, the National Economic and Social Development Board of Thailand), and Junhui Wu (formerly Sector Manager, Transport Energy and Mining Unit, East Asia and Pacific Region, World Bank).

Currency Equivalent

Currency unit = Baht (THB)

Exchange rate at March 31, 2008:

US$1.00 = THB31.6229

THB1.00 = US$0.03162

Government Fiscal Year

October 1- September 30

Weights and Measures

Metric units

1 meter (m) = 3.2 feet (ft)

1 kilometer (km) = 0.62 miles (mi)

Price Units

Prices in this report are expressed in approximately early 2008 prices unless otherwise noted

Executive Summary

This study addresses the question of how Thailand's transport sector can become more energy-efficient. It assesses the performance of the transport sector in energy utilization, analyzes where inefficiencies lie, and proposes options in order to improve transport energy efficiency.

Improved energy utilization is imperative for Thailand's national energy security and continued economic prosperity. Historically, Thailand has not performed well in terms of energy efficiency. Total energy intensity, defined as total final energy consumption per unit of Gross Domestic Product (GDP), is high compared to other countries and at least twice that of Germany, Japan and the USA. Moreover, Thailand's total energy intensity has remained more or less the same over the past three decades despite the availability of more energy efficient technologies. This is in sharp contrast to many other countries that have reduced their energy intensity over the same period. This implies that Thailand has high potential to achieve lower energy intensity.

At present, two sectors, 'manufacturing and mining' and 'transport', account for 70 percent of total energy use in Thailand, with each having approximately an equal share. Petroleum products account for half of the total final energy consumption in Thailand. Almost all energy used by the transport sector comes from petroleum products which represent 72 percent of the total consumption of petroleum products in Thailand. Seventy-six percent of transport energy is consumed in the road sector. With little fuel diversification, and with only a small amount of energy coming from renewable energy sources, the security of Thailand's energy supplies is highly vulnerable to possible future supply constraints or rapid price increases.

Thailand's transport energy intensity, defined as transport energy consumption per unit of GDP, is much higher than found in China, Germany, Japan, South Korea and the USA. More strikingly, it has remained at a high level between 1995 and 2006, while the comparator countries have been able to reduce their transport sector energy intensity. Clearly, Thailand's transport sector has significant potential to improve its energy efficiency.

The study found that the economic structure and spatial distribution of economic activities in Thailand do not impose extraordinary requirements on transport. Other factors—mainly the high level of motorization, heavy dependence on road transport and lack of fuel economy standards—contribute to the high level of transport energy intensity. Road transport overwhelmingly dominates freight and passenger transport markets, while rail plays a very small and declining role. The majority of Thailand's vehicles use diesel, and fuel economy standards are not applied to gasoline or diesel powered vehicles. The truck fleet is on average quite old and fuel-inefficient. Due to low taxes, fuel prices are relatively low compared to Japan and Western European countries. The estimated fuel efficiency of Thailand's passenger vehicle fleet today is approximately 25 to 30 percent lower than the levels found in Japan and Western Europe. Traffic congestion in the Bangkok Metropolitan Region (BMR) would also contribute significantly to Thailand's high transport energy intensity.

As a policy option, pricing fuels on the basis of their long-run marginal costs is expected to have a significant and sustained effect on the improvement in transport energy efficiency in Thailand. However, recognizing the political difficulties in implementing a comprehensive fuel pricing policy in the short to medium term, the study also examined 16 other policy and technology options. These are grouped into the following five categories:

- **Fuel efficiency and fuel switching:** upgrade engine technologies for buses and trucks, and use natural gas selectively in vehicle fleets, especially commercial vehicles.

- **Better vehicle standards:** establish and (progressively) tighten fuel economy standards of passenger vehicles to match European standards, and improve logistics practices in the road-based freight transport sector to better match truck sizes to the task and operating environment.

- **Rail investment and reform:** reform and modernize the rail sector, expand the role of rail in freight transport and long-distance passenger services; and in the BMR, expand Mass Rail Transit (MRT) and improve its integration with bus services, and improve accessibility and walkability to bus stops and mass rapid transit stations.

- **Better urban bus services:** increase the speed and quality of bus services through expansion of Bus Rapid Transit (BRT) and investment in new fleet which will bring improved passenger comfort, better fuel efficiency and lower emissions.

- **Policy and pricing measures:** upgrade the vehicle registration system and associated charges that reflect actual vehicle use; improve traffic management; and promote more efficient bus services through reforms that encourage competition and new investment.

These options are essential elements in any efficient transport sector strategy. Most of them are win/win options in terms of both transport performance and energy efficiency. A simple quantitative assessment of these options indicates that if all options are successfully implemented in Thailand, about one-third of the total annual transport energy use can be reduced in 2025 compared to the "business as usual" scenario. The savings would be more substantial if a comprehensive fuel pricing policy is also implemented.

To implement the above options requires strong commitment and serious effort by the government especially in overcoming political and institutional impediments that prefer the status quo. Fuel pricing offers great potential to induce favorable behavioral change in fuel usage and modal shift. Appropriate fuel pricing, and vehicle taxes and charges will underpin the technology and policy options by creating the right incentives for transport firms, logistics providers, and households to carefully consider the lifecycle energy consumption associated with their choices of location, activity patterns, modes and vehicles. To implement the majority of options requires strong institutional capacity to lead and coordinate the concerted effort. This may be a major challenge for the government. Thailand's own success in phasing out leaded gasoline and improving Bangkok's air quality in the 1990s provides many relevant lessons for application to the implementation of the transport energy efficiency agenda.

1 Introduction

1.1 Strategic Context

The recent rapid increases in global oil prices seriously impacted world economies. Despite a more recent price decrease, many countries are aiming to transition to more energy efficient technologies, production processes and logistics. Recognizing that the transition will take time and new investment to accomplish, policy makers in Thailand, as in many other countries, wish to develop a more resilient and sustainable economy that is better equipped to deal with oil price shocks and a possible sustained long-term real increase in the price of energy.

Improved energy sustainability is an imperative for Thailand's national energy security and continued economic prosperity. To achieve the goal of sustainability on the energy supply side, it is recognized that the country's energy mix must be diversified by developing more renewable and alternative energy options. On the energy demand side, great potential exists for energy efficiency improvement, particularly in the manufacturing and transport sectors, the two largest consumers of energy in Thailand.

Improved energy sustainability is an imperative for Thailand's national energy security and economic prosperity.

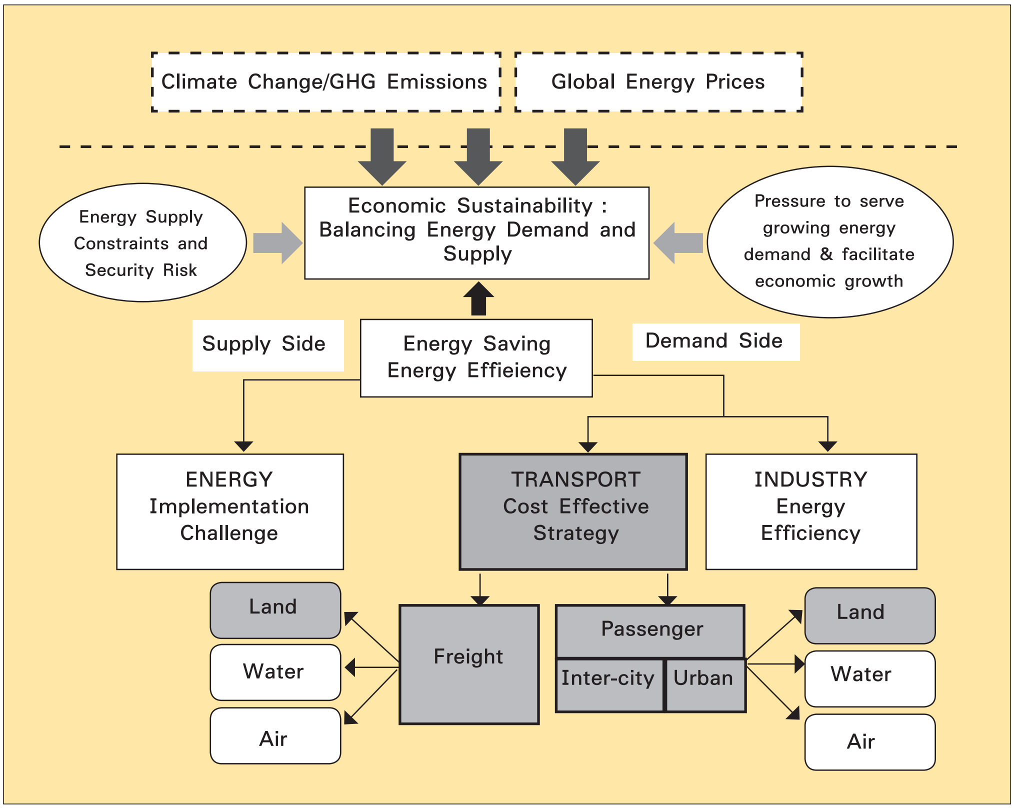
In the manufacturing sector, there is a consensus that improved energy efficiency can be achieved by encouraging upgraded technologies and processes, and by applying appropriate pricing and incentives. However, there has been no clear strategic direction for the transport sector. At present, high logistics costs, heavy traffic congestion in Bangkok, and capacity shortages in some interurban transport corridors are constraints on the economy. These problems could be compounded by future supply shortages and price increases of fossil fuels on which the transport sector is heavily dependent. Therefore, a clear strategy for efficient transport and energy use is needed, taking into account the complementary benefits of reduced global greenhouse gas (GHG) emissions and local air pollution.

1.2 Objective and Scope

The objective of this study is to provide analytical underpinning and support to the government's ongoing effort to develop and implement sustainable transport infrastructure and logistics strategies. The study focuses on land transport, which includes passenger (urban and inter-city) and freight transport (Figure 1). Land transport is a dominant transport subsector and will be required to contribute to the reduction of energy use and GHG emissions. Inland water transport is not included in the study scope as it only carries a very tiny fraction of all freight and passengers, and its role cannot be significantly developed.

This study first reviews the trends and patterns of transport energy use, and analyzes the main contributing factors to transport energy inefficiency. On this basis, the study examines the energy implications of various alternative land transport policy and technology options, most of which can be undertaken for broader reasons than energy savings alone. This broad consideration is necessary because energy savings have to be balanced against investment costs of new transport infrastructure, recurrent costs of operation and maintenance, and other benefits to consumers and producers.

Figure 1: Scope of the Study



Source:Study Team.

The study has its limitations. Transport is a demand derived from other social and economic activities. Urban land use development, for example, influences urban travel patterns and associated energy use. The transport energy implications of land use policies are outside of the scope of this study. Moreover, transport has many interrelated dimensions (e.g. locational, temporal, technological, modal, and organizational), and involves a variety of actors (e.g. shippers, multi-modal logistics providers, individual transport firms, drivers, infrastructure providers and users) who operate in an environment heavily influenced by market forces and public policies. The effects of policies to reduce excessive energy usage or improve energy efficiency in the transport sector are therefore generally more complicated than improving energy efficiency in a single stand-alone factory, which may respond well to pricing signals. This complexity is considered but not analyzed rigorously in the study. Finally, the study does not look into the indirect energy use and emissions caused by production, distribution, maintenance and disposal of fuels, vehicles and infrastructure.

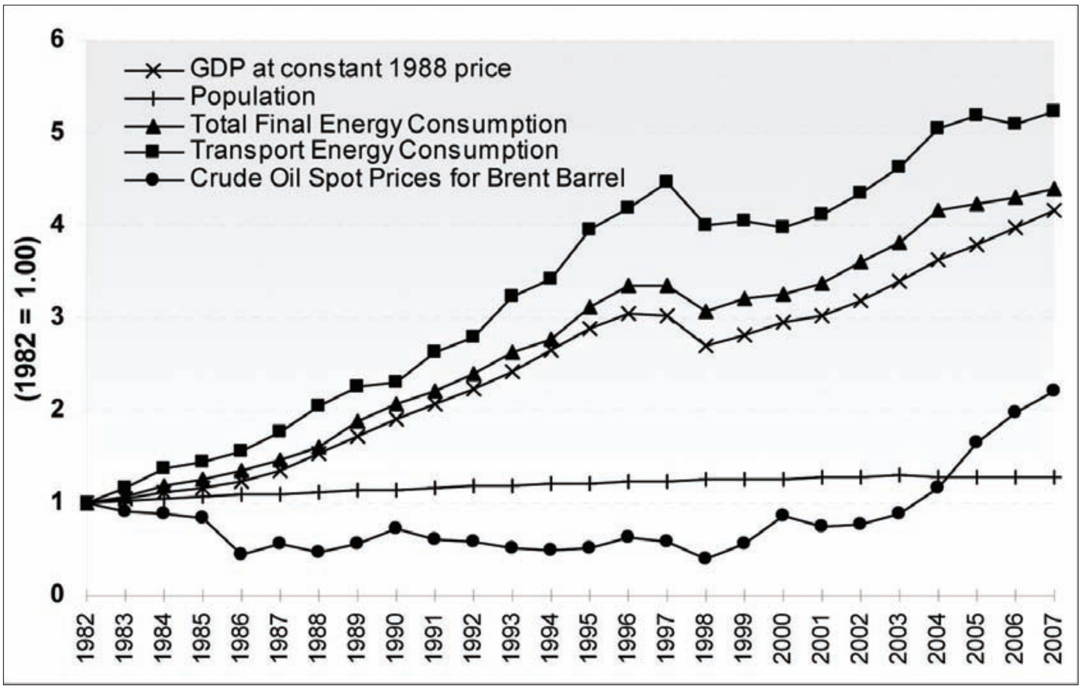
2 Transport Energy Use: How Thailand Compares to Other Countries?

2.1 Energy Intensity: Economy-wide and Transport Sector

Over the last 25 years, the growth of Thailand's total final energy consumption has followed a similar trend to GDP growth (Figure 2).[1] Both grew steadily from 1982 to 1997. Following the 1997 Asian financial crisis, total final energy consumption declined by over 10 percent, most likely caused by the abrupt economic downturn. With the recovery of the economy after 2001, total final energy consumption increased again.

Final energy consumption and transport energy consumption are closely linked with GDP growth.

Figure 2: Trends of Final Energy Consumption, GDP and Population in Thailand, 1982-2007



Source: Calculated based on data from Bank of Thailand and Department of Alternative Energy Development and Efficiency.

The close link between GDP and energy consumption indicates that total energy intensity, defined as total final energy consumption per unit of GDP, has remained relatively constant over time (Figure 3), despite the availability of more energy efficient technologies to reduce energy consumption. Since 2004, however, the total energy intensity has steadily declined, most likely due to the sharp increase in the price of crude oil in that year. During 1982-2007, transport energy consumption has grown faster than GDP and total final energy consumption in Thailand (Figure 2). The trend of transport energy intensity—defined as the ratio of transport Tonnes of Oil Equivalent (TOE) consumption over total GDP—has been quite constant for the last 25 years (Figure 3).

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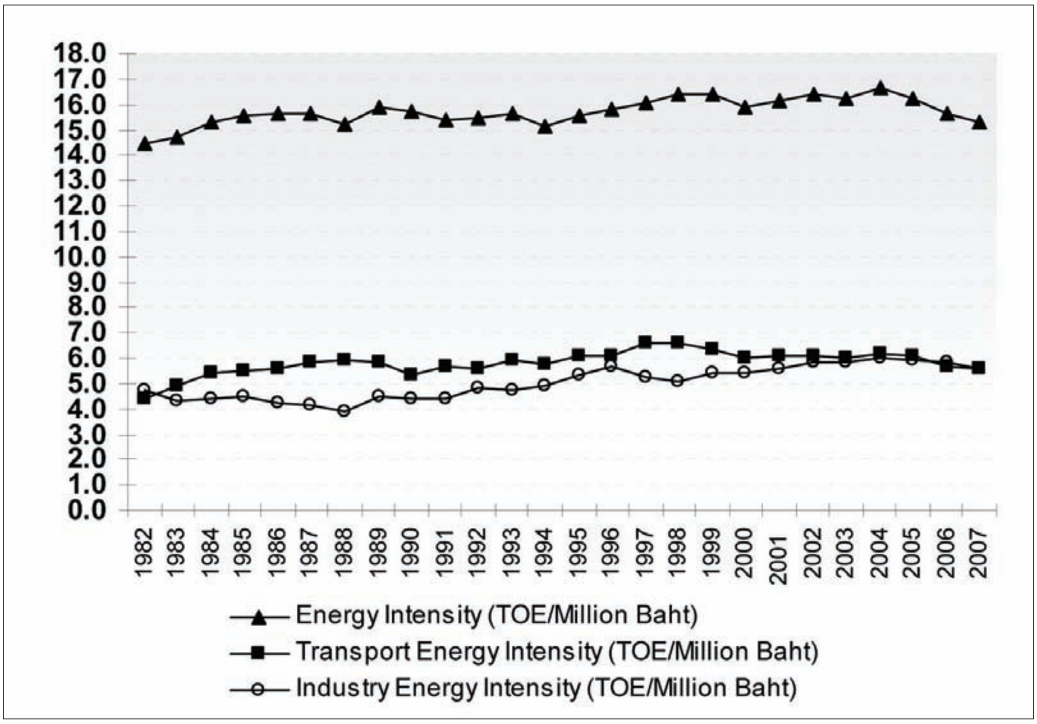
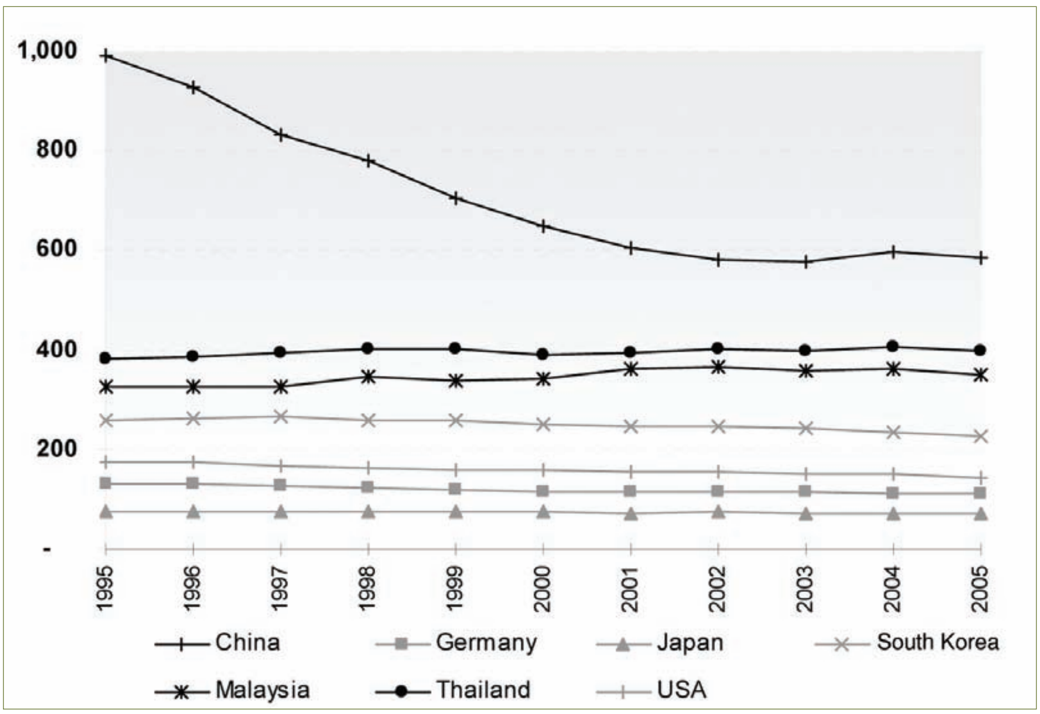
[1] *According to the European Environment Agency (EEA) Indicator Management Service, the final energy consumption covers energy supplied to the final consumer's door for all energy uses. It is calculated as the sum of final energy consumption from all sectors, and is measured in thousand tonnes of oil equivalent (TOE). It can be disaggregated to cover industry, transport, households, services and agriculture sectors. [see website: http://ims.eionet.europa.eu/IMS/ISpecs/ISpecification20041007132121/full_spec.]*

Figure 3: Trends of Energy Intensity in Thailand, 1982 - 2007



Source: Calculated based on data from Bank of Thailand, and Department of Alternative Energy Development and Efficiency.

Figure 4: Total Energy Intensity (TOE of Final Energy Consumption/Million USD of GDP at 2000 Constant Prices), Selected Countries



Source: Calculated based on total energy consumption data from IEA, which are available at http://data.iea.org/ieastore/default.asp, and GDP data from World Bank's Data Development Platform/World Development Indicators Database.

Thailand's total energy intensity has remained high and stable while comparator countries have successfully reduced total energy intensity during the last decade.

When compared to China, Germany, Japan, Korea, Malaysia and the USA, Thailand's total final energy consumption per dollar of GDP is consistently higher than all these countries except China (Figure 4). While all these countries except Malaysia have successfully reduced total energy intensity during the last decade (41 percent for China, 14 percent for Germany, 7 percent for Japan, 12 percent for Korea and 17 percent for the USA), Thailand's total energy intensity has remained high and stable, with a 9 percent increase during 1995-2005. Great potential appears to exist for Thailand to achieve a lower level of energy intensity.

Thailand's energy mix is vulnerable to oil price rises with little diversification of fuels.

2.2 Structure of Energy Consumption by Sector

Thailand's primary sources of energy include crude oil, natural gas, coal, hydropower and renewable energy. Most of the primary sources are imported. Electricity generation relies mainly on natural gas and coal. Electricity generated from renewable energy sources such as biomass, wind, and solar comprise a very small share (1.7 percent)[2] of the energy mix. Therefore, Thailand's energy supply is particularly vulnerable to increases in international energy prices.

The structure of final energy consumption in Thailand is shown in Table 1. Among all sectors, manufacturing/mining and transport are the two biggest consumers of energy, each consuming over 35 percent of the total in 2006. Petroleum products account for half of the total final energy consumption in Thailand, and 72 percent of total petroleum products were consumed by the transport sector. Petroleum products accounted for almost 100 percent of the energy consumed by the transport sector in 2006. The remaining tiny portion of less than one percent consisted of electricity for rail-based mass rapid transit (MRT) in Bangkok and natural gas for natural gas vehicles (NGV), which have been increasing as a result of the government's promotion of natural gas as an alternative energy source.

Energy consumption is dominated by transport and manufacturing.

The structure of final energy consumption among sectors has not experienced significant changes over the period from 1982 to 2006 (Table 2). Manufacturing/mining and transport have remained the two biggest consumers of energy. Only the share of residential (i.e. household) sector has significantly declined. Agriculture's share has also declined but to a lesser extent. In contrast, the commercial sector's share has increased.

2 Total electricity generated in 2007 was 147,026 GWh and electricity generated from renewable sources was 2,553 GWh (Source: EPPO).

Table 1: Final Energy Consumption (KTOE) in Thailand, 2006

	Coal & Its Products	Petroleum Products	Natural Gas	Electricity	New & Renewable Energy*	Total	% Share of Each Sector
Manufacturing	7,489	3,307	2,152	5,054	5,570	**23,572**	**37.3%**
Transport	-	22,898	82	5	-	**22,985**	**36.3%**
Residential	-	1,310**	-	2,301	5,423	**9,034**	**14.3%**
Agriculture	-	3,291	-	21	-	**3,312**	**5.2%**
Commercial	-	705***	-	3,510	-	**4,215**	**6.7%**
Construction	-	139	-	-	-	**139**	**0.2%**
Total Final Energy Consumption	**7,489**	**31,650**	**2,234**	**10,891**	**10,993**	**63,257**	**100%**
% Share of Energy Type of Total Energy	**12%**	**50%**	**3.5%**	**17.22%**	**17.4%**	**100%**	**///**

Source: Drawn from Department of Alternative Energy Development and Efficiency data.

*Note: * New and Renewable Energy includes Fuel Wood, Charcoal, Paddy Husk, Bagasse and Agricultural Waste.*

*** Petroleum products in residential sector include LPG and Kerosene.*

**** In commercial sector, more than 90 percent of petroleum products consumed are LPG.*

Table 2: Final Energy Consumption by Sector in Thailand, 1982 and 2006

Sector	1982		2006	
	KTOE	%	KTOE	%
Manufacturing & Mining	4,802	32.6%	23,572	37.3%
Transport	4,523	30.7%	22,985	36.1%
Residential	3,596	24.4%	9,034	14.3%
Agriculture	1,117	7.6%	3,312	5.2%
Commercial	578	3.9%	4,215	6.7%
Construction	111	0.75%	139	0.2%
Total	**14,727**	**100%**	**63,257**	**100%**

Source: Department of Alternative Energy Development and Efficiency.

2.3 Transport Fuel Use and Greenhouse Gas Emissions

Thailand's transport heavily depends on road-based modes. As a result, the majority of total transport energy consumption (of which liquid fuels account for 99 percent), about 77 percent, is in road transport (Table 3).[3] If international air and international water transport is excluded from the total, the share for road would reach 98 percent.

[3] *Annex 1 gives more details of fuel consumption in the BMR*

Table 3: Energy Consumption in the Transport Sector by Mode in Thailand, 1999 and 2006

Transport Mode	1999		2006	
	KTOE	%	KTOE	%
Road Transport	14,588	79.7%	17,499	76.1%
Rail Transport	103	0.6%	103	0.4%
Domestic Water Transport	65	0.4%	63	0.3%
International Water Transport	845	4.6%	1,626	7.1%
Domestic Air Transport	288	1.6%	249	1.1%
International Air Transport	2,408	13.2%	3,445	15.0%
Total	**18,297**	**100%**	**22,985**	**100%**

Source: Department of Alternative Energy Development and Efficiency.

The majority of transport energy consumption is in the road sector.

Diesel fuel consumption in transport accounted for approximately half of the sector's total energy consumed in 2006 (Table 4). The second and third most important fuels consumed in the sector were gasoline (23 percent, including gasohol blends) and jet fuel (16 percent), respectively. Bio-fuels, including gasohol, palm diesel and biodiesel, were introduced into the domestic market from 2001 and by 2006 represented just over four percent of energy consumption in the transport sector.[4] Alternative fuels such as LPG and natural gas had a two percent and 0.4 percent share respectively of total energy consumed in the transport sector in 2006.

Table 4: Energy Consumption in the Transport Sector by Energy Type, 1982 and 2006

Fuel Type	1982		2006	
	KTOE	%	KTOE	%
LPG	129	2.9%	535	2.3%
Unleaded Gasoline 91	919	20.3%	3,254	14.2%
Unleaded Gasoline 95	501	11.1%	1,086	4.7%
Gasohol 91	0	0.0%	71	0.3%
Gasohol 95	0	0.0%	883	3.8%
Jet Fuel	884	19.5%	3,694	16.1%
High Speed Diesel	1,897	41.9%	11,709	50.9%
Low Speed Diesel	20	0.4%	47	0.2%
Palm Diesel	0	0.0%	3	0.0%
High Speed Diesel (Biodiesel 5)	0	0.0%	37	0.2%
Fuel Oil	173	3.8%	1,579	6.9%
Natural Gas	0	0.0%	82	0.4%
Electricity	0	0.0%	5	0.0%
Total	**4,523**	**100%**	**22,985**	**100%**

Source: Department of Alternative Energy Development and Efficiency.

[4] Biodiesel, such as gasohol 91, gasohol 95 and biodiesel 5, has been promoted since 2003 to reduce petroleum imports. The Ministry of Energy specified a biodiesel blend consisting of five percent biodiesel and 95 percent high speed diesel fuel known as B5, which represented only 0.3 percent of high speed diesel fuel use in 2006. Similarly for gasoline, ethanol is mixed with gasoline to produce gasohol 91 and gasohol 95. Gasohol 95 was introduced in the market in 2001 while gasohol 91 was made available in 2005. Gasohol accounted for 22 percent of total gasoline consumption in 2006. To further encourage the use of ethanol, the government also introduced E20 (gasoline with 20 percent mix of ethanol) and E85 (gasoline with 85 percent mix of ethanol) in 2008. However, the penetration of these two fuels is currently limited.

The total amount of transport fuel use is driven by the economy and also influenced by fuel prices. A regression model was estimated using annual data on Thailand's fuel sales (in million liters), real GDP (in billion THB), and composite retail prices of fuels (in THB per liter) from 1986 to 2007. The model takes a "log-log" specification for both the dependent and independent variables so that the estimated coefficients of the independent variables can be interpreted as elasticities. The result is shown below, with the t-statistics, which are statistically significant, in parentheses:

$$\ln(\text{fuel sales}) = \underset{(1.06)}{1.00} + \underset{(3.62)}{1.12}\ln(\text{GDP}) - \underset{(-2.43)}{0.31}\ln(\text{fuel prices}) \quad R^2 = 0.83$$

This simple regression shows that income elasticity of fuel use is 1.12, implying that a one percent increase in real GDP would lead to 1.12 percent increase in fuel use. The price elasticity of -0.31 implies that a one percent increase in composite retail prices of fuels would lead to a 0.31 percent decrease in fuel use. These elasticity estimates are broadly consistent with empirical evidence found elsewhere, and suggest that Thailand's transport fuel use increases slightly faster than real GDP, but also responds to price changes, albeit to a lesser extent.

Fuel use is driven by GDP growth but also responds to price changes.

The contribution of Thailand's transport sector to GHG emissions can be estimated based on the level of the energy use in the sector. In 2006, the sector was estimated to have contributed around 26 percent of Thailand's total GHG emissions. This made the transport sector the second largest contributor after the electricity sector, which contributed 37 percent of total GHG emissions (Table 5).

Table 5: GHG Emissions (1,000 Tonnes of CO_2 Equivalent) by Sector, 2002 and 2006

Sector	2002		2006	
	1,000 tonnes of CO_2 Equivalent	%	1,000 tonnes of CO_2 Equivalent	%
Transport	48,110	29.29%	48,388	26.32%
Electricity	63,542	38.69%	68,849	37.45%
Manufacturing	37,198	22.65%	42,207	22.96%
Residential and Commercial	5,514	3.36%	14,254	7.75%
Others	9,872	6.01%	10,162	5.53%
Total	**164,236**	**100%**	**183,859**	**100%**

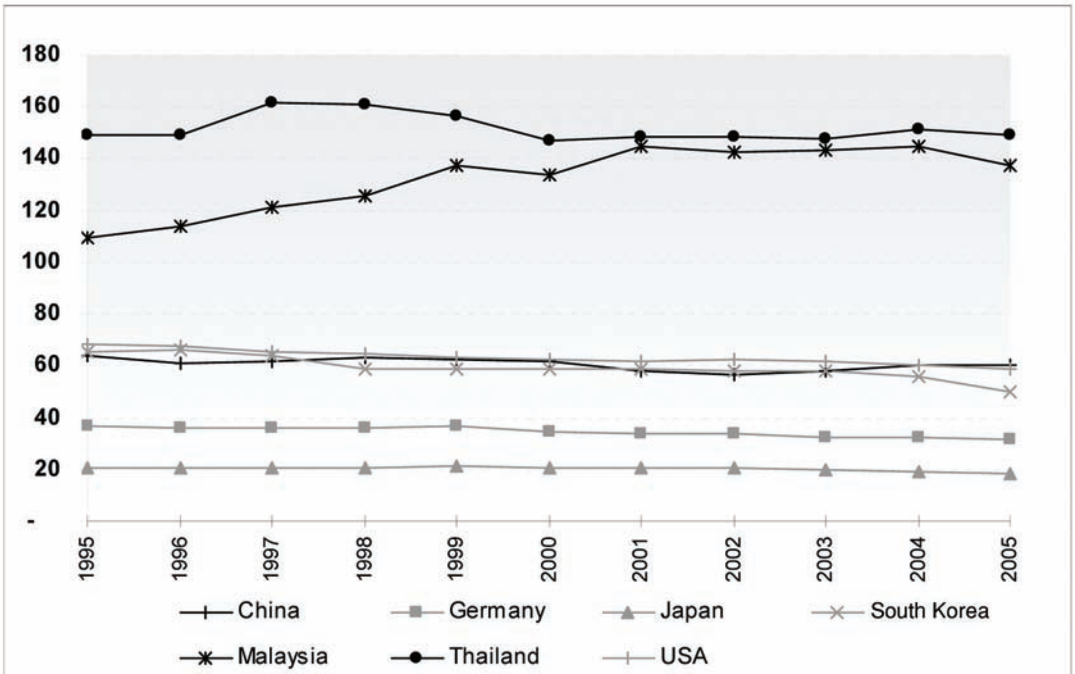
Source: Calculated based on Department of Alternative Energy Development and Efficiency data.

Note: GHG emissions shown here included CO_2 and CH_4. The conversion factors used are based on IPCC 1996 revised guideline. The emissions of other greenhouse gases excluded in this figure are negligible compared to the total.

2.4 Cross-Country Comparison of Transport Energy Intensity

How does Thailand compare with other countries in terms of transport energy intensity?[5] As Figure 5 indicates, Thailand has the highest level of transport energy intensity, when compared to China, Germany, Japan, Korea, Malaysia and the USA using data for the period from 1995 to 2006; it is seven times higher than Japan's. Moreover, over the same period, a few countries have achieved slight, but steady reductions in their transport energy intensity. This implies significant room for Thailand's transport sector to improve its energy efficiency.

Figure 5: Transport Energy Intensity (TOE/Million USD GDP at 2000 Constant Prices), Selected Countries



Source: Calculated based on transport energy consumption data from IEA available at http://data.iea.org/ ieastore/ default.asp, and GDP data from World Bank's Data Development Platform/ World Development Indicators Database.

Transport energy intensity in Thailand is much higher than those found in other countries.

Within the transport sector, the large amount of energy consumed in the road subsector is a key challenge for Thailand.[6] A cross-country comparison of road-based energy use per GDP at constant prices between 1990 and 2003 is shown in Figure 6. Energy intensity in the road subsector in Thailand and Malaysia was not only higher, but also experienced increases over the period. Some of the comparator countries

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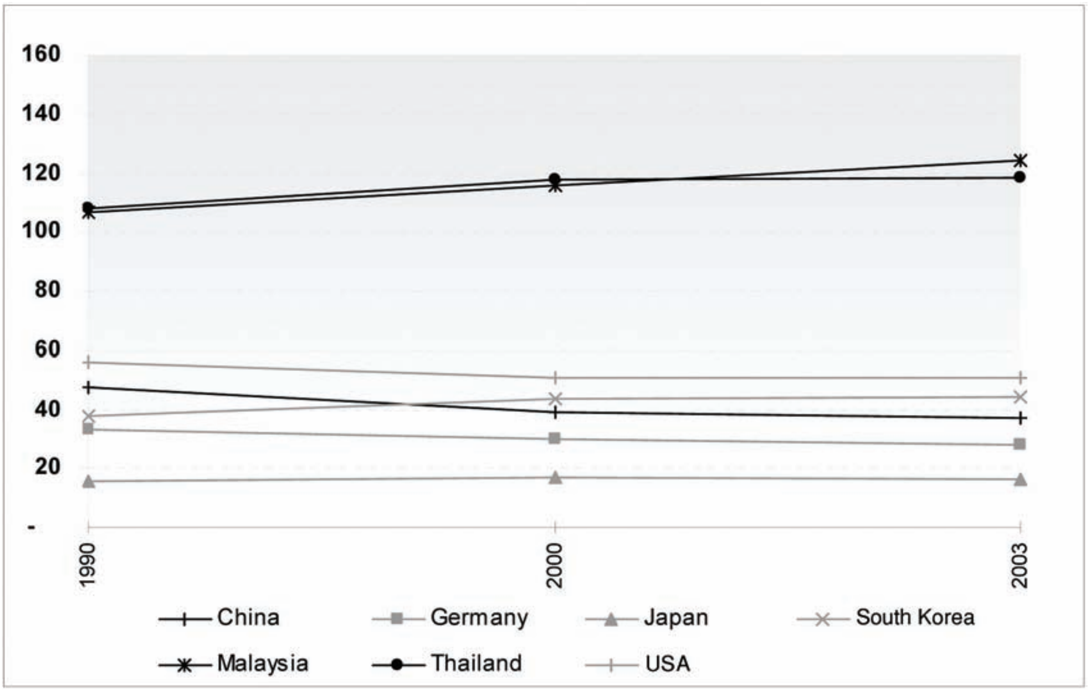
5 *The most commonly used indicators to assess performance of the transport sector in terms of energy efficiency or intensity are energy use per ton-kilometer of freight and per passenger-kilometer. However, these indicators are not readily available for Thailand. While transport energy consumption per unit of GDP converted to a common currency (US$) at market exchange rates is not the most desirable indicator, it has an advantage in reflecting the role of transport energy use in the whole economy.*

6 *The road sector energy consumption figure measures the amount of primary energy from all sources consumed for road transport in each country in the year specified. Data are reported in thousands of tonnes (metric tons) of oil equivalent (ktoe). Energy consumption from road transport includes all fuels used in road vehicles including agricultural and industrial highway use. The sector excludes military consumption as well as motor gasoline used in stationary engines and diesel oil used in tractors. [http://earthtrends.wri.org/searchable_db/index.php?theme=6]. Accessed May 29, 2009.*

(Germany, China, and The USA) were able to achieve a reduction in road sector energy intensity over the same period. Obviously, Thailand has potential for a major improvement in road subsector energy use.

Figure 6: Road Sector Energy Intensity (TOE/Million USD GDP at 2000 Constant Prices), Selected Countries

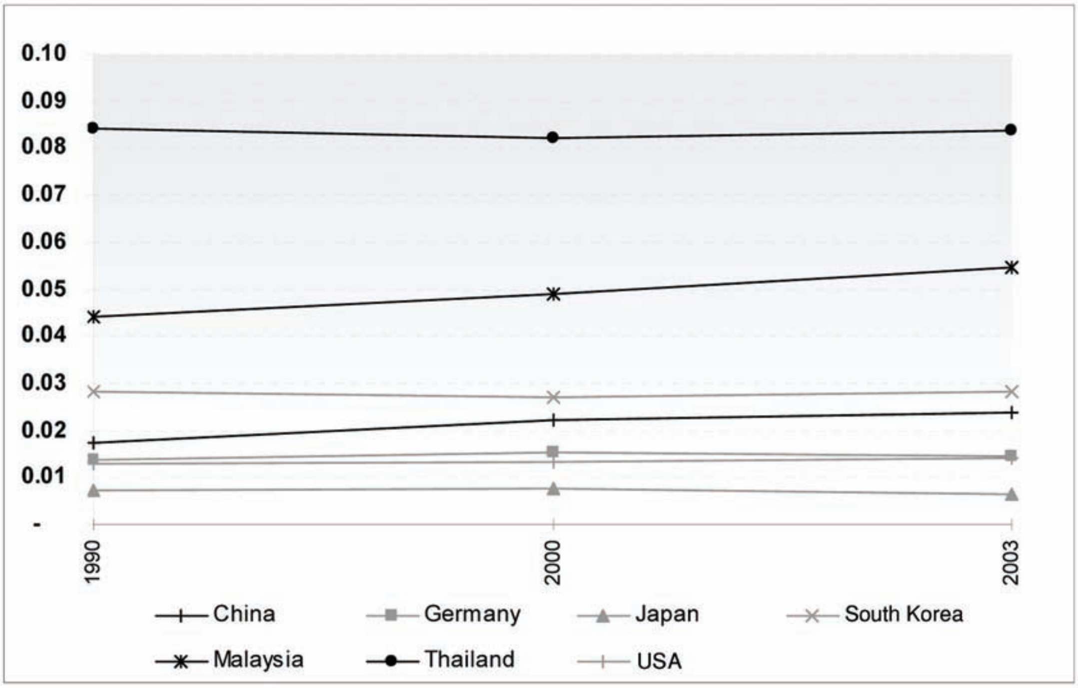


Source: Calculated based on data from IEA access via World Resources Institute at http://earthtrends.wri.org.

Data for diesel fuel intensity (for transport and industry) and motor gasoline intensity (for transport only) by country are shown in Figures 7 and 8, respectively. By comparison, Thailand is the least diesel fuel-efficient, and among the least gasoline fuel-efficient. Since diesel is used in both manufacturing and transport, more information is required to determine which sector is less diesel fuel efficient, but such information was not available. In terms of motor gasoline, Thailand compares well to the USA, and is more efficient than Malaysia,[7] but is less efficient than the other four countries presented. As Thailand's gasoline vehicle fleet relies generally on up-to-date passenger cars of Japanese, European and American origin, the nation's high motor gasoline intensity may reflect its particular economic structure, reliance on road-based travel and low taxes on fuels (refer Section 3.5) and vehicle registration charges.

[7] *Malaysia heavily subsidized its energy prices until June 2008. As a result of subsidies, the retail prices of gasoline and diesel were 23 percent and 39 percent lower than for Thailand's in US$ terms as shown in Section 3.5.*

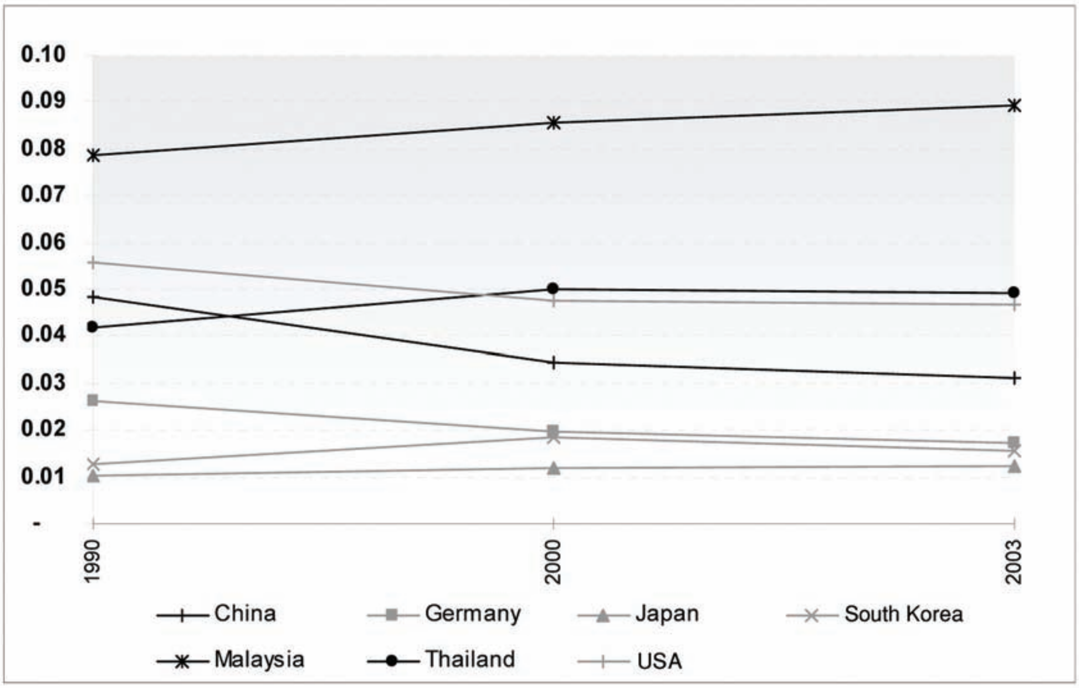
Figure 7: Diesel Intensity (Liters/USD GDP at 2000 Constant Prices), Selected Countries



Source: Calculated based on data from IEA access via World Resources Institute at http://earthtrends.wri.org.

Thailand is the least diesel fuel-efficient and among the least gasoline fuel-efficient countries.

Figure 8: Motor Gasoline Intensity (Liters/USD GDP at 2000 Constant Prices), Selected Countries



Source: Calculated based on data from IEA access via World Resources Institute at http://earthtrends.wri.org.

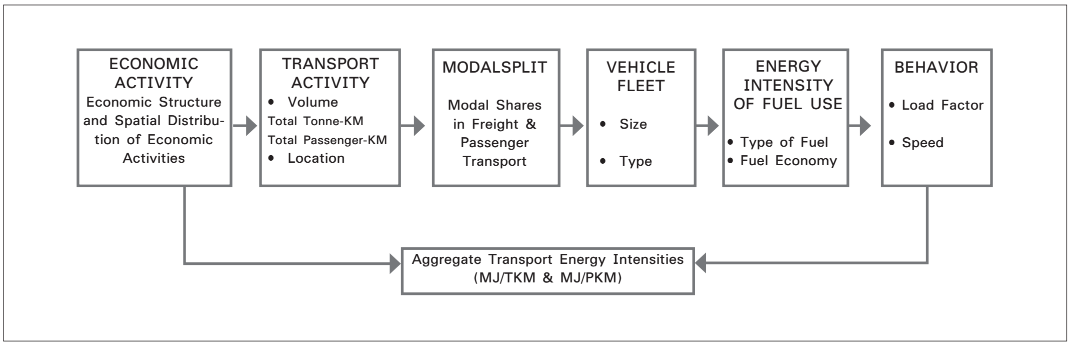
Overall, Japan and Germany are the most transport energy efficient among the countries compared. This appears to be due to factors such as the technological improvement in the fuel economy of vehicles, the significant role of the railways for passengers (Japan and Germany) and freight (Germany), the higher prices of fuel, and the growing contribution of the service sector to overall GDP. A decrease in transport energy intensity is common among most OECD countries including the USA. Interestingly, China's gasoline energy intensity has not always been moderate and in 1990 was higher than for Thailand.

In summary, Thailand stands out for its high energy intensity in the transport sector. This is all the more striking given the fact that an important part of GDP is generated in the BMR and the nearby Eastern Seaboard industrial clusters which, due to their mutual proximity, should contribute to reduced transport energy intensity. It implies that the high transport energy intensity has a lot to do with the factors within the transport sector.

3 A Diagnostic Analysis: What Contributes to Low Transport Energy Efficiency?

Transport energy intensity could be influenced by many factors, including a nation's economic structure, the spatial distribution of social and economic activities, modal splits, vehicle fleet composition, fuel efficiency of vehicles, and the transport choices of firms and individuals (Figure 9). This section examines the effects of these factors on transport energy consumption per unit of GDP in Thailand. As petroleum products account for 99 percent of the energy consumed in Thailand's transport sector, the analysis below essentially pertains to liquid and gaseous fuel consumption.

Figure 9: Factors Affecting Energy Efficiency of the Transport Sector



3.1 Economic Structure and Spatial Distribution

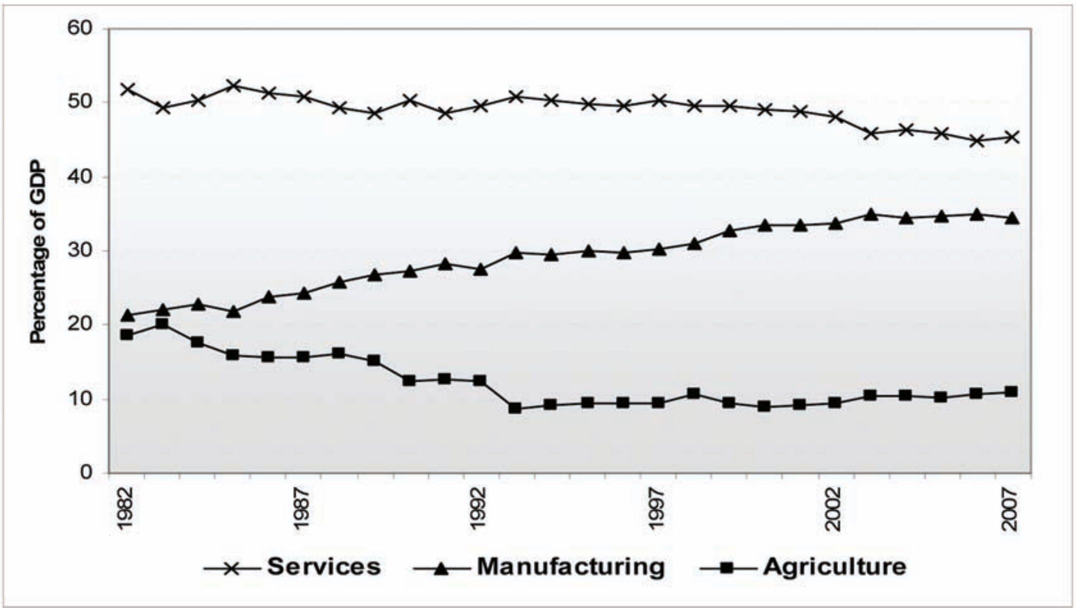
Economic structure matters because each sector would have different transport requirements. In Thailand, the share of agriculture in total GDP declined from just under 20 percent in 1982 to around 10 percent in the early 1990s and then remained stable at about 10 percent. During the same period 1982-2007, the share of manufacturing increased from 20 percent to 35 percent and the share of services declined from about 52 percent to 45 percent (Figure 10). The decline of the service sector's share of GDP is somewhat surprising, but might be explained by the more rapid growth of the manufacturing sector and the adverse impact of the 1997 Asian financial crisis on the financial and real estate sectors for a few years after the crisis. Because the manufacturing sector would appear to require more energy than the service sector, the more rapid growth of manufacturing compared to the service sector may explain in part why Thailand's total energy intensity has not changed much over the last 25 years despite the availability and use of more energy-efficient technologies.

To test if the service sector requires less transport related energy than the manufacturing sector does in Thailand, the study team used Thailand's national input-output tables for 2005 (the latest available) to simulate the change in energy demand in response to a marginal change in the service sector's share of GDP.[8] The simulation assumed a 10 percent increase in GDP, and then allowed the service sector to increase slightly faster than other sectors, in order to calculate the total energy required to

[8] *NESDB publishes the national input-output tables every five years.*

produce the 10 percent higher level of GDP under the new production structure. This was compared to the baseline case, where all sectors were assumed to contribute equally to a 10 percent increase in GDP. The result shows that for one percentage point increase in the service sector's share of GDP (i.e. the simulated case), the demand for petroleum products would be 0.89 percent less than what is required in the baseline case.[9] The analysis suggests that the service sector does have a lower transport related energy requirement than manufacturing.

Figure 10: Sectoral Share of GDP in Thailand from 1982 to 2007



Source: World Bank's Data Development Platform/World Development Indicators Database.

The spatial distribution of economic activities in Thailand is characterized by the heavy concentration of industrial productive activities in the BMR and the Eastern Seaboard industrial region. The significant freight transport flows within the country include agricultural products from the Northern and Northeastern regions to the BMR and seaports, and goods from the BMR and Eastern Seaboard to other parts of the nation. In contrast to China's economy that relies heavily on long-haul coal transport from a few major coal production bases to other parts of the country, Thailand's economy does not require large volumes of purely domestic freight transport over land, and this pattern will be unlikely to change in the future.

In summary, both the economic structure and spatial distribution of economic activities in Thailand do not appear to impose unusual requirements on land transport and thus transport related fuel consumption. It is unlikely that future changes in these two factors would lead to a major reduction in transport fuel consumption per unit of GDP.

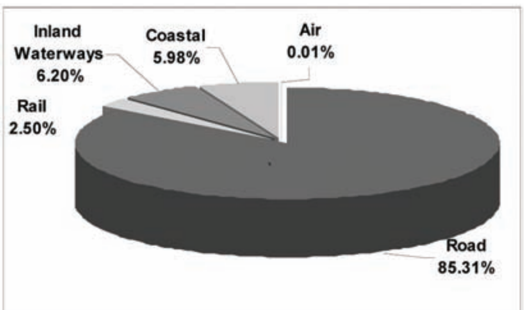
[9] *Transport sector uses about 72 percent of all petroleum products (see Table 1).*

Growth in freight transport closely follows GDP growth. Freight transport is heavily dominated by road.

3.2 Modal Splits

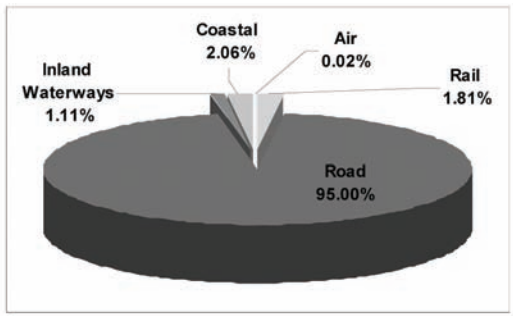
Similar to other countries, Thailand's freight transport demand grows at the similar rate to GDP growth. Road transport dominates the freight transport task as shown in Figure 11. As shown in Figure 12, the share of road transport of total freight tonne-km was 95 percent with the remaining five percent of the freight transport task distributed among coastal shipping (2.1 percent), rail (1.8 percent), and inland waterways (1.1 percent). Over the last few years, the share of freight carried by roads continued to increase (albeit slightly), while the shares of rail, inland waterways and coastal shipping all declined.[10] The increasingly marginal mode share of rail is in sharp contrast to what is observed in countries like China (51 percent), Germany (20.7 percent), Japan (6 percent), South Korea (9.1 percent), and the USA (44.8 percent) where rail has a significant role in freight transport.[11]

Figure 11: Modal Shares in Freight Transport in 2006 (tonne)



Source: Ministry of Transport and State Railway of Thailand.

Figure 12: Modal Shares in Freight Transport in 2006 (tonne-km)



Source: Ministry of Transport, Department of Highways and State Railway of Thailand data.

Passenger transport in Thailand is dominated by personal vehicles, primarily cars and personal pickups (both described as cars below) and motorcycles. The motorization rate—the number of motor vehicles per thousand persons—has grown rapidly in Thailand since the 1980s. National car and motorcycle ownership (expressed as in-use cars/motorcycles per thousand population) has been growing on average at 10 percent and 8 percent per year, respectively, over the period from 1999 to 2007, and the trend is expected to continue perhaps at a slower rate than in the past.

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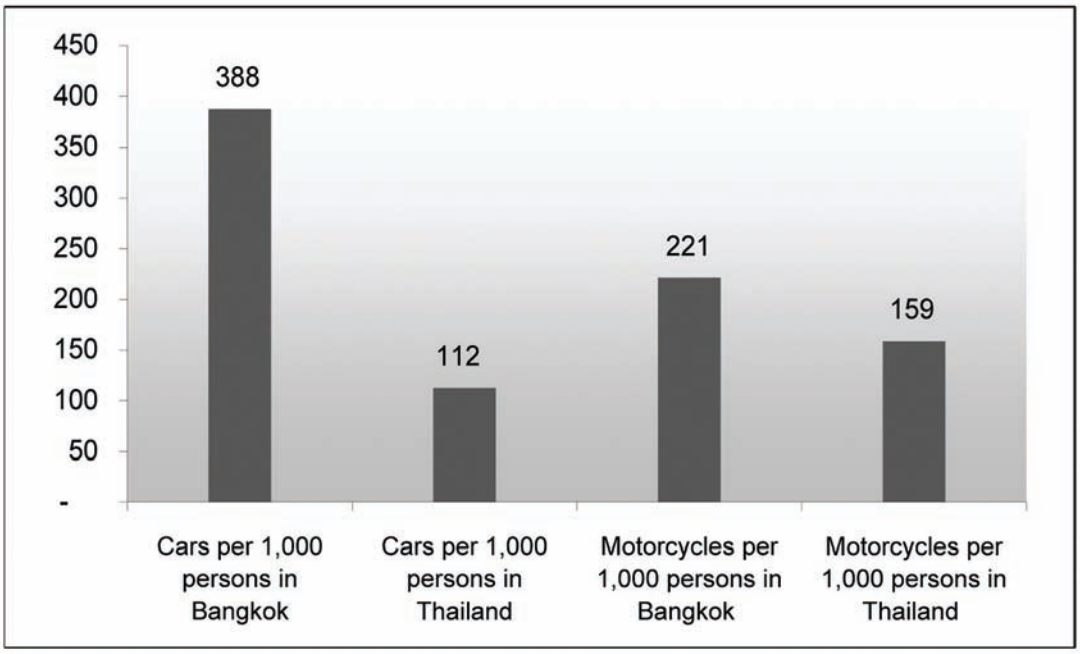
10 Annex 2 gives more details on the modal roles, vehicle types, and fuel use in Thailand.

11 Data on percentage share of rail from total freight tonne-kilometers for Germany (2006), Japan (2006), Korea (2005) and the USA (2005) are from OECD/ITF (2008). Data for China (2005) is from World Bank (2007a).

The split between motorcycle and car ownership is different in Bangkok and the rest of the country. In Bangkok, cars are a more popular mode of transport with 388 cars compared to 220 motorcycles per 1,000 persons. Motorcycles are dominant in areas outside Bangkok with 159 motorcycles and 112 cars per 1,000 persons (Figure 13). The differential ownership rates can be explained by the per capita income differences between Bangkok and the rural areas. With the continuing per capita income growth, it is expected that personal car ownership will grow faster than motorcycle ownership; and as a result, more energy will be required to satisfy the same amount of personal transport, especially in Bangkok and the wider BMR.

Passenger transport is dominated by personal vehicles.

Figure 13: Vehicles Ownership in Thailand and Bangkok in 2007 (In-use Vehicles per 1,000 persons)



The rising trend of car ownership means that more energy will be required to satisfy the same amount of travel.

Source: *Based on data from the Department of Land Transport.*

Note: *Cars include sedans, personal vans and pickups. Population data for Bangkok and Thailand used for this calculation is from NESDB.*[12]

Similar to the freight transport market, the passenger transport market in Thailand has overwhelmingly been dominated by road transport for the last few decades. Road transport has consistently taken a 98 percent share of land passenger-km for the last few years. By the mid-1990s, intercity buses and rural buses already carried three times more passenger-kilometers than rail (Asian Engineering Consultants et al 1995). The current split within road passenger transport between public and private modes is 55 percent versus 45 percent.[13] It is expected that the share of personal vehicle usage will increase further in the future.

12 *Population data from NESDB and Ministry of Interior is compiled using different methods. Ministry of Interior data are based on household registration, which is likely to be underestimated. NESDB data are projected based on the national census last conducted in 2000 by the National Statistic Office and is expected to be more accurate.*

13 *According to DOH data on passenger-km, see more detail in Annex 3.*

Improving transport energy efficiency of the BMR will be important.

How to improve rail performance and expand the role of rail in both passenger and freight transport remains a major challenge.

Almost a quarter of national passenger-km takes place in the BMR.[14] Therefore, any improvement in transport energy efficiency of the BMR will be important to the national effort in transport energy reduction. In 2003, approximately 46 percent of total daily person trips in the BMR were made by private modes (see Table 6). Bus transport was the second most important mode with a 37 percent share. However, the number of passengers carried by the publicly owned and operated urban bus company, the Bangkok Mass Transport Authority (BMTA), has been declining by six percent per annum over the last few years. In contrast, the ridership carried by the private bus companies operating under contracts with the BMTA has been increasing. MRT carried only three percent of total daily trips in 2003, but its share is expected to grow to 15 percent by 2015 if the planned MRT network is substantially completed and functioning well.

Table 6: Personal Travel Demand in the BMR

	2003	2015
Population (million)	10.8	13.0
Personal Travel Demand		
Person trips/day (million)	19.4	23.4
Mode of travel (%)		
Private modes	46	40
MRT	3	15
Bus & other public transport	37	31
Walk	14	14
Total	100	100
Motor Vehicles		
Number of in-use vehicles (million)	3.1	NA
% households with no vehicle	25	NA

Source: World Bank (2007b).

The growing motorization and increasing dependence on cars and other personal vehicles rather than public transport directly contributes to increased energy use. While an effort is being made to improve public transport in the BMR, how to improve rail performance and expand the role of rail in both passenger and freight transport remains a major challenge.

14 This is probably an understatement of the significance of Bangkok for passenger travel as DOH only tracks travel on DOH's highways and not on all urban roads.

3.3 Vehicle Types and Fuel Used

Almost all passenger cars use gasoline. Pickups, which are often modified to carry passengers in smaller cities and rural areas, normally use diesel fuel. As shown in Table 7, in Bangkok, approximately 54 percent of personal cars, including personal vans and pickups use gasoline. In the rest of the country, where the reliance on pickups is higher, 26.2 percent of cars and pickups use gasoline. Motorcycles wholly rely on gasoline. LPG is the main fuel for taxis in Bangkok, with 73 percent of the Bangkok taxi fleet using LPG. Diesel is a dominant fuel for buses and trucks. Over 80 percent of total buses and trucks and almost all heavy buses and trucks use diesel fuel. Given the heavy reliance on diesel fuel and as a liter of diesel fuel contains 12 percent more energy than a liter of gasoline, Thailand's road transport ought to be energy efficient. However, factors such as the aged fleet and its outdated technology level have engendered inefficiency in diesel fuel use.

Factors such as the aged fleet and its outdated technology level have engendered inefficiency in diesel fuel use.

Table 7: Share of Vehicles by Type of Fuel Use, 2007

Vehicle Type	The city of Bangkok						The rest of the country					
	Gasoline	Diesel	LPG*	CNG*	Electricity & Others	Total	Gasoline	Diesel	LPG*	CNG*	Electricity & Others	Total
Personal Cars**	54.0%	43.2%	1.9%	0.4%	0.5%	100%	26.2%	72.1%	0.8%	0.1%	0.8%	100%
Motorcycles	100.0%	0.0%	0.0%	0.0%	0.0%	100%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
Taxis***	10.5%	0.6%	73.2%	15.6%	0.0%	100%	43.2%	2.7%	53.6%	0.0%	0.4%	100%
Others	0.2%	95.9%	0.0%	0.0%	3.9%	100%	3.5%	94.3%	0.1%	0.0%	2.2%	100%
Buses	0.9%	91.0%	3.5%	4.4%	0.1%	100%	7.8%	90.6%	0.9%	0.3%	0.2%	100%
Trucks	0.1%	79.4%	0.1%	0.4%	20.1%	100%	0.1%	87.8%	0.1%	0.2%	11.9%	100%
TOTAL	70.4%	26.1%	2.3%	0.5%	0.7%	100%	76.2%	22.9%	0.3%	0.0%	0.6%	100%

Source: Department of Land Transport.

*Note: *The majority of LPG and CNG vehicles have dual fuel capabilities (with gasoline or diesel).*

***Personal Cars include sedan, personal vans and personal pickups.*

****Taxis include motortricycle taxis.*

3.4 Fuel Economy

Currently, no compulsory fuel economy standards are applied to newly manufactured or imported vehicles in Thailand. The only existing fuel economy standard was set to promote the development of fuel-saving small cars (so-called eco-cars). To qualify as an eco-car and be eligible for tax incentives, the fuel economy standard of five liters per 100 kilometers (or 20 kilometers per liter) must be met.[15]

Data on actual average fuel economy of the current in-use vehicle fleet are not available. According to IEA (2008), in 2005 the average fuel intensity of the in-use car fleet was around 12.5 kilometers per liter (or around 8 liters per 100 kilometers) in European countries and 9 kilometers per liter (or around 11 liters per 100 kilometers) for

[15] *To promote the development of fuel efficient cars, the Ministry of Finance has put in place a tax incentive scheme which reduces the excise tax rate on standard passenger cars that meet fuel-efficiency criteria, and qualify as so-called "eco cars." Starting from October 1, 2009, the excise tax rate for eco cars will be cut from 30 percent to 17 percent. The cars eligible for the 17 percent tax rate must have an engine size of not more than 1,300 cc for gasoline engines and not more than 1,400 cc for diesel engines. Eco cars have to comply with certain specifications including fuel economy and minimum pollution standards of EURO4 or higher, emitting no more than 120 grams of carbon dioxide per kilometer.*

IEA's non-European countries (i.e. the USA, Canada, Australia and Japan). With a fleet of vehicles predominantly of Japanese origin, the average fuel economy of Thailand's in-use passenger vehicles is considered to be similar to that for Japan, at between 9 and 9.5 kilometers per liter or approximately 30 percent lower than that for Europe. However, more information and analysis is needed to better assess the current actual fleet average fuel economy, which will be crucial in developing fuel economy standards in the future.

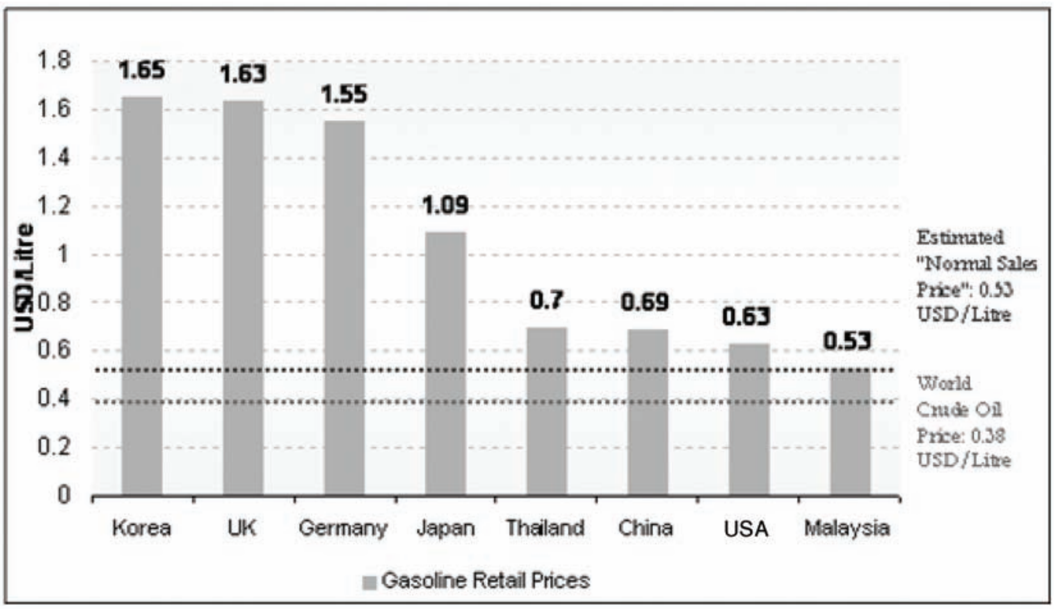
The average fuel economy of in-use passenger vehicles is approximately 30 percent lower than that for Europe.

3.5 Fuel Prices

The retail prices of gasoline and diesel (inclusive of resource cost, sales margin and various taxes) in several countries as of November 2006 are compared in Figure 14 and Figure 15.[16] The estimated "normal sales prices" (i.e. exclusive of taxes) are around US$0.53/Liter and US$0.59/Liter for gasoline and diesel, respectively. Thailand's fuel taxes are comparable to China and the USA, but much lower than those of Japan, Korea, Germany, and the UK. With relatively low prices of fuel, Thailand has some room to use pricing and taxation to curb use of transport fuel.

Fuel taxes in Thailand are comparable to the levels in China and the USA, but much lower than the levels in Japan and Europe.

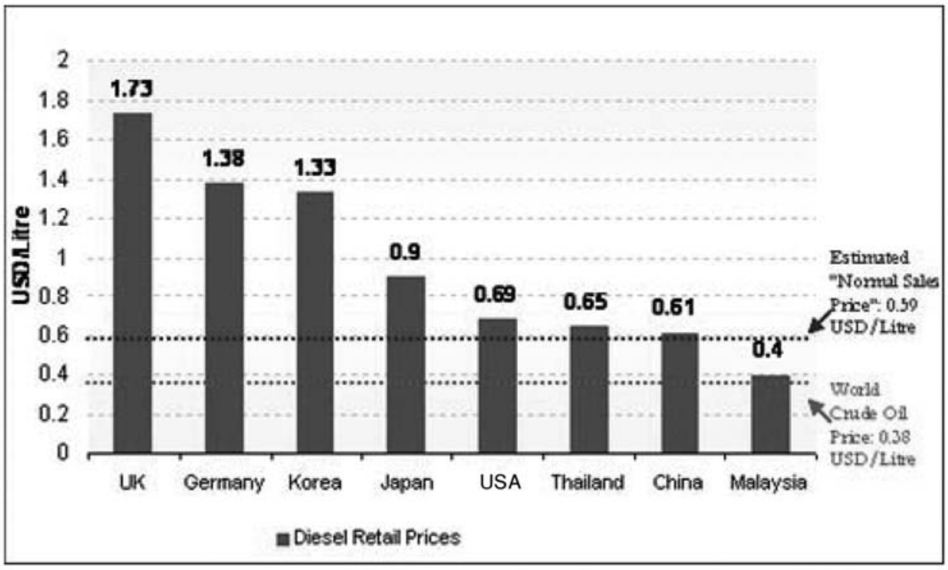
Figure 14: Retail Prices of Gasoline, Selected Countries



Source: GTZ (2007).

[16] *Retail prices as of November 2006. Normal Sales Price is an average USA price level, which is an average of cost recovering retail prices including industry margin and VAT, but after deducting highway tax levied at 10 cents per liter. The "normal sales price" is used by GTZ (2007) as a benchmark to compare taxes and subsidies among countries. "Normal sales price" is shown here as a benchmark for commercial prices net of taxes and subsidies. In fact, countries may have different commercial prices for their fuels. Ex-refinery prices of fuels in each country can vary due to a number of factors, such as industry margin, transportation costs, world market price references, etc. This figure is shown here for the purpose of international comparison and relativity of prices and taxes/subsidies.*

Figure 15: Retail Prices of Diesel, Selected Countries



Source: GTZ (2007).

Household affordability is an issue that must be examined when future fuel taxation policy is considered. In 2006, expenditures on energy as a percentage of total monthly household expenditure were 10 percent, rising from 8 percent in 2004 (Table 8). Similarly, the share of energy expenditure of total average household income rose to 8 percent in 2006 from 7 percent in 2004. By comparison, energy expenditure in the USA represented 8.5 percent of household income in 2005.[17] Between 2004 and 2006, monthly household energy expenditure in Thailand in nominal terms grew by 35 percent, while average monthly household income grew by 19 percent and total household expenditure by 16 percent. Such abrupt increases in energy expenditure would strongly influence the public acceptance of any tax-based policy measures which would raise fuel prices further. Households will find it difficult to absorb and adjust to rapidly increasing fuel prices.

The level of affordability varies by household income level. As the data shown in Figure 16 indicate, the share of expenditure for petroleum products in a household's energy bill rises with the level of the household income. The low-income households spend a smaller share of their energy bills on petroleum products (larger shares go to electricity and conventional energy) than higher income groups. Consequently, any increase in fuel taxes imposed on motor fuels would be borne by the richer households to a greater extent than the poorer households.

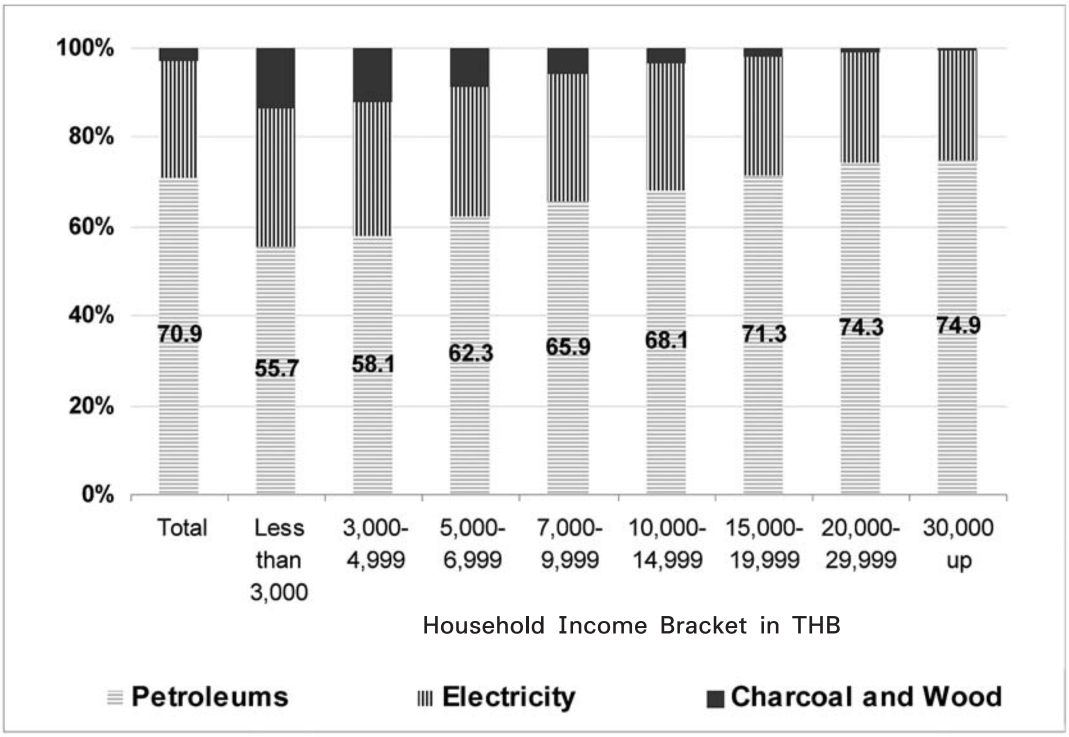
Table 8: Share of Energy Expenditures of Total Household Expenditure and Income in 1996 - 2006

	1996	1998	2000	2002	2004	2006
Total Monthly Income (Baht)	10,779	12,492	12,150	13,736	14,963	17,787
Total Monthly Expenditure (Baht)	9,190	10,389	9,848	10,889	12,297	14,311
Monthly Energy Expenditure (Baht)	590	793	826	932	1,066	1,434

Source: National Statistical Office.

[17] *The USA Census Bureau: (http://www.census.gov/compendia/statab/cats/income_expenditures_poverty_wealth/consumer_expenditures.html). Accessed in July 2008.*

Figure 16: Share of Energy Expenditure by Fuel Type, 2006



Source: National Statistical Office.

4 Policy Directions and Implications for Transportation Energy Use

Thailand's energy supply depends substantially on imported primary energy sources. This creates a vulnerable situation for the country's energy security, and raises an important question of future sustainability in energy use since there is little cushion against external shocks. To reduce energy supply risk, interventions should be made to improve energy efficiency in the transport sector not only because of its significance but also its potential for improvement.

Thailand has significant potential to realize efficiency gains in the transport sector. One source of gains may come from a likely shift in the economic structure as it moves toward a higher-value, more knowledge-based economy, which is likely to be less transport-dependent. However, it is unclear if these gains will materialize and how large these gains will be. Other sources of gain will need to come from within the sector through more balanced modal shares, more diversified fuels, improved fuel efficiency, and transport behavioral response to price incentives and policies. These possibilities are examined in this section.

4.1 Options for Intercity Transport

Overall, the capacity and accessibility of intercity transport systems are adequate, with some emerging capacity shortages.

Overall, the capacity and accessibility of Thailand's intercity transport system are adequate. Due to reduced levels of transport infrastructure investment since the 1997 Asian financial crisis and the growth in transport demand in recent years, congestion and capacity shortages have emerged in limited parts of the system.

However, freight transport appears to show signs of inefficiency as reflected in the country's high logistics costs estimated at about 19 percent of GDP in 2002 by the NESDB. This is high compared to other countries, for example, the USA where logistics costs represents around 10 percent of GDP. Transportation cost represented eight percent of the 19 percent or 42 percent of the total logistics cost in Thailand, which is in line with international standards where transport typically represents 40-50 percent of the total logistics cost.[18] OTP (2006) estimated logistic costs of several commodity groups and found that the share of transportation cost in the total lies between 20 and 40 percent with a few commodities falling outside this range.

The principal reasons that Thailand's freight transport services appear to exhibit some undue inefficiencies include aged fleets of trucks with low load limits and low fuel efficiency (NESDB and World Bank, 2008; JETRO, 2003), the low penetration of multi-modal logistics providers (ADB et. al. 2005), limited capital for new investment by small firms and limited use of Electronic Data Interchange for facilitating shipment and delivery and supply chain management (see Section 4.1.2 below for further discussion). There are substantial room for efficiency gains and associated energy savings. While transport infrastructure

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[18] Estimates for 2000 indicate that the transport component of logistics cost represented 46 percent in the USA, 41 percent in EU and 40 percent in Australia, with transport being the single largest component of logistics cost. While as a whole, non-transport activities (inventory, storage, and administration) are estimated to be more economically significant than transport, the land transport component of logistics, which would usually exceed the international transport component in terms of cost, is where considerable efficiency gains are possible. See Industry Steering Committee (2002).

investment is needed to address capacity shortages, the key challenges will be in achieving more efficient services through appropriate management of both road and rail modes.

4.1.1. Rail Modernization and Reform[19]

One of Thailand's most obvious areas for consideration is the role of rail transport. International experience shows that railways could play an important role in transport and logistics development. A well-run railway provides significantly lower cost transport for bulk and semi-bulk freight and concentrated flows of inter-modal goods to and from ports. Moreover, efficient rail transport with good load factors would help increase the energy efficiency of transport and reduce reliance on imported petroleum fuels.

Thailand currently has a small, mixed-use railway of just over 4,000 kilometers, run by the State Railways of Thailand (SRT). This compares with approximately 52,000 kilometers of highgrade roads and a further 130,000 kilometers of rural and local roads. However, with the railway network radiating into northern, northeastern, eastern, the Eastern Seaboard and southern corridors and serving 42 of the country's 76 provinces, it is a potentially strong backbone system serving many major cities and the main ports, without the economic burden of a multiplicity of low density branches.

The quality and capacity of rail infrastructure and rolling stock assets are major impediments limiting rail's ability to expand its role in the future.

Average rail traffic density per kilometer is about the same as in the EU. Since Thailand's railway system mainly comprises single-track lines, average track utilization is considerably higher than in the EU. In 2005, SRT carried about 13 million tonnes of freight. However, this was only about three percent of the total freight task in Thailand.

The principal cargoes of rail are petroleum products, cement and stones (i.e. building materials) and containers. Most cargo is concentrated between Bangkok, the principal Bangkok ports, the deep seaport of Laem Chabang on the Eastern Seaboard, and the associated inland container depot (ICD) at Lad Krabang. Supporting this "hub and spoke" system are container yards in key regional areas such as Uttaradit, Khon Kaen, Nakhon Ratchasima and Surat Thani.

The Eastern Seaboard is also the center of considerable manufacturing and industrial output for Thailand. Rail has potential to maintain or better its share of the freight market by enhancing its current demonstrated strengths in this key corridor. Service quality on the Laem Chabang line was assessed by OTP (2005) to be of good quality but constrained by the single-track line between Lad Krabang and Laem Chabang port and old, unreliable rolling stock. Service quality on other lines is generally lower in part due to longer lengths, the extensive sections of poorly maintained single-track line and use of old rolling stock.

The heavy investment in roads and highways in the last 20 years has not been matched in the long distance railway subsector. Railway assets are now comparatively old, in some respects obsolete, and many are of low quality compared to market expectations. With steady economic growth over the last several years, serious bottlenecks have emerged. The quality and capacity of Thailand's rail infrastructure and rolling stock assets are major impediments limiting rail's ability to efficiently and effectively expand its role in future.

19 Part of the rail discussion is cited from an unpublished technical assessment note prepared by Paul Amos (formerly Transport Advisor at the World Bank) in 2007.

Priority should be given to investment that can reduce transport operating costs ... investment must be complemented by rail sector reform.

In the short to medium term, priority should be given to investment that can reduce transport operating costs in the key domestic and international trade corridors serving the Eastern Seaboard port of Laem Chabang. Equally important, investment must be complemented by rail sector reform. The government has been considering a rail modernization and reform program. Under the program, the government is expected to be responsible for rail infrastructure investment while SRT's role would be restricted to network management and administration and carriage of passengers. For freight services, the private sector would be allowed to invest in their own locomotives and rolling stock, and SRT could compete to provide services.

To prepare for the rail reform, the following actions should be taken: (i) preparation of a long-term railway development strategy and medium-term implementation plan; (ii) development, evaluation and implementation of options to increase private sector participation in rail transport; (iii) consideration of institutional and regulatory arrangements for a fair and transparent introduction of the above options; and (iv) capacity building to facilitate changes in corporate culture and business processes as the operating regime shifts from an exclusive state-owned train operation to one that may embrace various forms of private railway operation and participation.

The development of multi-modal logistics in Thailand should be considered along with rail modernization and reform. Multi-modal logistics services have been very limited due to several constraints, including the slow progress in rail development. Recognizing this limitation, the government's logistics strategy articulated in the Five Year Plan of 2006-2010 aims to establish a world-class logistics system to support Thailand as Indo-China's trade and investment center. Efficient multi-modal logistics reduces duplication of services, enhances energy savings, and lowers costs of transport. Institutional, regulatory, and operational improvements are required for a successful multi-modal shift. Multi-modal logistics providers do not only provide the strong foundation in truck and rail transport, but they can also play a role in providing a variety of supply chain options to customers with different service expectations and cost preferences.

Road infrastructure does not seem to pose severe threats to the freight transport efficiency.

4.1.2. Truck Transport

Truck transport dominates Thailand's freight transport component of the logistics industry, carrying over 95 percent of tonne-km of freight. The extensive national highway network is of good quality and has benefited the logistics industry greatly. Outside the BMR, vehicles are generally able to travel without excessive delays. Congestion occurs mainly in peak periods in some interurban corridors, especially on the approaches to Bangkok and in the Eastern Seaboard, where the high traffic flows relative to available capacity is often compounded by the high proportion of heavily loaded, slow moving trucks.

Within the BMR, there is no overwhelming evidence that truck transport is greatly inefficient due to traffic congestion. Truck transport benefits from the presence of strategic road infrastructure around and within Bangkok that supports the bypass function, and the plentiful supply of industrial land within the region permitting industrial firms to locate conveniently near their supply chains. Moreover, distribution of goods within the central city of Bangkok is provided by a large fleet of small trucks operated by thousands of private firms in a competitive market that has adapted to the operating environment over many years.

Overall, the quality and availability of road infrastructure within Bangkok and elsewhere do not seem to pose severe threats to the freight transport efficiency. Operational inefficiencies may exist because the sector relies heavily on third party truck operations, but these are of varying quality and fragmented. It also appears that there is inadequate use of Electronic Data Interchange in supply chain management for the production and distribution of high-value goods (e.g. electronics and automobile). However, given the dominant role of the private sector and market in this sector, public policy might have a limited role in addressing these issues.

One area of policy intervention to improve truck transport efficiency is by influencing the choice of vehicles. The truck fleet is old and inefficient, consisting of many energy-inefficient and polluting 6 and 10 wheel diesel-fueled trucks which are cheap to purchase and maintain. Current medium and heavy truck taxes or charges are not differentiated by age, emissions, and energy performance, thus providing no incentive for the use of less polluting and more energy efficient vehicles. A review of vehicle taxation and charges is needed as a basis to formulate differentiated taxation and charges. This could help minimize the distortions between old and new trucks, between heavy and light trucks, and among rail, water and truck transport. Another area of public policy directions should focus on the improvement of vehicle fuel efficiency (see Section 4.3).

A review of vehicle taxation and charges is needed to help minimize the distortions in vehicle and mode choice.

Related important considerations to improve road freight transport efficiency are axle load and truck load limits. Currently, Thailand's maximum axle load limit is 8.2 tonnes while the truck-load limit is 25 tonnes, which increased from 21 tonnes in 2006 (NESDB and World Bank, 2008). The axle load limit is lower than those in Malaysia and China, while the truck load limit is comparable to other countries in Asia but significantly lower than Europe and Australia. Higher axle load and truck load limits will improve Thailand's freight transport efficiency in the long run, but will also lead to increases in road pavement costs. A careful review of the likely impact of axle load and truck load policy on truck transport costs and road costs is needed.

4.1.3. Intercity Passenger Transport

Intercity bus services are operationally efficient, due to high passenger load factors. However, growing traffic congestion on the key corridors leading to Bangkok particularly at peak periods and on weekends and holidays are reducing passenger transport efficiency and increasing fuel use. Improvements in efficiency of operation of the national highways within the BMR will likely yield substantial vehicle energy savings. The congestion is often related to the manually handled toll booths and the at-grade U-turns which fail to function properly when traffic becomes heavy. Better highway traffic management, expanded use of electronic tolling systems, and construction of overpasses and elevated U-turns will help reduce delays and reduce undue fuel use of passenger vehicles.

Better highway traffic management will help reduce delays and reduce undue fuel use.

Scope for efficiency gains from intercity rail passenger transport exists but is limited. Hampered by poor quality track and aged rolling stock and without the extensive spatial reach of highways, the utilization of rail passenger services is low. The proposed rail modernization and reform program, which is needed mainly for the improvement of freight transport, would potentially generate efficiency benefits for intercity passenger transport. However, the benefits may be quite limited as the rail network in Thailand does not seem to have the comparative advantages of buses and cars in meeting intercity passenger transport demand.

4.2 Options for Urban Passenger Transport

Thirty-two percent of total fuels are consumed in Bangkok and 42 percent in the BMR.[20] Forty-seven percent of gasoline and 44 percent of diesel, respectively, are consumed in the BMR. Improvements to the urban passenger transport sector in the BMR will be important for increasing transport energy efficiency in Thailand.

Bangkok's severe traffic congestion has improved markedly but the city still has a long way to go.

4.2.1. Recent Achievement and Current Strategy

In the early 1990s, Bangkok's severe traffic congestion was widely considered to be one of the worst in the world. Since then, the situation has improved markedly, thanks largely to the completion and operation of several major expressways and mass rail transit lines, the adaptive travel behavior of commuters (for example, choice of travel time based on real-time traffic information), the contribution to traffic management by a large number of traffic supervisors employed by private developers, and a significant share of motorcycles in the traffic mix which are more traffic-efficient.[21] The high fuel prices and the removal of subsidies for gasoline in recent years also add to the favorable situation.

According to data from the OTP, in central Bangkok, the average speed on major roads is 18.1 kilometers per hour during the morning rush hour and 21.7 kilometers per hour in the evening rush hour during 2008. These rush-hour average speeds are comparable to those seen in many other major world cities. Congestion has spread outwards geographically and to the offpeak periods. Consequently, Bangkok has not seen major declines in peak hour traffic speeds despite the continuing growth of population and vehicle ownership. Severe congestion still occurs due to traffic incidents but it occurs less frequently than in the past. Traffic congestion also contributes to the declining performance of public buses by reducing bus operating speeds and reliability. Falling productivity of the fleet has added to costs and pressure for fare increases. This in turn contributed to the vicious circle of passenger losses and declining service (World Bank 2007b).

MRT requires good accessibility and supporting road-based public transport systems.

Bangkok has a long way to go to catch up with the transport performance of best-practice cities like Singapore and Hong Kong. The challenge is that the recent achievement may be quickly eroded by the continuing growth. Currently, the need to develop a well-functioning public transport system to alleviate traffic congestion and improve mobility is well recognized by policy makers. The government strategy focuses on the expansion of MRT system. However, MRT alone will not be enough to fully address future traffic challenges. Service coverage of MRT will be limited for many years. A well-functioning MRT system requires good accessibility and supporting road-based public transport systems to feed the system.

Efforts on other fronts, such as BRT development, conventional bus service improvement, public transport modal integration, pedestrian accessibility improvement, and road pricing, are equally important. All these will contribute not only to the improvement of transport system performance, but also to energy savings if they induce a shift away from personal vehicles to public transport.

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20 *Based on DEDE's data on petroleum products consumption by provinces in 2007 (see Annex 1 for more details).*
21 *Traffic supervisors guide traffic in and out of large buildings during morning and evening rush hour.*

4.2.2. Improving Bus Transport Services

Introducing BRT. BRT could contribute significantly to the improvement of the speed and reliability of bus services, as well as bus transport energy efficiency. The municipal government of Bangkok, the Bangkok Metropolitan Administration (BMA), has recently promoted the development of several BRT routes with an initial route of 15 kilometers under construction. While the effectiveness of BRT in Bangkok remains to be seen, it offers a more flexible and cost-effective alternative to MRT. The current BRT routes are planned to have dedicated fleet and services operating as a closed BRT system. Its advantage in service reliability and quality could be offset by the requirement for many passengers to make a transfer from or to other modes in order to complete a journey. An open system where buses run on and off the BRT track between their origins and destinations would have the advantage of not requiring forced passenger transfers, and its application in Bangkok should be considered further.

BRT could contribute significantly to improved bus services.

Bus sector reform. Bangkok's urban bus services are mainly provided by a state monopoly—the BMTA—and supplemented by a number of private operators under subcontracts with BMTA. According to the State Enterprise Policy Office (SEPO) data, the current bus system is deteriorating and losing patronage at the rate of six percent per annum. At the operational level, BMTA has a staff/bus ratio of 5, considerably over the international good practice norm of 3.5. BMTA's own fleet is older than 16 years on average. Due to the low fare policy, BMTA's fare revenues are around 50 percent of its operating costs (including depreciation and interest expenses). As a result, BMTA has accumulated a deficit of over THB 50 billion (US$1.5 billion). While BMTA is generally considered to be an inefficient operator by policy makers, there is no clear consensus among government agencies on the specific measures to reform the BMTA and the urban bus transport sector in Bangkok. This remains a major challenge to the government, and also a major potential for efficiency gains, including direct energy savings expected from better management of routing, smoother operations, and more energy-efficient buses as a result of reform and associated new investment.

Urban bus sector reform remains a major challenge, but has major potential for energy efficiency gain.

Improving accessibility to public transport services. For MRT and public buses to successfully attract users, they have to be easily accessible. The poor walkability of Bangkok's streets is notorious. Despite walking being a vital component of most trips and a substantial means of travel in its own right, pedestrians and sidewalks are generally given low priority in Bangkok. Improving the quality of pedestrian access to MRT stations and bus stops is much needed. At present, there are encouraging signs of improvement, mainly by the private sector in building the pedestrian bridges and elevated corridors to connect the BTS with activity centers. However, effort by the government remains minimal. Budget allocation to sidewalk maintenance and improvement is insignificant. While there are new ways to improve the sidewalk management, such as the introduction of performance-based maintenance contracts to the private sector, there is no political commitment to do so.

Improving walkability of Bangkok's streets through better management is much needed to enhance MRT accessibility.

Integrating public transport services. With all the systems in place, the last element is how to ensure that services provided by different modes and operators are integrated and functioning together as a whole network. The aim of service integration is to facilitate convenient travel and this can be achieved through physical integration of MRT stations and bus stops and introduction of a common fare structure. Fare integration will also allow the government to exercise fare policy more effectively in urban public transport management.

4.2.3. Improving Traffic Management

There is also room for improving the scope and effectiveness of bus priorities as part of a comprehensive approach to traffic management, particularly in support of heavy investment in MRT which when opened, will relieve traffic in adjacent corridors. While the technical measures to more efficiently and effectively manage the transport and traffic management system are well known, the key barrier is the current institutional arrangement and allocation of roles and responsibilities of agencies involved (World Bank 2007). There is also considerable scope for reducing congestion impacts through other complementary measures such as management of parking to discourage unnecessary vehicle trips and facilitate efficient traffic circulation and access to car parks.

4.2.4. Urban Road Pricing

Currently the financial imposts on motorists in the country can be categorized into three main types of user charges: (i) tolls for the use of expressways and motorways; (ii) taxes and charges on vehicle including related license fees; and (iii) taxes and levies imposed on fuels. The first one is a road usage charge and applies to controlled-access roads or expressways. The others are not related to the use of specific roads. No additional charges are applied to motorists in the BMR.

The current system of road use charges do little to moderate use of vehicles at congested times and in congested locations. The annual vehicle registration fees in Thailand are also very low. For example, the annual fee for a passenger car under 2,500 cc is THB 1,900 (US$60) and for a truck 7 tonnes or more is THB 4,350 (US$130). By comparison, the registration fees in developed countries, such as Australia, the USA and Europe are several times higher. There is a scope to increase the level of charges and modify the structure of the current vehicle registration fees and charges regime (World Bank, 2007b). This could start with the review of the existing legislation governing the administration and use of heavy vehicles (Land Transport Act) and passenger vehicles (Motor Vehicles Act) under the DLT. A more comprehensive pricing scheme would allow the public to recover the average cost that motoring imposes on the community at large which includes the cost of providing roads and environmental and social costs.

Given the current institutional capacity, the introduction of a comprehensive road pricing policy targeted at the BMR to improve traffic efficiency is not foreseeable in the near future. However, successful implementation of congestion pricing in Singapore, London and Stockholm has proved that it is possible and should be considered by developing cities such as Bangkok.

4.3 Vehicle Standards and Fuel Choice

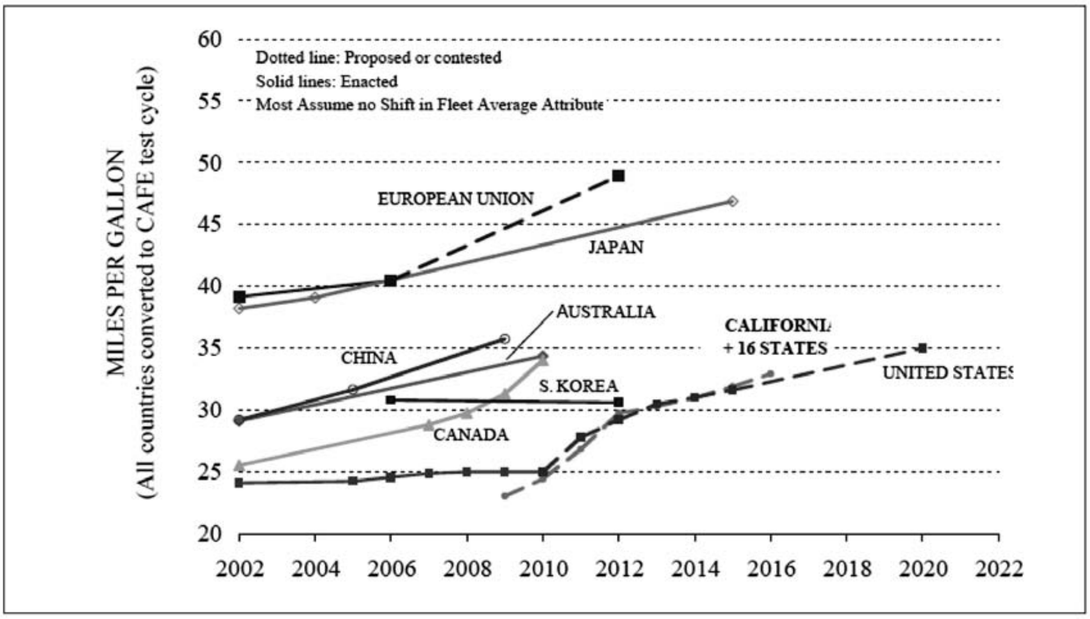
The fuel efficiency of vehicles and the type of fuels used are significant determinants of overall energy use. Improving the fuel efficiency of vehicles is vital in Thailand and this could be done through both direct regulation of fuel economy and the maximum age for registered vehicles. The introduction of alternative fuels needs careful long-term consideration and policies set in an integrated manner taking into account various issues, such as fuel pricing, safety, long-term adequacy of supply, service stations infrastructure cost, fuel efficiency, the health impacts of exhausts and engine maintenance issues.

4.3.1. Vehicle Fuel Economy Standards[22]

Currently there is no compulsory standard for fuel consumption for newly manufactured or imported cars in Thailand. As mentioned in Section 3.4, the fuel economy of Thailand's in-use passenger vehicle fleet is estimated to be some 30 percent below that of Europe today and roughly similar to that for Japan and Australia. ICCT (2007) reports the scheduled fuel economy standards for new vehicles, which indicate that all countries surveyed will improve fuel economy dramatically over the next few years (as shown in Figure 17). The trend for each country indicates roughly similar improvement over time, averaging around 1.4 to 1.9 percent per annum. As a poor performer in terms of fuel economy, Thailand should take immediate action to introduce compulsory standards for vehicle fuel consumption.

Thailand should take immediate action to introduce compulsory standards for fuel consumption.

Figure 17 : Standardized Comparison of International Fuel Economy for New Passenger Vehicles



Source: International Council on Clean Transportation (2007).

4.3.2. Age Limits of Trucks and Buses

Replacing the existing truck and bus fleets with younger, more fuel-efficient buses and trucks will generate further efficiency gains in fuel use. At present, Thailand's heavy truck and bus industries rely on the practice of rebuilding vehicles on an old chassis to lower the costs of ownership. In the bus sector, rebuilding is estimated to be cheaper than purchase of a new bus by a third or more. Consequently, due to the presence of rebuilt buses, the average age of buses in Bangkok's urban bus fleet is over 16 years for the BMTA-owned buses and over 20 years for their private joint venture partners.

Age limits can be adopted to discourage rebuilding practice and upgrade technological level of buses and trucks fleet.

22 *Annex 4 provides information on fuel economy standards in selected countries.*

Rebuilding on the scale that has existed allowed vehicle owners to avoid investing in new trucks and buses with advanced technologies, and consequently lose the opportunity for progressive improvements in emissions, fuel economy and safety performance. Reducing the rate of urban bus chassis recycling and thus enhancing the technological level of the in-use urban bus fleet would reduce emissions and improve safety. Age limits, which have been adopted in some developed nations as a strategy to save energy, reduce emissions and improve safety can achieve the same outcome for the BMR.

4.3.3. The Use of Alternative Fuels and Fuel Switching

A variety of alternative fuels are available and increasingly gaining popularity. With a potentially higher energy content than diesel and gasoline and almost no particulate emissions, CNG is promoted by the government. As Thailand's commercial transport sector is heavily dependent on diesel fuel, fuel switching offers the potential for energy savings. According to the analysis of options considered in this study (refer Section 4.4 and Annex 5), fuel switching results in small energy savings estimated to be below five percent.

Taxis, buses, trucks and increasingly, personal vehicles are targeted for conversion to CNG. By March 2008, PTT figures showed that 65,349 vehicles operated on CNG, using up to 45 million cf/d, or 403 ktoe per year (according to DEDE conversion factors); this was a 400 percent increase over 2006 CNG consumption in vehicles. However, the non-availability of CNG throughout much of Thailand is preventing expansion. Until recently, CNG conversions in taxis were generally not favored by operators because of the low tank capacity requiring two refills in a single 12 hour shift with each refill taking approximately 20 minutes. Recently there was a proposal to convert much of the Bangkok bus fleet operated by the BMTA and private operators to CNG. With the recent high oil prices some private bus operators have converted their engines to either a dual CNG-diesel or a dedicated CNG engine.

Preferably, CNG should only be used by dedicated natural gas vehicles with engine and emission equipment provided by quality Original Equipment Manufacturers (OEM) of such gas systems. Without OEM systems, the conversion of existing engines to natural gas use often leads to problems with engine maintenance, excessive methane emissions and poor fuel efficiency. Therefore, regulations are needed to specify permitted types of CNG engines and fuel systems. Advanced and costly computer controlled fuel injection systems should be used to deal with the variable methane content of CNG.

LPG is widely used in taxis although it has penetrated little into other vehicle types.[23] The quality of LPG equipment which is usually retrofitted in vehicles is often poor, but the recent increases in fuel prices and a widening price advantage of LPG (LPG price is subsidized by the government[24]) have triggered an improvement in the quality equipment installation and maintenance. Although LPG has about a 30 percent lower energy content than gasoline at current ex-refinery prices according to EPPO data (as of March 2009), its production price was about half of that of gasoline. Another alternative fuel is LNG, which is natural gas condensed into liquid and refined to remove impurities. But it is not used as a transport fuel to any significant extent in Thailand.

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[23] The main use of LPG is for domestic cooking.

[24] As of February 2009, the domestic retail price of LPG was below the international price by about 30 percent.

Although the use of alternative fuels provide short-term relief from oil price increases to transport users and service providers, the long-term desirability of the measure needs to be examined more carefully. The current pricing subsidies of LPG and CNG have helped conversions. However, future subsidies are likely to be reduced due to the burden they place on the public purse. There are also problems with regards to the safety of converted engines and the adequacy and quality of natural gas supplies. These issues must be addressed by the government if these fuels are to play a significant, long-term role.

As shown in Section 2.3, the current penetration of biofuels is limited. The government plans to introduce the Fuel Flexible Vehicles (FFVs), which can better utilize gasohol with higher ethanol content such as E20 (gasoline with 20 percent ethanol) and E85 (gasoline with 85 percent ethanol). While the government strongly supports biofuels for a range of reasons including energy security concerns, there are many complex issues to resolve before deciding on a beneficial approach to future biofuels development. A long-term strategy needs to be developed to determine the prospects for future economic expansion of biofuels.

Cutting edge technology options such as hybrid-electric and fuel cell technology options exist but were not investigated in detail in this study. With significant cost barriers to development and widespread implementation, hybrid technology will be an option for the long term. The International Energy Agency (2004) found hybrid technology options in the gasoline powered vehicle segment may be cost-effective in reducing energy and CO_2 emissions. The government may consider promotion of hybrid electric vehicles. However, due to the high initial cost of hybrid vehicles, major penetration into the Thai market is unlikely in the near future. Fuel cell technology was shown by the IEA to have high potential but it is likely to exhibit low cost effectiveness.

Perhaps more importantly, as argued by Wright and Fulton (2005), transport planning options to increase public transport mode share can offer much higher cost effectiveness in reducing energy usage and CO_2 emissions. Wright and Fulton (2005) also suggested that other more conventional vehicle efficiency measures, including those through technological improvements, offered the highest potential for energy and CO_2 reduction. Nevertheless, the use of hybrid and advanced clean diesel technologies in light vehicles may form part of industry's response to more stringent fuel economy standards in the future, as they have in other nations.

Although the use of alternative fuels provide short-term relief from oil price increases, the long-term desirability needs to be examined more carefully.

Transport planning to increase public transport mode share can offer much higher cost effectiveness option in reducing energy usage.

4.4 Analysis of Policy Options

A series of practical and realistic technology and transport policy options, as set out in Table 9, are proposed for Thailand. The options exclude fuel pricing which is discussed separately in the next section. Among the 16 options, two pairs are joint options that need to be implemented jointly[25].

25 The two joint options D1 and D2 are combinations of the individual options: passenger car fuel economy standards for urban and inter-urban areas (individual options B2 and C7); and improve passenger and freight rail (individual options A2 and B3), respectively. These options are indivisible as economy standards would apply to the entire fleet and investment for rail infrastructure can benefit both freight and passenger services.

Table 9: Policy and Technology Options (except fuel pricing)

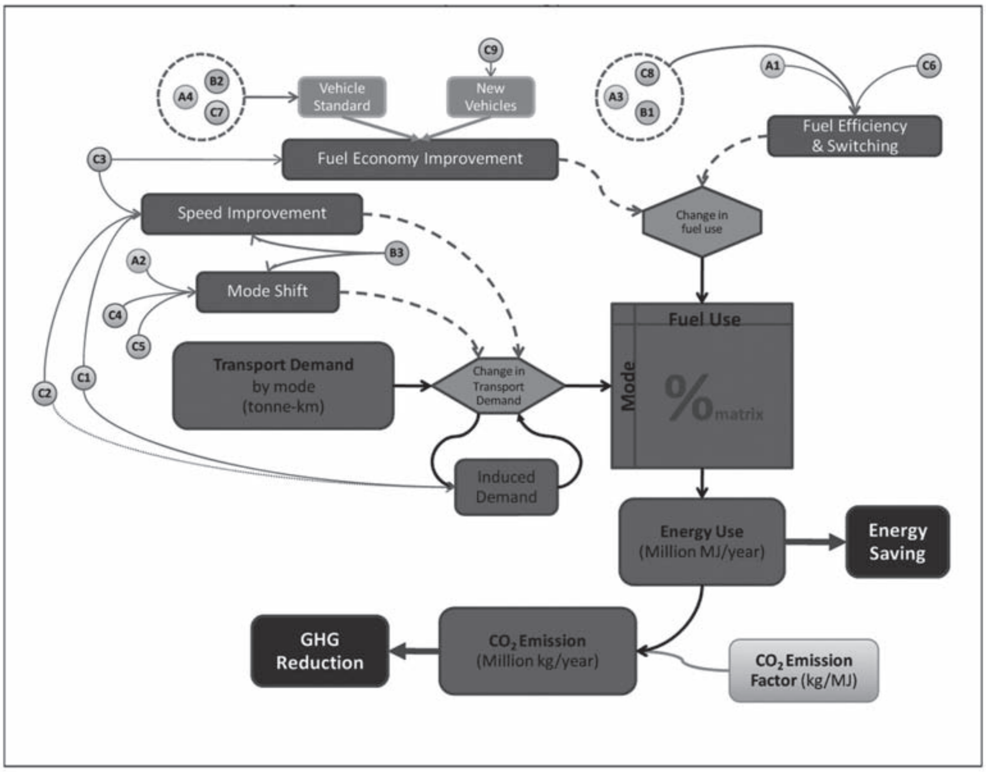
Freight Transport Options
A1 Non-fixed route trucks use 25% CNG
A2 More efficient freight rail
A3 Fuel efficiency improvement in diesel vehicles through engine and technology upgrades
A4 Use of more efficient and higher payload trucks
Interurban Passenger Options
B1 Fuel economy improvement in diesel vehicles
B2 Improve passenger car's fuel economy standards
B3 Improve passenger trains
Urban Passenger Options
C1 Improve traffic management
C2 Improve road user pricing
C3 Improve bus industry's efficiency
C4 Introduce BRT
C5 Integrate MRT/Bus/Walking
C6 Use CNG in bus fleet
C7 Improve passenger car's fuel economy standards
C8 Improve fuel efficiency in BMTA diesel buses through engine and technology upgrades
C9 Set and enforce age limits for all heavy Bangkok buses
Joint Options
D1 Fuel economy improvements in private sector's vehicles (Options B2+C7)
D2 Railway investment (Options A2+B3)

These policy options can be grouped into five main categories:

- **Fuel efficiency and fuel switching:** upgrade engine technologies for buses and trucks, and use natural gas selectively in vehicle fleets, especially commercial vehicles.
- **Better vehicle standards:** establish and (progressively) tighten fuel economy standards of passenger vehicles to match European standards, and improve logistics practices in the road-based freight transport sector to better match truck sizes to the task and operating environment.
- **Rail investment and reform:** reform and modernize the rail sector, expand the role of rail in freight transport and long-distance passenger services; and in the BMR, expand mass rail transit and improve its integration with bus services, and improve accessibility and walkability to bus stops and mass rapid transit stations.
- **Better urban bus services:** increase the speed and quality of bus services through expansion of BRT and investment in new fleet which will bring improved passenger comfort, better fuel efficiency and lower emissions.
- **Policy and pricing measures:** upgrade the vehicle registration system and associated charges that reflect actual vehicle use; improve traffic management; and promote more efficient bus services through reforms that encourage competition and new investment.

A simple quantitative approach was adopted to roughly assess the costs and benefits of these options. The evaluation model structure is shown in Figure 18. Full details of the model and results are provided in Annex 5.

Figure 18: Transport Energy Model Structure



Source: Study Team.

Table 10 summarizes the estimated cost and energy reduction performance of the five categories of options. Estimated costs and energy reduction performance of the underlying 16 options are presented in Annex 5.

Table 10: Summarized Option Groups and Policy Impacts

	Policy Options*			Total Cost		Annual Energy Reduction by 2025
	Freight	*Inter-urban*	*Urban*	*THB Million*	*US$ Million*	
Fuel Efficiency & Switching	A1,A3	B1	C6,C8	114,980	3,342.44	4.00%
Better Vehicle Standards	A4	B2	C7	114,544	3,329.77	11.90%
Rail Investment & Reform	A2	B3	C5	378,607	11,006.02	4.80%
Better Urban Bus Service			C4,C9	41,037	1,192.94	0.50%
Policy & Pricing			C1,C2,C3	5,000	145.35	11.90%

*Note: *Details of each individual option are explained in Annex 5.*

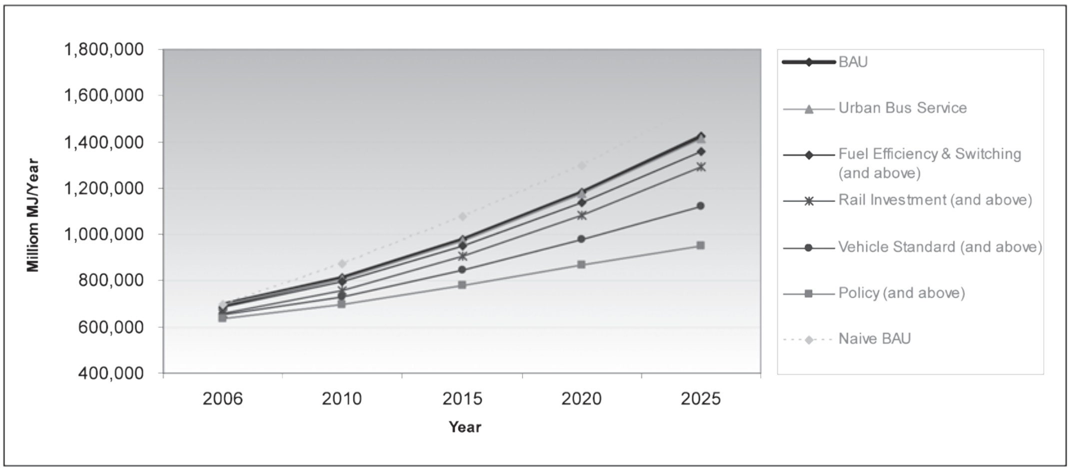
The results are also illustrated in Figure 19, which summarizes the cumulative impacts of the five categories of options. The analysis starts with the Business as Usual (BAU) or the baseline scenario projected from 2006 to 2025, which assumes five percent annual economic growth with the current energy intensity in transport and a two percent standard annual energy efficiency improvement. For comparison purpose, the naive BAU is also presented; this is a scenario where there is no standard annual energy efficiency improvement.

Annex 5 sets out full details of the analysis including cost-effectiveness of each option based on cumulative energy savings over the period between 2006 and 2025. The analysis presented in Annex 5 is different from, though consistent with, the "snapshot" approach presented in this section which showed estimated energy savings at 2025 compared to the BAU. An assessment of the ease of implementation is also made in Annex 5 for the interested reader, although all options are considered implementable in practical terms if political will is engendered.

If all of the policy options are successfully implemented, the transport sector's energy use during 2025 can be reduced by approximately 33 percent.

Figure 19 illustrates that, if all of the policy options are successfully implemented, the transport sector's energy use during 2025 can be reduced by approximately 33 percent from the BAU baseline. This is largely contributed by the better vehicle standards option and the policy and pricing option, since together they are estimated to contribute over 70 percent to the total energy saving. The 33 percent saving can reduce Thailand's transport energy intensity to around 80 TOE/million USD of GDP per year for 2025. This level would still be higher than the USA's 2005 level (58.97 TOE/Million USD GDP) and four times higher than Japan's 2005 level (see Figure 5), which implies that the 33 percent saving is quite achievable from the technological perspective.

Figure 19: Estimated Impacts of Transport Policy Options



4.5 The Importance of Fuel Pricing Policy

Transport energy use has been growing at approximately seven percent per annum over the past two decades. Consequently, five years growth in transport energy demand would easily nullify the maximum potential savings from the policy and technology options set out above. The implementation of all of the above options requires commitment and serious effort by the government to overcome political and institutional barriers. What can be done to enhance the chances of success and sustain the impact of the policy options over time?

Fuel pricing can be used as an impetus to induce transport behavioral changes and sector structural adjustment. Appropriate pricing of fuels would underpin the technology and policy options described above by inducing firms, government enterprises, logistics providers and households to carefully consider and adjust their modal and vehicle choices given the higher costs of motoring.

As shown earlier, Thailand's taxes on fuels are considerably lower than other countries such as Germany and Japan, which are more gasoline and diesel-efficient. There is room for the government to exercise fuel pricing policy. An appropriate adjustment to taxes on fuels to favor clean and efficient technologies would also signal the government's commitment to energy efficiency, which is inhibited by several factors including structural impediments in the economy and regulatory and institutional bottlenecks due to entrenched vested interests (in urban bus transport, for example).

Will the demand respond to fuel price increase as expected? As described in Section 2.3, the fuel price elasticity of demand for fuel use is estimated to be -0.31, which is consistent with fuel price elasticity estimated in other countries, and implies that Thailand's transport fuel users are reasonably sensitive to price changes. If the recent high fuel prices were to prevail in the medium to long term, it will lead to an absolute reduction in energy use (additional to that calculated above). Use of a price elasticity estimate of -0.31 indicates that a 10 percent increase in real fuel prices would lead to a three percent reduction in fuel use. However, the extent of the reduction would also depend on several factors including the state of the economy, and the level of embedded inefficiency, which is expected to decline over time.

Fuel pricing can be used to induce transport behavioral changes and sector structural adjustment.

4.6 Institutional Support to the Transport Energy Efficiency Agenda

The analyses described above indicate large potential gains in transport energy efficiency if the options analyzed are implemented. However, the implementation of several options will not be easy as they would incur substantial overhead and agency costs and require a concerted effort from various ministries and agencies.

Transport energy efficiency has not been treated as an inter-ministerial agenda under the current institutional structure.

Transport energy efficiency has not been treated as an inter-ministerial agenda under the current institutional structure. Many agencies have responsibility for some aspects of the transport energy efficiency issue, but none is in overall charge. The primary objective of the Ministry of Transport (MOT) is to deliver transport infrastructure and services that are convenient, safe, and affordable, and transport energy efficiency has not yet been emphasized as a top priority. On the other hand, energy efficiency is among the top priorities of the Ministry of Energy (MOE), but policies relating to transport energy efficiency are constrained by the Ministry's general coverage which is mainly on the supply side (i.e. fuel quality, fuel pricing, energy technology, and electricity generation). The provision of urban transport infrastructure and services in the BMR involves both the central and municipal governments, traffic police, state enterprises (BMTA and MRTA), and the private sector (such as the urban rail/MRT concessionaires BTSC and BMCL). Without coordination among the various agencies, gaps could emerge and hinder the implementation of transport energy efficiency options. Strong institutional support would be needed to bridge these potential gaps.

Institutional support should focus on developing a mechanism that forges leadership and coordination for consensus building, strategy formulation, implementation, and monitoring and evaluation. In this regard, Thailand could learn from its own successful experience in the implementation of the national air quality improvement program in the 1990s (see Box 1). It is also important, in fostering appropriate institutional support, that the government recognizes the complexity of improving transport energy efficiency and sees the benefit of mainstreaming energy efficiency and climate change into whole-of-government decision making and sector management.

Box 1. Institutional Leadership and Coordination for Air Quality Improvement in Thailand

Following the introduction of the 1992 National Environmental Quality Act (first promulgated in 1990), Thailand embarked on an ambitious, and ultimately successful, air quality improvement program. The major component of the program was the rapid phase-out of leaded gasoline and the improvement of the quality of all fuels across the board. The program was led by the National Environmental Policy Council (NEPC), with the National Energy Policy Office (NEPO) acting as its Secretariat. NEPO (later to become EPPO) played a critical and influential role in developing the overall strategy and action plan and provided "hands on" leadership and managerial and technical support for implementation. NEPO's role was critical in consensus building with the oil companies, Thai agencies and other stakeholders.

A key feature of the action plan was the assignment of responsibility for each key component to a single agency. Fuel quality improvements and fuel pricing were assigned to NEPO who coordinated the necessary actions among the Ministry of Science and Technology, Ministry of Industry and Ministry of Commerce. The responsibility for the air quality initiatives including ambient air pollution monitoring and recommendations on air quality standards was assigned to the Pollution Control Department (PCD). With strong leadership and coordination by the NEPO, a number of ministries and agencies took responsibility for various components of the program. The implementation of the fuel and air quality initiatives was overwhelmingly successful. This could be attributed to the good working relationships established among the agencies and their similar science-based technical cultures.

The program faced numerous obstacles at various times. But these were overcome by fast, informed action often backed up by consumer research and studies of various technical issues. Timely and appropriate communication with the media, motorists, industry and the public at large was also an important contributing factor to smooth implementation.

Less successful were the components that involved the assignment of responsibilities to agencies with conflicting objectives or without the relevant span of authority. For example, the Department of Land Transport was responsible for the reduction of emissions from in-use vehicles, but their principal objective was the safety and fitness of vehicles. Consequently the management of vehicle emissions was a second priority.

Source: Phil J. Sayeg (1998), "Successful Conversion to Unleaded Gasoline in Thailand". World Bank Technical Paper No. 410. Washington D.C.

Annex 1 : Fuel Consumption in the Bangkok Metropolitan Region

This annex provides additional information on fuel use in Bangkok and the BMR compared to total fuel use. Table A-1.1 shows that 52 percent of all fuel consumed (regardless of the sectors) in Thailand in 2007 was diesel. The BMR - which consists of Bangkok and the five nearby provinces of Nonthaburi, Pathumthani, Samut Prakan, Samut Sakhon and Nakon Pathom - represents 44 percent of all diesel fuel use in Thailand. For fuels of all kinds, the BMR represents 46 percent of all Thailand fuel use.

Table A-1.1: Fuel Consumption by Type and Provinces (million liter), 2007

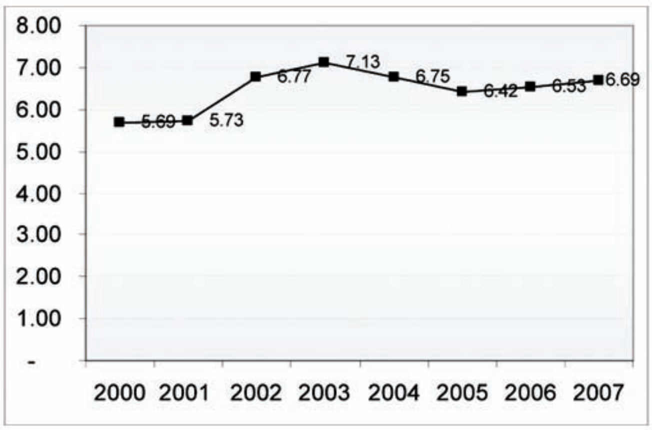
Fuel Type	Total	BMR	BMR % Share of Total	Bangkok	Bangkok % Share of Total
Liquefied Petroleum Gas (LPG)	5,663.198	2,830.823	49.99%	1,268.580	22.40%
Unleaded Gasoline 91	4,467.323	1,813.530	40.60%	1,452.701	32.52%
Unleaded Gasoline 95	1,106.698	655.130	59.20%	536.825	48.51%
Gasohol 91	244.254	171.013	70.01%	116.995	47.90%
Gasohol 95	1,518.508	850.155	55.99%	633.374	41.71%
High Speed Diesel	18,048.773	7,927.594	43.92%	6,022.817	33.37%
High Speed Diesel (Biodiesel 5)	627.450	289.204	46.09%	157.005	25.02%
Palm Diesel	2.657	2.657	100.00%	2.570	96.73%
Low Speed Diesel	32.764	29.709	90.68%	27.646	84.38%
Fuel Oil	4,244.343	2,135.805	50.32%	1,369.511	32.27%
Total	35,955.968	16,705.620	46.46%	11,588.024	32.23%

Source: Department of Alternative Energy Development and Efficiency.

Annex 2 : Modal Roles, Vehicle Types, and Fuel Uses

Passenger transport in Thailand is dominated by road mode and personal vehicles, i.e. cars and motorcycles. The rate of car ownership based on in-use vehicles in Bangkok was approximately 388 cars for every 1,000 Bangkok residents in 2007, which is over three times higher than the national ownership rate at 112 cars for every 1,000 population. The overall trend of car ownership in Bangkok continued to rise with an 8 percent average annual growth during 1999 to 2007. Within road transport, the passenger task measured by passenger-km had increased in the period before 2003, experienced negative growth during 2003 to 2005 and since then started to pick up again. Almost a quarter of national passenger-km occurs in Bangkok and vicinities.[26] The road passenger task, expressed as 1,000 road passenger-km per capita increased from 5.69 in 2000 to 6.69 in 2007. Refer Figure A-2.1.

Figure A-2.1: 1,000 Road Passenger-km per Capita for Thailand



Source: Bank of Thailand and Department of Highways.

The modal split within road passenger transport is relatively equal between public and private modes as shown in Table A-2.1. Around 45 percent of trips are made by personal vehicles while the remaining 55 percent of trips are made by public transport. However, the share of personal vehicle usage has increased since 2004 at the expense of public transport usage.

Table A-2.1: National Modal Split within Road Transport (passenger-km)

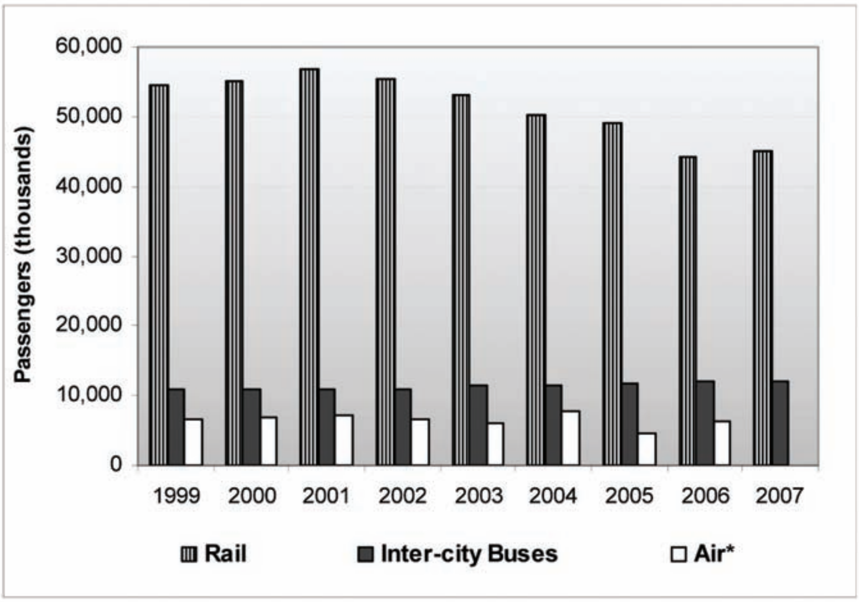
	2004	2005	2006	2007
Personal Vehicles				
Sedan with less than 7 passengers	100,949,058,354	104,148,919,564	105,586,499,256	112,521,171,668
Van with more than 7 passengers	69,451,094,562	69,817,915,965	73,802,362,888	77,963,622,006
Public Vehicles				
Small public buses	29,227,148,451	27,199,043,011	27,246,936,455	27,642,565,488
Medium public buses	85,533,434,131	73,955,652,447	75,636,841,261	76,887,887,604
Large public buses	133,189,099,784	125,363,823,481	128,111,484,791	126,502,427,854
Total Road	418,349,835,282	400,485,354,468	410,384,124,651	421,517,674,620

Source: Department of Highways.

[26] *This is probably an understatement of the significance of Bangkok for passenger travel as DOH only includes travel on DOH's highways.*

For public inter-urban transport, rail has been serving a declining number of passengers as shown in Figure A-2.2. From 1999 to 2007, the number of passengers using rail services has dropped by an annual average rate of 2 percent. The average distance traveled per train passenger of 200 kilometers has not changed much over the period. The number of passengers using public inter-city bus services operated by the state-owned Transport Company Limited has stayed relatively steady with around 1 percent annual growth during the same period.[27] Apart from the Transport Company, private sector operators also serve a significant share of inter-city bus transport, however, data on number of passengers are not readily available.

Figure A-2.2: No. of Passengers in Inter-city Public Passenger Transport by Mode



Source : Ministry of Transport.

*Note : *2007 data are not available for the air mode. Under the air mode, passengers using low-cost airlines are not included in Ministry of Transport's data.*

Inter-city bus transport between Bangkok and regional cities and between the regional cities is relatively efficient due to high load factors, fairly direct routing and relatively few delays due to congestion. However, the inter-urban bus fleet is fairly old on average. The Transport Company's buses are around 10 years old on average and that of their private sector Joint Venture partners is likely 15 years or older. Although buses are rebuilt extensively, the inherent engine and fuel consumption technology is pre Euro or at best Euro 1. Air transport has been experiencing increasing share in inter-city passenger transport with 2.4 percent average annual growth during 1999-2007.[28] Due to limitations of data, the precise share of trips for each mode in inter-city passenger public transport cannot be accurately determined.

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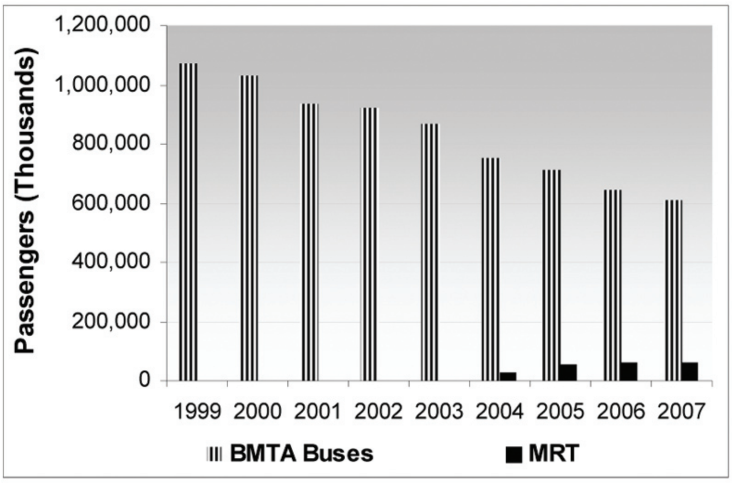
27 However, this might be underestimated as data collected only represents number of passengers using Transport Company services but not includes other sub-contracted buses.

28 In reality, the shares might be even larger since the MOT data collection represented here does not include low-cost airlines.

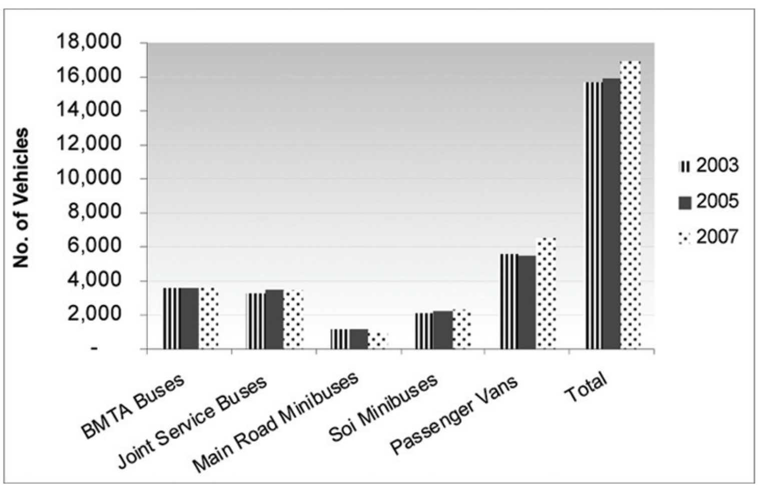
In Bangkok, public transport's share of person trips has actually been declining in recent years. BMTA's bus passengers declined by about six percent per annum from 1999 to 2007 as shown in Figure A-2.3 and Figure A-2.4. However, the growth in mass rapid transit passengers has countered this trend to a certain degree. The downward trend in BMTA bus patronage does not represent the whole picture of urban public transport since the data do not include passengers of joint service buses nor para-transit such as passenger vans which were legalized in 1999 and have become another important mode of urban public transport. Due to age and servicing problems, BMTA's fleet has also declined since 2003. In contrast, numbers of joint service buses, minibuses and passenger vans have increased. In total, the number of total buses providing urban transport services has increased from 15,677 in 2003 to 16,903 in 2007. Taking these trends into account, it cannot be concluded that urban passenger transport usage in absolute terms has decreased greatly since 1999.

Figure A-2.3: Number of Passengers in Urban Public Passenger Transport



Source: Ministry of Transport.

Figure A-2.4: Number of Public Buses



Source: Bangkok Mass Transit Authority.

Fuels Use in Transport Sector

Historically, Thailand has made an effort to stabilize the gasoline and diesel retail price through various interventions particularly through use of the oil fund. Since 2003, the sustained rise in the world price of oil has had significant impacts on Thailand's approach to energy price control. Thailand floated its gasoline price in October 2004 although diesel prices were partially subsidized. By June 2005, facing a major deficit in the oil fund, the government shifted diesel prices to a "managed float" and then fully floated prices in July 2005. However, the government still subsidizes prices of alternative fuels such as CNG and LPG.

Fuel pricing in Thailand is determined primarily by market but the government also intervenes through various taxes and levies. Ex-refinery prices are set with reference to international prices. Taxes and duties (which vary by type of fuel) then applied to the various stages of production and distribution. Marketing margin is the only variable component of the price which is free to be set by the retailer to give a final retail price.

The government has also been active in the promotion of renewable fuels. Currently the automotive industry in Thailand accepts bioethanol blended with gasoline to a maximum of 20 percent by volume. Complementary measure which reduces excise tax rate for cars with engine size of less than 3,000 cc applies if they use up to a 20 percent ethanol blend was also introduced. The tax adjustment has been effective since January 1, 2008. The tax cut is expected to lower the price of a typical new car by at least THB10,000.

Thailand has been very active in developing modern fuel specifications. Lead in gasoline was phased out by January 1996. Maximum sulfur content in diesel fuel was lowered to 350 ppm sulfur in January 2004 and a standard of 50 ppm sulfur is currently proposed for 2010 (in compliance with EURO V standards). In August 2005, Thailand implemented two biodiesel standards, one for a B5 blend (5-percent biodiesel blended with 95-percent standard diesel fuel) and the other for B100 (neat biodiesel), which allow for quality blending of biodiesel to conventional diesel.

Annex 3 : Transport of Key Commodities in Thailand

The types of goods transported play an important role in choice of mode and freight characteristic of each mode is different. Within land transport, road serves a more diverse range of products with sugar cane having the largest share (measured in tonnes) followed by solid stones and sands, minerals, fuels, and mineral fuels. The top five products carried by road account for almost 50 percent of total tonnes carried by road as shown in Table A-3.1.

Table A-3.1: Top 10 Commodities Using Road in 2006

	Types of Goods	Thousand Tonnes	% of Total	Million Tonne-KM	% of Total	Average KM
1	Sugar Cane	60,278	14%	2,398	2%	39.78
2	Soils, stones and sands	51,023	12%	4,824	5%	94.55
3	Minerals	36,412	9%	3,210	3%	88.17
4	Fuels	30,922	7%	9,621	10%	311.13
5	Mineral Fuels	30,146	7%	5,191	5%	172.20
6	Miscellaneous	29,002	7%	12,120	12%	417.90
7	Construction Materials	26,792	6%	9,304	9%	347.27
8	Rice	26,558	6%	12,174	12%	458.39
9	Cement	24,390	6%	5,171	5%	212.03
10	Household Appliances	22,787	5%	6,630	7%	290.97
	Total	**427,581**	**100%**	**100,942**	**100%**	**236.08**

Source: Ministry of Transport.

Rail freight is heavily concentrated in a few products mainly, miscellaneous items, fuel oil and cement as shown in Table A-3.2. Rail serves a very limited variety of goods and the top five commodities already make up 99 percent of total freight transported by rail.

Table A-3.2: Top 5 Commodities Using Rail in 2006

	Types of Goods	Thousand Tonnes	% of Total	Million Tonne-KM	% of Total	Average KM
1	Miscellaneous	7,129	61.57 %	1,018	35%	142.75
2	Fuel Oil	2,634	22.75 %	1,351	47%	512.95
3	Cement	1,695	14.64 %	465	16%	274.27
4	Household Appliances	57	0.49 %	34	1%	596.78
5	Minerals	28	0.24 %	8	0%	281.46
	Total	**11,579**	**100%**	**2,904**	**100%**	**250.85**

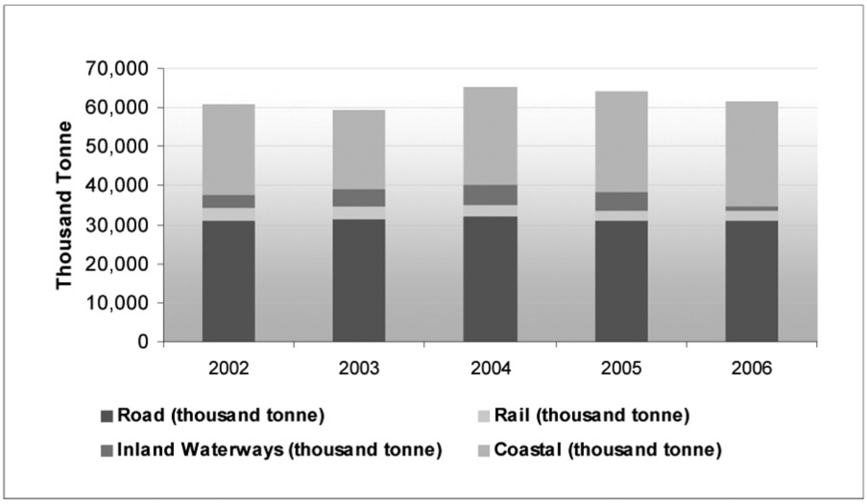
Source: Ministry of Transport.

Looking at how key products in Thailand are transported can also tell the pattern of freight movement and the potential for modal shift and efficiency gains in freight. Three key products; rice, cement and petroleum products, which have strategic importance to Thai economy are examined here.

About 50 percent of petroleum tonnes or 65 percent tonne-km is carried by road. Another 44 percent (measured in tonne) or 24 percent (measured in tonne-km) are transported by coastal shipping as shown in Figure A-3.1.

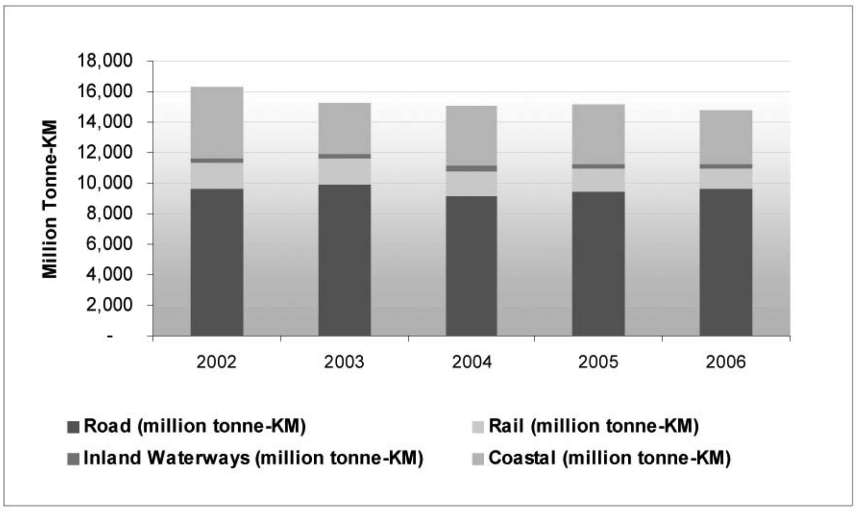
Figure A-3.1: Modal Shares of Petroleum Transport

Petroleum Transport (Tonne)



Source: Ministry of Transport.

Petroleum Transport (Tonne-KM)

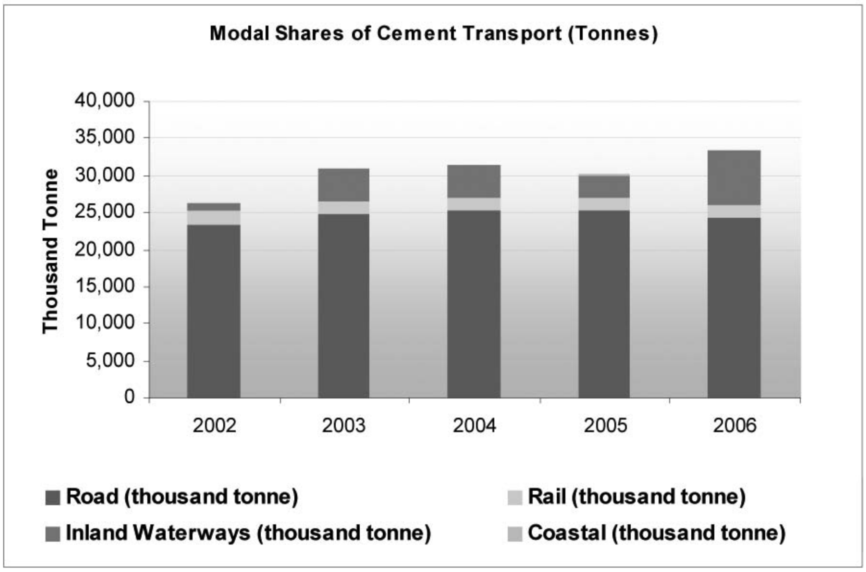


Source Ministry of Transport.

For cement products, more than 70 percent (measured in tonne) or 90 percent (measured in tonne-km) are transported by road. Inland waterway is the second most important mode carrying around 20 percent of total tonnes. However, when looking at tonne-km, share of cement carried by rail is more than that of inland waterways. Refer Figure A-3.2.

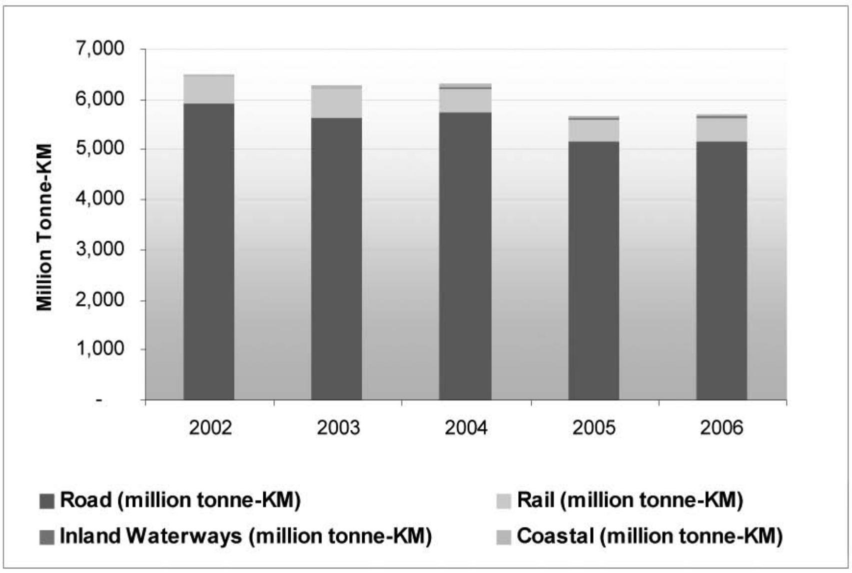
Figure A-3.2: Modal Shares of Cement Transport

Cement Transport (Tonne)



Source Ministry of Transport.

Cement Transport (Tonne-KM)

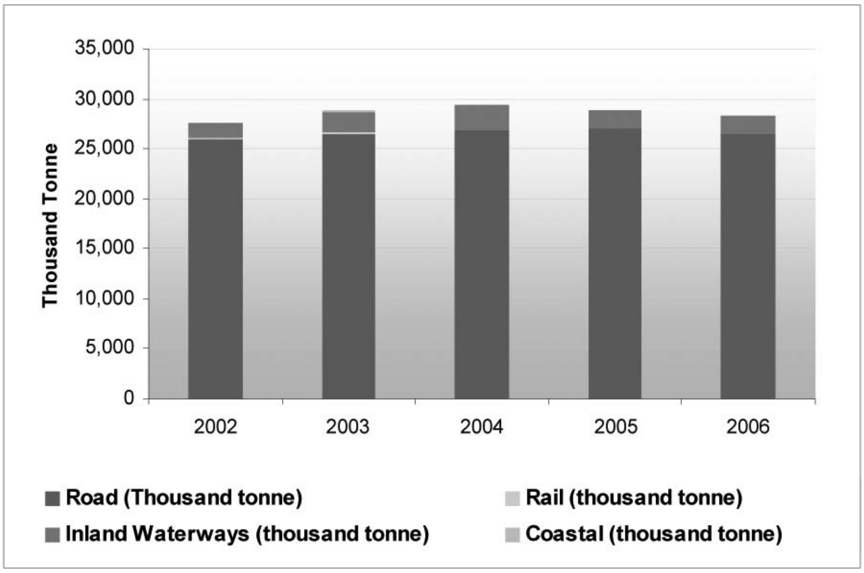


Source Ministry of Transport.

Transport of rice almost entirely relies on one mode of transport, road, as 93 percent of total tonnes and 98 percent total tonne-km are carried by trucks. Inland waterways and rail have very small role in rice transport, with around 1 percent and 0.08 percent in terms of tonne-km, respectively. Refer Figure A-3.3.

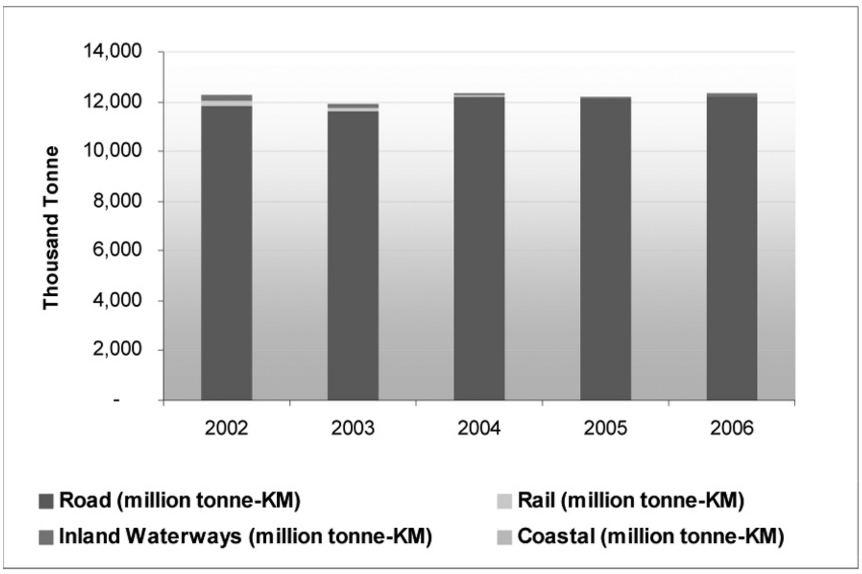
Figure A-3.3: Modal Shares of Rice Transport

Rice Transport (Tonne)



Source: Ministry of Transport.

Rice Transport (Tonne-KM)



Source: Ministry of Transport.

This quick snapshot seems to suggest that there is a room for key classes of freight traffic to diversify their modes of transport. Transport of rice is most reliant on road while the transport of cement and petroleum products uses rail, coastal shipping and inland waterways. Inland waterways and coastal shipping play a more significant role in petroleum transport than rail. There is potential to increase the role of rail for the transport of petroleum products given its current small share. Similarly, for cement and rice which are transported in bulk, although rail provides less flexibility than road, its role could be enhanced as an alternative mode that could provide a more cost-effective transport choice under appropriate conditions. For example, NESDB (2007) suggests that road might be an appropriate mode to transport rice in the northeastern region where production sites are smaller and more scattered. Rail, however, could provide an alternative cost-effective transport choice for rice grown in the central region which is mostly transported to Laem Chabang seaport for export.

Annex 4 : Fuel Economy Standards in Other Countries

EU: The European Union is striving to reduce average CO_2 emissions for all new passenger cars to 120 g/km by 2012 through voluntary agreements with car manufacturers or legally binding regulation. With European, Japanese and Korean car producers it was agreed in 1998 and 2000, respectively, to achieve an objective of 140 g CO_2/km by 2008/2009. This is equivalent to a medium fleet consumption of 5.8 liters gasoline or 5.25 liters diesel per 100 kilometer and a decrease in fuel consumption by 25 percent compared to 1998.[29]

USA: The USA Corporate Average Fuel Economy (CAFE) Act sets minimum acceptable standards of fuel economy that an average vehicle sold by each manufacturer must meet. The first value set for passenger cars was 18 miles per gallon (mpg) in 1978 and this was progressively increased to 27.5 mpg by 1985 and has remained unchanged since then. The values must be met separately by each firm's domestically produced and imported cars. Fines of US$5 per vehicle for every 0.1 mpg below the established standard are levied on manufacturers failing to meet the required level. Less stringent CAFE values are applied on light duty trucks (currently 21.0 mpg). In addition, the USA congress is considering raising CAFE standards by 10 mpg over a decade, to 35 mpg in 2020.[30]

China: In late 2004, China decided to introduce fuel economy standards for cars and light trucks through a weight-based approach. Each vehicle sold in the country is required to meet the standard for its weight class. The standards are classified into 16 weight classes and are on average slightly more stringent than the USA standards. They are being implemented in two phases: Phase 1 started on 1 July 2005 for new vehicle models, and on 1 July 2006 for continued vehicle models. Phase 2 takes effect on January 2008 for new models and on January 2009 for continued vehicle models. Phase 1 increased overall passenger vehicle fuel efficiency by approximately nine percent, from 26 mpg in 2002 to an estimated 28.4 mpg in 2006.[31]

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29 Regulation (EC) No. 443/2009 of the European Union Parliament and of The Council setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles. [Available at: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF]. Accessed in October 2008; Communication from the European Commission Report on Demonstrable Progress under the Kyoto Protocol (1 December 2005). [Available at: http://unfccc.int/resource/docs/dpr/eur1.pdf]. Accessed in October 2008; UNEP (2008), "Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World "Real potential, formidable challenges"". [the chapter on car fuel economy available at: http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-GreenJobs-E-Bookp148-171-Part2section3.pdf]. Accessed in October 2008.

30 European Federation for Transport and Environment (2005), "Reducing CO_2 Emissions from New Cars". [Available at: http://www.transportenvironment.org/docs/Publications/2005pubs/05-1_te_co2_cars.pdf]. Accessed in October 2008; Information on the US Vehicles Standards is available at: http://www.nhtsa.dot.gov/nhtsa/Cfc_title49/ACTchap321-331.html#32902. Accessed in October 2008.

31 International Council on Global Transportation (2007), "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update". [Available at: http://www.theicct.org/documents/ICCT_GlobalStandards_2007_revised.pdf]. Accessed in October 2008.

Japan: The Japanese government has established a set of fuel economy standards for gasoline and diesel powered light-duty passenger and commercial vehicles, with fuel economy targets based on average vehicle fuel economy by weight class. Penalties, although limited, apply when targets are not met. The standards are set by the "top runner" method, which aims to improve average energy efficiency of future cars above the level of the most energy-efficient cars currently available in the market. Targets are to be met in 2010 and 2015. For example, the gasoline passenger vehicles target is 15.1 kilometer/liter in 2010, and 16.8 kilometer/liter in 2015, implying a 23 percent improvement from 2004 to 2015.[32]

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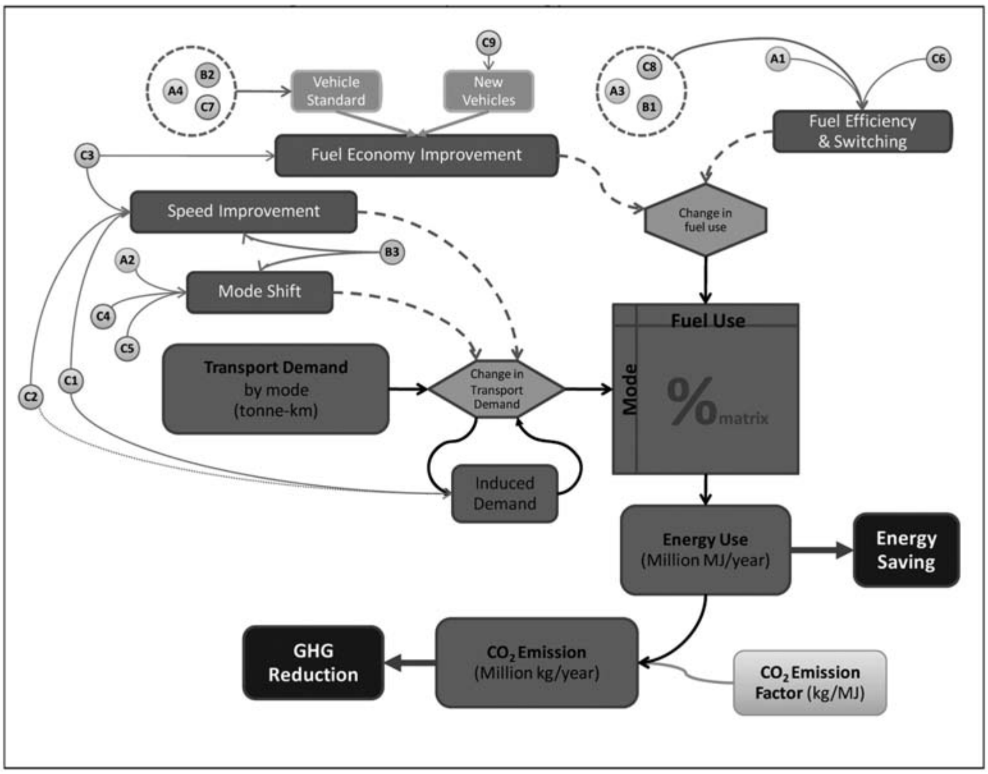
32 The Energy Conservation Center (2007), "The Final Report of Joint Meeting between the Automobile Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy and the Automobile Fuel Efficiency Standards Subcommittee, Automobile Transport Section, Land Transport Division of the Council for Transport Policy". [Available at: http://www.eccj.or.jp/top_runner/pdf/vehicles_gasdiesel_feb2007.pdf]. Accessed in October 2008.

Annex 5 : A Simple Transport-Energy Model

Determining Energy Savings

Conceptual Framework. A simple model was built to conduct the quantitative analysis, which is based on the concept illustrated in Figure A-5.1.

Figure A-5.1: Transport-Energy Model Structure



Source: Study Team.

The model first aims to determine the amount of energy - and subsequent GHG emissions - required to serve transport demand and associated energy savings as a result of introducing various transport policy options. The model starts from transport activities, which are expressed in terms of total tonne-kilometers (in case of freight transport) or passenger-kilometers (in case of urban and inter-urban passenger transport) by mode. For each mode, the percentage share of fuel use (i.e. petroleum, diesel, electricity, and natural gas) is roughly determined. For example, all cars use petroleum (i.e. gasoline and diesel) while MRT uses only electricity. Fuel efficiency for each type of vehicle and fuel type (in MJ/tonne-km or MJ/passenger-km), is then applied to calculate the amount of energy use in MJ unit.

Key Formula. The derivation of energy use from transport demand for freight and passenger for each mode can be represented by the following equations:

Freight: Energy use for Each Mode [*MJ*] = Transport Activities [*Tonne-km by mode*] × Fuel Share [%] × Fuel Efficiency [*MJ/tonne-km*]

Passenger: Energy use for Each Mode [*MJ*] = Transport Activities [*Passenger-km/passengers per vehicle by mode*] × Fuel Share [%] × Fuel Efficiency [*MJ/vehicle-km*]

MJ of energy use for each mode is then aggregated to determine total energy use for freight and passenger transport. For passenger transport, two separate models for urban and inter-city were developed and analyzed.

The amount of energy use (in MJ) will serve as the basis to estimate GHG emissions, which is calculated according to emission factors by types of fuel (i.e. tCO_2e of Emission = MJ of Energy Use × Emission Factor by fuel).

Steps of Calculation. With the above method, the amount of energy use of the base case is first calculated. Several policy options are then introduced into the model by assuming what would be the potential impacts of each option and how these impacts would be translated into energy savings. Sixteen (16) options covering inter-city freight transport, urban passenger transport, and inter-urban passenger transport were evaluated. Some of the options are "jointly" implemented, for example, railway investment serves both freight and passengers. Each option is assumed to have impacts on behavioral change of existing users, induced demand effects, mode shifts, improved fuel efficiency, and improved speed effects. These effects are operated through the model via changes in the three main variables: change in modal share, change in fuel share, and change in fuel efficiency.

Assumptions and Results. The assumptions on potential impacts of each option are summarized in Table A-5.1. Energy saving for each option, which is the difference between estimated energy use in the base case and energy use in the case when policy option is implemented, can then be determined.

Table A-5.1: Assumptions on Impacts of Policy and Technology Options

Options		Impact Assumptions	Impact on Total Energy Saving (Million MJ)
Freight Transport			
A1	**Non-fixed Route trucks use 25% CNG**	25% of non-fixed route trucks (or 18% of total fleet, or 134,592 trucks based on DLT data in 2007) switch to CNG	66,150
A2	**More efficient freight rail**	With the investment in railway (also see D2), freight rail's market share is expected to increase by half of existing share (approximately 1.4% increase)	*See D2*
A3	**Fuel efficiency improvement in diesel vehicles through engine and technology upgrades**	20% fuel efficiency improvement to 10% of all heavy trucks, which is about 64% of total fleet (approximately 478,550 heavy trucks in total, based on DLT data 2007)	14,859
A4	**Use of more efficient and higher payload trucks**	10% fuel efficiency improvement to overall trucks due to acceleration of old trucks' retirement and the gradual increase in minimum payload	30,223
Inter-city Passenger Transport			
B1	**Fuel economy improvement in diesel vehicles**	20% fuel efficiency improvement to 90% of Transport Co., Ltd. Fleet (which is around 933 buses)	6,298
B2	**Improve passenger car's fuel economy standards**	10% fuel efficiency improvement to passenger cars	*See D1*

B3	**Improve passenger trains**	100% train speed improvement which consequently leads to 10% fuel efficiency improvement of passenger trains. With the investment in railways (also see D2), inter-city passenger rail's market share is assumed to increase by half of rail's existing share, 50% of which is from private vehicles and the remaining 50% from buses	*See D2*
Urban Passenger Transport			
C1	**Improve traffic management***	Increase speed by 5% which consequently improves fuel efficiency by 2% Induced demand = 20% of maximum additional vehicles	2,000
C2	**Improve road user pricing***	Increase speed by 5% which consequently improves fuel efficiency by 2% 2% share moves from Autos to Buses (1%) and MRT (1%) Induced demand = 5% of maximum additional vehicles	1,000
C3	**Improve bus industry's efficiency***	Increase diesel fuel efficiency by 20% through operational measures, shorter route and better orientation to demand	2,000
C4	**Introduce BRT***	1% share of total urban passenger-km shifts to BRT with 0.8% shift from Buses and 0.2% shift from Autos	20,000
C5	**Integrate MRT/Bus/Walking***	5% share of total urban passenger-km shifts to MRT: 60% of which is from bus, 15% from private vehicles, 10% from auto passenger, and 15% from taxis	310,768
C6	**Use CNG in bus fleet**	All public buses switch to CNG	43,948
C7	**Improve passenger car's fuel economy standards**	10% fuel efficiency improvement to passenger cars	*See D1*
C8	**Improve fuel efficiency in BMTA diesel buses through engine and technology upgrades**	20% fuel efficiency improvement to 90% of BMTA buses	16,227
C9	**Set and enforce age limits for all heavy Bangkok buses**	Expediting the replacement of old buses with new buses, which implies 20% fuel efficiency improvement to all JV buses (about 3,293 JV buses)	21,037
Joint Options			
D1	**Fuel economy improvements in private sector's vehicles**	Combining B2 and C7	84,321
D2	**Railway Investment**	Combining A2 and B3	67,839

Drawbacks. Where possible the model was calibrated to actual fuel usage by type in Thailand. One drawback of the model is that by aiming to roughly calculate the potential impact of transport policies, it does so in a static way. A dynamic model, where trends in various factors (such as travel demand, fuel efficiency improvement, prices of fuel and vehicles) are sophisticatedly integrated and endogenously accounted for, would have given more accurate estimates. However, to provide supporting insights and analyses for policy purpose given the available time and resource, the static model can give indicative results that serve such purpose. Another drawback of the approach is that this type of strategic analysis does not include important network-wide and speed-flow effects which would need to be rectified for more detailed modeling. For the urban passenger transport options (i.e. in Bangkok and the BMR), where there is considerable congestion, the effect of induced traffic was taken into account in a general way.

Determining Cost Effectiveness

Once energy savings of various options are calculated, the second part of the analysis is to determine cost effectiveness in implementing each policy option. Cost effectiveness was calculated in a simple way with similar approach to that of Wright and Fulton (2005) by taking a snapshot of the current situation (e.g. today in 2008) and assuming to hold constant over time. The cost effectiveness of each option was then expressed as the cumulative savings in energy usage (in MJ) over 20 years, which is the difference between energy use in the projected 'baseline' scenario and the options of interest, divided by the estimated initial investment cost plus any recurrent cost over the same period. This can be simply expressed in the following equation:

Cost Effectiveness Ratio [*MJ per THB*] = Cumulative Energy Saving [*million MJ*]/(Investment + Recurrent Costs) [*THB million*]

The MJ-per-THB effectiveness indicator was developed to allow comparison among options. The cost effectiveness ratings so established were then generalized to avoid giving the impression of exceptional analytical precision. Consequently, one can also calculate the effectiveness in GHG emission reduction (per THB of investment) as well. Detailed assumptions of each option's cost are summarized in Table A-5.2.

Table A-5.2: Assumptions on Costs of Policy and Technology Options

Options		Cost Assumptions	Estimated Total Cost (THB Million)	Estimated Total Cost (US$ Million)
Freight Transport				
A1	**Non-fixed Route trucks use 25% CNG**	Replacing 134,592 trucks with CNG engine. CNG engine is assumed to cost THB500,000, and last for about 10 years	33,648	978.14
A2	**More efficient freight rail**	Based on government's investment plan in rail development	*See D2*	*See D2*
A3	**Fuel efficiency improvement in diesel vehicles through engine and technology upgrades**	Technology upgrades of all existing heavy trucks. The cost of upgrade is assumed to be 15% of the cost of new trucks (or about THB310,500 from the estimated cost of new trucks at THB2,070,000)	14,859	431.95
A4	**Use of more efficient and higher payload trucks**	Replacement cost is calculated based on the assumption that replacement will take place every ten years. The cost of each replacement is the difference between the cost of new trucks and the net present value of trucks at year 10. The cost of new truck is assumed to be THB2,070,000. 13,600 trucks, which are older than 15 years, are assumed to be replaced in each lot.	30,223	878.58
Inter-city Passenger Transport				
B1	**Fuel economy improvement in diesel vehicles**	Replace around 840 buses of the existing Transport Company's bus fleet with new buses. Cost of inter-urban bus is assumed to be 50% more expensive than urban bus (the cost of new bus is estimated to be THB5,000,000)	6,298	183.08
B2	**Improve passenger car's fuel economy standards**	Replacing old cars (>15 years old) with the more fuel efficient vehicles through introduction of a standard on fuel economy (Approx. from 1600-3000cc vehicles with cost less than THB2 million)	*See D1*	*See D1*
B3	**Improve passenger trains**	Based on government's investment plan in rail development	*See D2*	*See D2*

Urban Passenger Transport				
C1	**Improve traffic management**	Based on the cost of a new Area Traffic Control System for over 1000 intersections as proposed for Bangkok	2,000	58.14
C2	**Improve road user pricing**	Assumed to be THB50 million each year for 20 years for the administration and adjustment of license and registration cost	1,000	29.07
C3	**Improve bus industry's efficiency**	Assumed to be THB100 million each year for 20 years for the improvement in management and routing of bus network	2,000	58.14
C4	**Introduce BRT**	Assumed to be slightly higher than government's original plan for the first two BRT lines, which is around THB16,000 million	20,000	581.40
C5	**Integrate MRT/Bus/Walking**	According to government's mega project investment plan to build 7 MRT lines	310,768	9,033.95
C6	**Use CNG in bus fleet**	Full cost of converting all buses to CNG (based on THB1,300,000 cost of conversion)	43,948	1,277.56
C7	**Improve passenger car's fuel economy standards**	Replacing old cars (>15 years old) with the more fuel efficient vehicles through introduction of a standard on fuel economy (Approximate from 1600-3000cc vehicles with cost less than 2 million Baht)	*See D1*	*See D1*
C8	**Improve fuel efficiency in BMTA diesel buses through engine and technology upgrades**	Diesel buses upgrade for 35% of total fleet (or 90% of BMTA fleet which is around 3,245 buses) at the new bus cost of THB5,000,000	16,227	471.72
C9	**Set and enforce age limits for all heavy Bangkok buses**	Replacement cost is calculated based on the assumption that replacement will take place every five years. The cost of each replacement is the difference between the cost of new bus and the net present value of trucks at year 5. The cost of new bus is assumed to be THB5,000,000. All 3,293 JV buses are assumed to be replaced.	21,037	611.54
Joint Options				
D1	**Fuel economy improvements in private sector's vehicles**	Combining B2 and C7	84,321	2,451.19
D2	**Railway Investment**	Combining A2 and B3	67,839	1,972.06

Results and Analysis

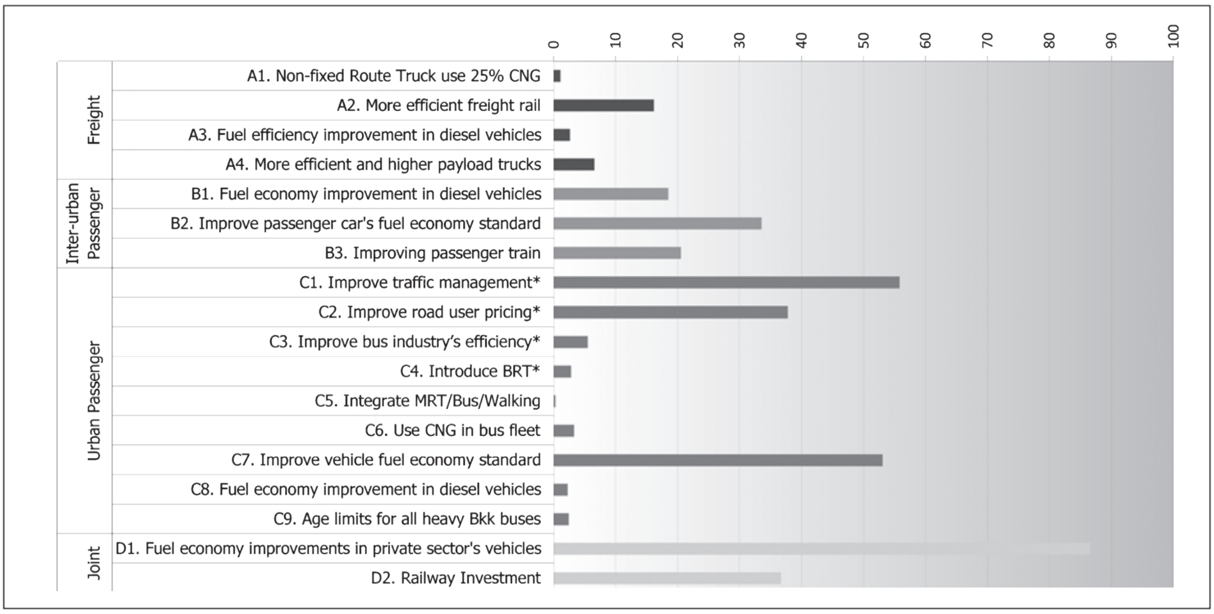
In Section 4 of the report, the results of the analysis of the 16 options (plus underlying 2 joint options) are summarized in five categories. The results are presented as a snapshot of the estimated energy saving at 2025 in a scenario where all the policy options are implemented versus business-as-usual scenario at 2025. In this section, the results of the analysis are presented as the cumulative energy savings over 20 years, from 2006 to 2025. This is important as the profile of savings for each policy option will be different. Such an approach is needed to estimate a cost effectiveness ratio for each policy. The summary of the results for each policy option are summarized in Table A-5.3 which shows the estimated cost, cumulative energy saving over 20 years from 2006 to 2025, cost effectiveness ratio and assessment of implementation difficulty for each option. Figure A-5.2 shows the estimated cumulative carbon dioxide-equivalent (tCO_2e) emissions for each option up to year 2025.

Table A-5.3: Summary of Options and Results (Total Impacts over 20 Years)

	Options	Estimated Total Cost (THB Million)	Total Energy Saving (Million MJ)	Cost Effectiveness (MJ per THB)	Indicative Cost Effectiveness	Implementation Difficulty	Total CO_2 Emission Reduction (Million kg)	Energy Saving from projected baseline for the year 2025 (Percentage)
Freight Transport								
A1	**Non-fixed Route trucks use 25% CNG**	33,648	66,150	1.9659	Low	Low	1,051	0.34%
A2	**More efficient freight rail**	See D2 below						4.10%
A3	**Fuel efficiency improvement in diesel vehicles due to engine and technology upgrades**	14,859	41,701	2.8065	Low	Low	2,611	0.32%
A4	**Use of more efficient and higher payload trucks**	30,223	104,685	3.4637	Medium	High	6,554	0.81%
Inter-city Passenger Transport								
B1	**Fuel economy improvement in diesel vehicles**	6,298	294,961	46.8359	Very High	Medium	18,467	2.46%
B2	**Improve passenger car's fuel economy standards**	See D1 below						4.23%
B3	**Improve passenger trains**	See D2 below						1.83%
Urban Passenger Transport								
C1	**Improve traffic management***	2,000	796,386	398.1928	Very High	High	55,772	7.33%
C2	**Improve road user pricing***	1,000	599,266	599.2656	Very High	High	37,740	3.79%
C3	**Improve bus industry's efficiency***	2,000	77,892	38.9460	Very High	High	5,455	0.79%
C4	**Introduce BRT***	20,000	41,707	2.0853	Low	Medium	2,779	0.21%
C5	**Integrate MRT/Bus/Walking***	310,768	305,417	0.9828	Low	Medium	258	1.59%
C6	**Use CNG in bus fleet**	43,948	106,612	2.4259	Low	Low	3,270	0.55%
C7	**Improve passenger car's fuel economy standards**	See D1 below						6.81%
C8	**Improve fuel efficiency in BMTA diesel buses through engine and technology upgrades**	16,227	31,663	1.9513	Low	Medium	2,217	0.29%
C9	**Set and enforce age limits for all heavy Bangkok buses**	21,037	34,143	1.6230	Low	Medium	2,391	0.30%
Joint Options								
D1	**Fuel economy improvements in private sector's vehicles**	84,321	1,292,395	15.3271	High	Low	86,535	11.04%
D2	**Railway Investment**	67,839	585,066	8.6243	Medium	High	36,630	5.93%

With **induced demand: When speed increases or when people move away from the road (to MRT or walking), road space frees up and convenience increases. Congestion is reduced, which is an incentive for some people to use roads. However, with higher speed, more space between vehicles is required (for safety reasons). Therefore, proportionately less road space is freed up with higher speed.*

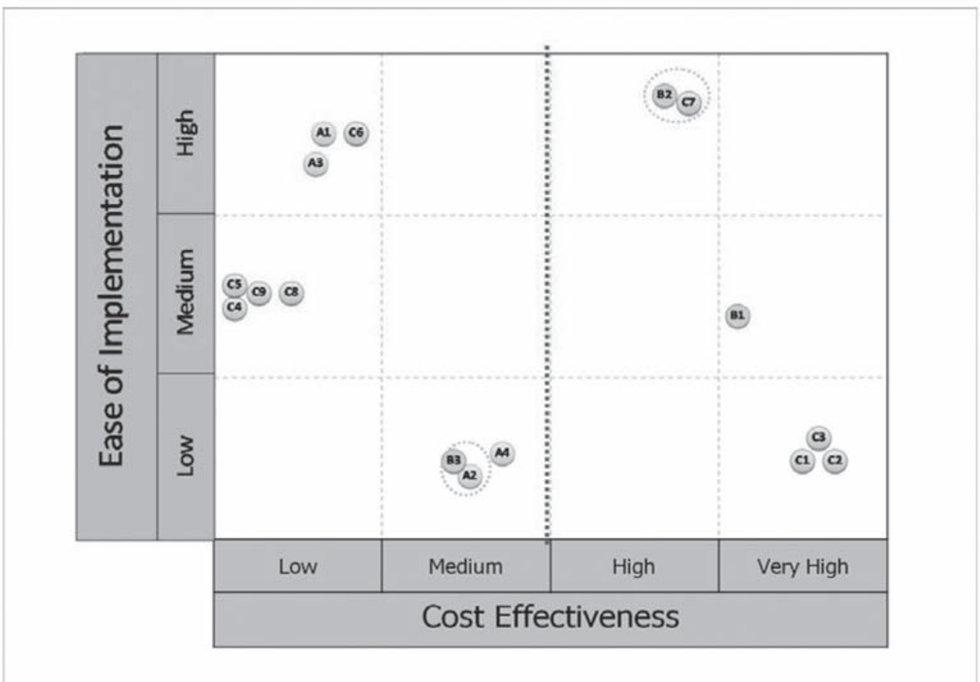
Figure A-5.2: Cumulative Total Carbon Dioxide-Equivalent Emission Reduction from Energy Savings (in Million tCO2e)



Source: Study Team.

Implementation difficulties were rated qualitatively, in order to compare the options in conjunction with the cost effectiveness ratings. The options comparison is illustrated in Figure A-5.3.

Figure A-5.3: Options Comparison – Cost Effectiveness vs. Ease of Implementation



Source: Study Team.

Very high or high cost effectiveness and low implementation difficulties are preferred. But only **Option D1 – fuel economy improvements in private sector's vehicles** – has these attributes. This option can be introduced at very low cost as it responds to consumers' preferences for more fuel-efficient cars and the continual car design improvements by automotive producers to meet consumer demand.

There are another four options which exhibit very high cost effectiveness but are assessed as having medium to high implementation difficulties:

- **Option B1 – fuel economy improvement in diesel inter-urban buses –** rated as having medium implementation difficulty because the decision to accelerate bus replacement with modern vehicles may have political implications.
- **Option C2 – improved road user pricing in Bangkok** – offers a significant energy saving and high cost effectiveness because it deals with demand management. It involves revision of the current administrative system of road use charges and increases in charges which have been historically low. Cost of implementation is low but it would be politically difficult to implement.
- **Option C1 – improved traffic management in Bangkok** – has similar attributes to C2 but with a higher cost. However, international experiences show that implementation difficulties should not be underrated.
- **Option C3 – improved bus industry efficiency in Bangkok** – offers high energy saving potential, has high cost effectiveness, but is considered to be of high implementation difficulty with potential political implications.

Appendix Tables

Appendix Table 1: Thailand's GDP, Population, Total Final Energy Consumption and World Crude Oil Prices from 1982-2007

Year	GDP constant 1988 prices Billion Baht	Population (million)	Total Final Energy Consumption (KTOE)	Crude Oil Spot Prices for Brent Barrel (US$/Barrel)
1982	1,019.5	48.84	14,727	32.86
1983	1,076.4	49.51	15,846	29.73
1984	1,138.4	50.58	17,420	28.74
1985	1,191.3	51.79	18,554	27.62
1986	1,257.2	52.97	19,698	14.44
1987	1,376.8	53.87	21,560	18.43
1988	1,559.8	54.96	23,749	14.92
1989	1,750.0	55.89	27,799	18.23
1990	1,945.4	55.84	30,642	23.73
1991	2,111.9	57.03	32,548	20.00
1992	2,282.6	57.62	35,234	19.32
1993	2,470.9	58.44	38,616	16.97
1994	2,693.0	59.24	40,802	15.82
1995	2,941.7	59.28	45,729	17.02
1996	3,115.3	59.90	49,250	20.67
1997	3,072.6	60.50	49,455	19.09
1998	2,749.7	61.20	45,102	12.72
1999	2,872.0	61.80	47,129	17.97
2000	3,008.4	61.88	47,806	28.5
2001	3,073.6	62.31	49,542	24.44
2002	3,237.0	62.80	52,979	25.02
2003	3,468.2	63.08	56,289	28.83
2004	3,688.2	61.97	61,262	38.27
2005	3,855.1	62.42	62,397	54.52
2006	4,052.0	62.83	63,257	65.14
2007	4,244.6	63.00	64,886	72.39

Source: Data on GDP constant 1988 prices in Baht and Population are from BOT website. Available at www.bot.or.th. Data on Total Final Energy Consumption are from DEDE. Data on Crude Oil Spot Prices ($) for Brent Barrel which is used as referral price are from IEA.

Appendix Table 2: Energy Consumption by Sector in Thailand from 1982-2006 (KTOE)

Year	All Sectors	Transport	Manufacturing & Mining	Agriculture	Construction	Residential	Commercial
1982	14,727	4,523	4,802	1,117	111	3,596	578
1983	15,846	5,274	4,649	1,043	78	4,099	703
1984	17,420	6,180	5,015	1,029	100	4,396	700
1985	18,554	6,540	5,293	841	125	5,035	720
1986	19,698	7,017	5,302	881	123	5,562	813
1987	21,560	8,031	5,648	835	111	5,958	977
1988	23,749	9,213	6,111	834	98	6,315	1,178
1989	27,799	10,169	7,768	1,639	109	6,959	1,155
1990	30,643	11,386	8,599	1,785	147	7,239	1,486
1991	32,549	11,910	9,353	1,827	194	7,622	1,642
1992	35,234	12,652	10,931	1,897	220	8,145	1,389
1993	38,616	14,581	11,717	2,616	182	7,379	2,141
1994	40,803	15,420	13,269	2,497	333	7,207	2,076
1995	45,729	17,903	15,768	2,432	273	6,865	2,488
1996	49,250	18,984	17,512	2,896	315	6,958	2,585
1997	49,455	20,253	16,104	2,638	369	7,359	2,732
1998	45,102	18,075	13,848	2,661	265	7,334	2,919
1999	47,129	18,297	15,627	2,854	237	7,251	2,863
2000	47,806	18,022	16,293	2,791	149	7,434	3,117
2001	49,542	18,632	17,015	2,847	128	7,484	3,436
2002	52,979	19,636	18,785	3,032	149	7,909	3,468
2003	56,289	20,927	20,103	3,308	152	8,173	3,626
2004	61,262	22,812	22,092	3,520	171	8,801	3,866
2005	62,397	23,491	22,768	3,207	152	8,933	3,846
2006	63,257	22,985	23,572	3,312	139	9,034	4,215

Source: Data on Energy Consumption by Sector are from DEDE.

Appendix Table 3: Sectoral Share of GDP in Thailand from 1982 to 2007 (% of GDP)

Year	Services	Manufacturing	Agriculture
1982	51.94	21.32	18.55
1983	49.36	22.13	20.06
1984	50.45	22.91	17.57
1985	52.35	21.92	15.81
1986	51.25	23.88	15.66
1987	50.92	24.25	15.73
1988	49.24	25.84	16.18
1989	48.67	26.75	15.08
1990	50.28	27.20	12.50
1991	48.69	28.24	12.65
1992	49.65	27.52	12.30
1993	50.88	29.65	8.66
1994	50.31	29.55	9.09
1995	49.75	29.90	9.51
1996	49.68	29.72	9.50
1997	50.39	30.17	9.45
1998	49.59	30.87	10.78
1999	49.68	32.65	9.39
2000	48.99	33.59	9.02
2001	48.72	33.43	9.13
2002	48.13	33.69	9.43
2003	45.96	34.84	10.41
2004	46.25	34.49	10.32
2005	45.78	34.76	10.17
2006	44.78	34.99	10.68
2007	45.31	35.50	10.84

Source: World Bank's Data Development Platform/World Development Indicators Database.

Appendix Table 4: GDP Constant 2000 USD from 1990-2005, Selected Countries (US$)

Year	GDP Constant 2000 USD			
	China	Germany	Japan	S. Korea
1990	444,600,549,376	1,543,200,702,464	4,122,339,704,832	283,561,099,264
1991	485,503,795,200	1,622,028,713,984	4,260,463,640,576	10,196,502,528
1992	554,445,373,440	1,658,135,248,896	4,301,877,673,984	328,422,686,720
1993	632,067,719,168	1,644,831,440,896	4,312,530,419,712	348,567,437,312
1994	714,868,588,544	1,688,538,841,088	4,359,911,112,704	378,322,944,000
1995	792,789,254,144	1,720,462,475,264	4,445,374,513,152	413,011,181,568
1996	872,068,153,344	1,737,562,128,384	4,567,445,012,480	441,916,260,352
1997	953,170,526,208	1,768,914,681,856	4,639,174,950,912	462,469,595,136
1998	1,027,517,775,872	1,804,827,754,496	4,544,107,380,736	430,769,799,168
1999	1,105,609,097,216	1,841,127,751,680	4,537,667,551,232	471,634,018,304
2000	1,198,480,293,888	1,900,221,169,664	4,667,449,278,464	511,657,803,776
2001	1,297,954,242,560	1,923,788,439,552	4,676,051,271,680	531,288,358,912
2002	1,416,068,071,424	1,923,788,439,552	4,688,318,562,304	568,320,720,896
2003	1,557,674,852,352	1,920,176,881,664	4,754,592,235,520	585,922,379,776
2004	1,714,999,918,592	1,944,112,726,016	4,885,069,692,928	613,633,949,696
2005	1,893,359,943,680	1,961,792,897,024	4,978,244,583,424	639,391,891,456
Year	GDP Constant 2000 USD			
	Malaysia	Thailand	United States	-
1990	45,459,496,960	79,359,844,352	7,055,000,207,360	-
1991	49,798,815,744	86,151,667,712	7,041,300,037,632	-
1992	54,223,499,264	93,115,645,952	7,276,199,936,000	-
1993	59,588,886,528	100,798,660,608	7,472,000,008,192	-
1994	65,078,239,232	109,857,619,968	7,775,499,845,632	-
1995	71,474,831,360	120,005,697,536	7,972,799,905,792	-
1996	78,624,243,712	127,087,648,768	8,271,399,747,584	-
1997	84,381,696,000	125,344,800,768	8,647,599,980,544	-
1998	78,171,701,248	112,171,098,112	9,012,500,234,240	-
1999	82,969,575,424	117,160,058,880	9,417,099,575,296	-
2000	90,319,740,928	122,725,244,928	9,764,800,036,864	-
2001	90,607,140,864	125,385,023,488	9,838,899,757,056	-
2002	94,365,220,864	132,052,467,712	9,997,599,637,504	-
2003	99,730,612,224	141,480,984,576	10,249,799,991,296	-
2004	106,512,293,888	150,456,631,296	10,651,700,297,728	-
2005	111,837,904,896	157,266,083,840	10,995,799,949,312	-

Source: World Bank's Data Development Platform/World Development Indicators Database.

Appendix Table 5: Final and Transport Energy Consumption (KTOE) from 1995-2005, Selected Countries

Year	Final Energy Consumption						
	China	Germany	Japan	S. Korea	Malaysia	Thailand*	United States
1995	786,377	222,795	335,308	107,599	23,276	46,220	1,393,477
1996	810,589	230,851	341,104	115,671	25,740	50,823	1,437,943
1997	794,785	225,259	342,961	123,118	27,402	51,449	1,457,333
1998	802,223	223,525	337,270	110,902	27,083	47,099	1,456,107
1999	777,919	218,700	345,369	122,326	28,165	49,818	1,509,857
2000	779,090	218,098	348,361	128,151	30,848	51,220	1,565,971
2001	788,197	223,940	343,079	130,741	32,791	53,091	1,537,968
2002	822,127	219,240	349,198	140,508	34,644	56,439	1,555,046
2003	901,982	221,938	346,678	143,134	35,937	59,706	1,570,927
2004	1,022,544	220,381	350,355	145,344	38,624	64,559	1,599,737
2005	1,112,532	218,369	350,849	146,068	39,180	66,232	1,598,105
Year	Transport Energy Consumption						
	China	Germany	Japan	S. Korea	Malaysia	Thailand*	United States
1995	50,580	63,078	91,404	27,007	7,824	17,970	544,689
1996	53,313	62,783	94,030	29,320	8,947	19,495	557,819
1997	59,026	63,944	94,901	29,654	10,203	19,606	568,313
1998	64,999	65,039	94,951	25,394	9,799	17,658	581,459
1999	69,364	67,093	95,152	27,699	11,399	17,602	598,420
2000	73,788	66,188	95,192	30,028	12,075	17,402	609,509
2001	75,699	64,804	95,757	31,078	13,145	17,982	608,589
2002	79,940	64,371	95,043	33,176	13,449	18,870	621,173
2003	90,491	62,596	94,159	34,161	14,279	19,931	629,707
2004	103,389	63,219	94,595	34,248	15,383	21,630	639,078
2005	114,230	62,149	93,013	31,837	15,329	22,051	648,412

Source: *IEA Statistics Division. 2006. Energy Balances of OECD Countries (2006 edition) and Energy Balances of Non-OECD Countries (2006 edition). Paris: IEA. Available at http://data.iea.org/ieastore/default.asp.*

Note: **Note that there is discrepancy between Thailand's data on Final and Transport Energy Consumption from IEA-OECD database and from local government agency (DEDE) database. For the purpose of international comparison, IEA-OECD data for Thailand will be used. However, in other parts of the analysis, data from DEDE will be used.*

Appendix Table 6: Road Sector, Diesel Oil and Motor Gasoline Consumption in 1990, 2000 and 2003, Selected Countries

	Road Sector Energy Consumption (KTOE)						
	China	**Germany**	**Japan**	**S. Korea**	**Malaysia**	**Thailand**	**United States**
1990	21,008	51,427	62,910	10,750	4,844	8,558	392,554
2000	46,635	57,267	78,282	22,418	10,482	14,452	492,577
2003	57,260	53,335	76,805	26,071	12,371	16,742	521,469
Diesel Oil Consumption (Million Liters)							
1990	7,741	21,438	30,192	8,029	2,015	6,672	90,974
2000	26,840	29,587	35,201	13,840	4,441	10,111	130,004
2003	37,284	28,092	31,768	16,681	5,432	11,823	146,308
Motor Gasoline Consumption (Million Liters)							
1990	21,524	40,320	42,563	3,584	3,569	3,320	394,059
2000	41,351	37,090	55,806	9,452	7,735	6,156	464,290
2003	48,295	33,254	57,746	9,202	8,916	6,968	478,474

Source: IEA Statistics Division. 2006. Energy Balances of OECD Countries (2006 edition) and Energy Balances of Non-OECD Countries (2006 edition). Paris: IEA. Available at http://data.iea.org/ieastore/default.asp. Access via World Resources Institute at http://earthtrends.wri.org.

Technical Notes:

1) *Road sector energy consumption measures the amount of primary energy from all sources consumed for road transportation in each country in the year specified. Data are reported in thousand tonnes (metric tons) of oil equivalent (ktoe). Energy consumption from road transportation includes all fuels used in road vehicles as well as agricultural and industrial highway use. The sector excludes military consumption as well as motor gasoline used in stationary engines and diesel oil used in tractors. Consumption equals indigenous production + imports - exports - energy delivered to international marine bunkers +/- stock changes. The International Energy Agency (IEA) refers to these data as Total Primary Energy Supply (TPES). Energy losses from transportation, friction, heat, and other inefficiencies are included in these totals.*
2) *Diesel oil consumption measures the volume of diesel oil consumed by a specified country for use in the transportation sector. Diesel oil—referred to as "gas/diesel oil" by the International Energy Agency (IEA)—includes heavy gas oils obtained from distillation of crude oil. Most (90 %) of the diesel consumption listed here is used for road transport; the remaining diesel fuel is used for rail transport, pipelines, and domestic navigation. In the transport sector, diesel oil is used for the compression ignition of cars, trucks, marine, etc. Gas/diesel oil does not include the liquid biofuel blended with gas/diesel oil. Data are reported in millions of liters. The transport sector includes International Standard Industrial Classification (ISIC) Divisions 60, 61 and 62. It includes transport in the industry sector and covers road, railway, air, internal navigation (including small craft and coastal shipping not included under marine bunkers), fuels used for transport of materials by pipeline, and non-specified transport. Fuel used for ocean, coastal and inland fishing (included under fishing) and military consumption (included in other sectors non-specified) are excluded from the transport sector. Diesel oil used for non-transport related purposes (heating oil for industrial and commercial uses, petrochemical feedstocks, etc.) is not included here. Consumption equals indigenous production + imports - exports - energy delivered to international marine bunkers +/- stock changes. The IEA refers to these data as Total Primary Energy Supply (TPES). Energy losses from transportation, friction, heat, and other inefficiencies are included in these totals.*
3) *Motor gasoline consumption measures the average volume of motor gasoline consumed by a specified country for use in the transportation sector. Nearly all (>99%) of the gasoline consumption listed here is used in road transport. Motor gasoline is used in spark-ignition engines (e.g. the engines of most passenger cars) and includes both leaded and unleaded grades of finished gasoline, blending components, and gasohol. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (Tetraethyl lead) and TML (tetramethyl lead). Motor gasoline does not include the liquid biofuel or ethanol blended with gasoline. Data are reported in millions of liters. The transport sector includes International Standard Industrial Classification (ISIC) Divisions 60, 61 and 62. It includes transport in the industry sector and covers road, railway, air, internal navigation (including small craft and coastal shipping not included under marine bunkers), fuels used for transport of materials by pipeline, and non-specified transport. Fuel used for ocean, coastal and inland fishing (included under fishing) and military consumption (included in other sectors non-specified) are excluded from the transport sector. Motor gasoline used in stationary engines is not measured here. Consumption equals indigenous production + imports - exports - energy delivered to international marine bunkers +/- stock changes. The International Energy Agency (IEA) refers to these data as Total Primary Energy Supply (TPES). Energy losses from transportation, friction, heat, and other inefficiencies are included in these totals.*

Appendix Table 7: Freight Transport by Mode in Thailand in 2004, 2005 and 2006

	2006		2005		2004	
	Million Tonnes	**Million Tonne-KM**	**Million Tonnes**	**Million Tonne-KM**	**Million Tonnes**	**Million Tonne-KM**
Road	427,581	184,498	430,275	176,915	435,147	4,089
Rail	12,537	3,508	12,792	3,622	13,871	178,089
Inland Waterways	31,074	2,164	29,569	2,103	29,135	2,107
Coastal	29,981	4,009	28,322	5,093	27,767	3,396
Air	48	31	54	34	53	34
Total	**501,221**	**194,209**	**501,012**	**187,767**	**505,973**	**187,715**

Source: Data on freight tonnes and tonne-km are compiled from different sources. Data of freight activity in tonnes for all modes except rail are taken from MOT's data. Data on tonne of rail freight are from SRT. Data on road tonne-km are compiled from DOH. Data on rail tonne-km are from SRT. Data on Inland Waterways, Coastal and Air tonne-km are from MOT. DOH and MOT use different methodologies to calculate tonne-km. MOT estimates tonne-km of each mode based on tonnes of goods transported. DOH estimates tonnekm of trucks based on vehicle-km of trucks traffic on national highways.

Appendix Table 8: Number of Registered Vehicles by Fuel Type, as of December 2007

Type of Vehicles	The city of Bangkok					
	Total	Gasoline	Diesel	LPG*	NGV**	Electricity & Others***
Total	**5,715,078**	**4,024,877**	**1,490,420**	**129,278**	**29,428**	**41,075**
Total Vehicle under Motor Vehicle Act	**5,570,791**	**4,024,419**	**1,371,985**	**127,994**	**27,535**	**18,858**
1. Sedan (not more than 7 passenger)	1,974,751	1,610,342	298,922	53,638	9,987	1,862
2. Personal Passenger Van (more than 7 passenger)	197,075	27,306	157,943	1,097	2,038	8,691
3.Personal Pick Up	940,886	41,969	888,446	3,434	632	6,405
4. Motortricycle	599	437	22	137	2	1
5. Interprovincial Taxi	640	624	11	3	-	2
6. Urban Taxi	78,792	3,723	201	61,690	13,174	4
7. Fixed Route Taxi	4,319	3,879	5	424	-	11
8. Motortricycle Taxi (Tuk Tuk)	9,019	149	1	7,240	1,629	-
9. Hotel Taxi	1,745	1,341	292	30	72	10
10. Tour Taxi	537	227	21	288	1	-
11. Car For Hire	99	38	61	-	-	-
12. Motorcycle	2,261,545	2,260,709	16	3	-	817
13. Tractor	21,128	23	21,010	5	-	90
14. Road Roller	3,301	9	3,248	4	-	40
15. Farm Vehicle	1,819	16	1,786	1	-	16
16. Automobile Trailer	909	-	-	-	-	909
17. Public Motorcycle	73,627	73,627	-	-	-	-
Total Vehicle under Land Transport Act	**144,287**	**458**	**118,435**	**1,284**	**1,893**	**22,217**
1. Bus : Total	33,716	317	30,681	1,191	1,490	37
1.1 Fixed Route Bus	21,649	270	18,793	1,167	1,412	7
1.2 Non Fixed Route Bus	9,009	28	8,864	22	71	24
1.3 Private Bus	3,058	19	3,024	2	7	6
2. Truck : Total	110,571	141	87,754	93	403	22,180
2. 1. Non Fixed Route Truck	45,785	10	28,769	62	274	16,670
2.2. Private Truck	64,786	131	58,985	31	129	5,510
3. Small Rural Bus	-	-	-	-	-	-

Type of Vehicles	The rest of the country					
	Total	Gasoline	Diesel	LPG*	NGV**	Electricity & Others***
Total	**19,903,369**	**15,162,161**	**4,556,059**	**53,458**	**4,449**	**127,242**
Total Vehicle under Motor Vehicle Act	**19,167,161**	**15,153,920**	**3,906,767**	**52,204**	**3,097**	**51,173**
1. Sedan (not more than 7 passenger)	1,585,471	1,131,766	402,651	34,980	2,715	13,359
2. Personal Passenger Van (more than 7 passenger)	184,555	14,935	165,901	872	102	2,745
3.Personal Pick Up	3,430,598	215,881	3,180,936	6,749	273	26,759
4. Motortricycle	700	308	19	354	-	19
5. Interprovincial Taxi	14	3	11	-	-	-
6. Urban Taxi	778	424	172	164	1	17
7. Fixed Route Taxi	528	497	5	5	-	21
8. Motortricycle Taxi (Tuk Tuk)	14,677	5,615	166	8,861	4	31
9. Hotel Taxi	941	748	94	96	2	1
10. Tour Taxi	74	62	8	4	-	-
11. Car For Hire	11	10	1	-	-	-
12. Motorcycle	13,700,382	13,695,487	278	5	-	4,612
13. Tractor	77,753	1,150	75,016	67	-	1,520
14. Road Roller	6,191	72	6,088	5	-	26
15. Farm Vehicle	81,505	4,553	75,418	41	-	1,493
16. Automobile Trailer	570	-	-	-	-	570
17. Public Motorcycle	82,413	82,409	3	1	-	-
Total Vehicle under Land Transport Act	**736,208**	**8,241**	**649,292**	**1,254**	**1,352**	**76,069**
1. Bus : Total	87,026	6,402	79,284	784	334	222
1.1 Fixed Route Bus	60,245	1,912	57,428	465	302	138
1.2 Non Fixed Route Bus	20,190	4,460	15,326	316	24	64
1.3 Private Bus	6,591	30	6,530	3	8	20
2. Truck : Total	637,164	487	559,521	323	1,008	75,825
2. 1. Non Fixed Route Truck	90,211	21	60,598	71	420	29,101
2.2. Private Truck	546,953	466	498,923	252	588	46,724
3. Small Rural Bus	12,018	1,352	10,487	147	10	22

Source: Department of Land Transport.

Note: The number of vehicles is cumulative registered vehicles.

**LPG is Liquefied Petroleum Gas, and includes those with dual fuel capability (with gasoline or diesel).*

***NGV is Natural Gas Vehicle and includes those using dual fuel capability (with gasoline or diesel).*

****Electricity and Others include hybrid and other fuels.*

Appendix Table 9: In-use Vehicles, Selected Categories, Selected Years

Year	Sedan		Personal Vans		Personal Pick ups		Motorcycles	
	Thailand	Bangkok*	Thailand	Bangkok*	Thailand	Bangkok*	Thailand	Bangkok*
1999	1,416,595	846,779	332,125	177,985	2,184,039	450,204	6,031,218	716,679
2002	1,848,257	1,093,347	319,798	169,699	2,579,607	529,071	6,558,879	836,027
2003	2,027,107	1,182,755	308,889	157,464	2,788,843	609,701	7,498,499	917,710
2004	2,346,308	1,445,751	290,810	145,796	2,901,780	658,665	8,893,383	1,057,744
2005	2,807,756	1,612,038	319,172	160,958	3,359,551	800,957	9,934,908	1,343,379
2006	2,800,726	1,501,312	288,063	128,736	3,523,029	837,808	10,021,325	1,477,650
2007	3,208,647	1,635,622	310,878	132,049	3,907,410	885,454	10,480,188	1,512,339

Source: Department of Land Transport.

Note: The study team estimated an approximation of the in-use vehicles fleet for each year by adding the vehicles re-registered from the previous year together with the newly-registered vehicles for the year in question. No account was taken of the vehicles de-registered during the year. The data from the DLT website are available only for the selected years presented here.

**Bangkok includes only the province of Bangkok.*

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