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Land Transport Demand Analysis and Energy Saving Potentials in Thailand

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Abstract: Transportation sector has been the largest energy consuming sector in Thailand, accounting for 38% of total final energy consumption. In order to reduce the energy consumption, the energy policies and measures would be implemented. This study aims at prediction of the number of vehicles in road transport sector from 2005 to 2020 and its implication on energy demands and emissions. A non-linear forecasting model derived from the gross domestic product and the number of annual registered cars. The energy consumption in the transport sector in the business as usual scenario is analyzed by an end-use model, namely "Long-range Energy Alternative Planning system" or LEAP model. In order to reduce the energy demands and emissions, the scenarios for long-range energy alternative planning in road transport are (1) fuel substitution such as policy on compressed natural gas (CNG), (2) promotion of new transport technology such as hybrid vehicles, and (3) improved fuel economy of the gasoline and diesel engines have been examined comparing to business as usual scenario. The results of the study have shown that, in 2020, the number of vehicles, the energy demands and the emissions in business as usual scenario in road transport would be increased to 42.6 million vehicles, 34,386 ktoe and 146,877 thousand tons of CO_2 equivalent, respectively. The CNG would be able to substitute for conventional fuel by 5.6% of total final energy demands and in 2020. The fuel economy improvement scenario has the highest potential to reduce the energy demand in road transport, accounting for 5.7% of total final energy demands.

Keywords: Energy Demand, Transport Sector, End-use Model, Fuel Substitution, Energy Efficiency Improvement, CO_2 Emission

Introduction

Transportation is one of the major economic sectors in energy consumption. For Thailand, this sector has been the largest energy consuming sector. It accounted for about 38% of the total energy consumption and about 80% of this sector was used in the road transport in 2004. During 2000 – 2004, the energy consumption in the transport sector in Thailand increased from 18,022 ktoe to 22,907 ktoe [1]. Annual growth rate of the energy consumption was 6.8%, whereas the Gross Domestic Product (GDP) was only 5.6% in the same period [2]. The elasticity of total energy demand in the same period was accounted for 1.4:1. However, the Ministry of Energy set a target of the elasticity of total energy demand to be 1:1 in 2008. One of the energy policies and measures to achieve the energy elasticity target is to promote alternative energy sources and increase energy efficiency in the transport sector.

In the analysis, the land transport in Thailand is classified into two main modes: passenger and freight transports. The types of vehicles stock in each transport mode have been determined. In road transport, the fuel economies of the transport technology are assumed for formulation of energy consumption in the baseline or business as usual (BAU) scenario.

The energy consumption in the transport sector in the BAU is analyzed by using an end-use model, called "Long-range Energy Alternative Planning system" or LEAP model. The LEAP model has been developed by the Stockholm Environment Institute (SEI), Boston centre and used to evaluate energy development policies in many countries [3].

This study aims at projection of energy demands and emissions in road transportation sector and analyzing the potential of scenarios of energy saving and substitution of the energy demands, and emissions reduction. The current energy situation is created in the starting year, 2005, and the BAU scenario is developed assuming a contribution of current trends. The planning period of the study is 2005-2020. The scenarios for long-range energy alternative planning in the transport sector are 1) fuel substitution such as policy on CNG, 2) new transport technology such as hybrid vehicles, and 3) improved fuel economy of the gasoline and diesel engines. Results of the analyses are presented in terms of energy use in transportation and potential of energy savings in each scenario.

Methodology

In order to forecast the energy demands and the emissions and to analyze the potential of scenarios for saving energy demands and reducing emissions, this study can be divided into two parts; the first part is the prediction of vehicle ownership. This part predicts the number of vehicles in each type from 2005 to 2020 by using the econometric analysis. The second part is the energy demands and the emissions forecasting

The concept of this study is the end-use analysis, by which the energy demands can be calculated from the products of two factors: the levels of the activity and the energy intensity. The level of the activity depends on socio-economic and the transportation factors, such as GDP, the number of vehicles, and the vehicle kilometers traveling. The level of the energy intensity depends on the energy efficiency of the vehicles such as fuel economy. The emissions of the vehicles can be calculated from the product of the energy demands and the emission factors, which depends on the technology of vehicles and the fuel types.

In order to examine the energy demands and the emissions in the concept of end-use analysis, this study employed the Long-range Energy Alternatives Planning (LEAP) model developed by the Stockholm Environmental Institute (SEI). This computer software contains the useful data for the calculation of the energy demands and the emissions such as the Technology and Environment

Database (TED), which is used to estimate the emissions from the energy utilization in different activities or sectors, i.e. transport sector.

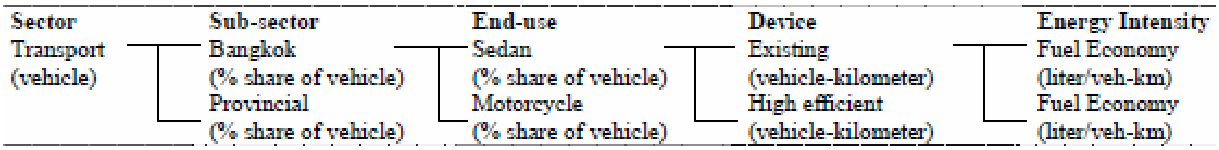

Fig .1 Example of tree structure in the energy demand module of LEAP model

The data used in this study are the numbers of registered vehicles obtained from Department of Land Transport (DLT) [4], and the number of population and GDP at the constant price obtained from National Economic and Social Development Board (NESDB) [2]. The framework for the calculation of the energy demands and the emissions are presented as follows.

Energy demand

The energy demand of the vehicle by fuel types is formulated as a function of the numbers of cars, the average vehicle kilometer mtraveling, the proportion of fuel types, and the fuel economy of cars. Therefore, total energy consumption of vehicle can be calculated by the following equation:

$$ED_i = NV \times VKT \times PV_i \times FE_i, \qquad (1)$$

where ED_i represents the energy demand of fuel type i (ktoe), NV is the number of vehicles (vehicle), VKT is the average vehicle kilometer traveling (kilometer), PV_i is the proportion of vehicle by fuel type i, FE_i is the fuel economy of fuel type i (liter/vehiclekilometer). The variables in equation (1) can be calculated as follows.

Level of activity

The activity levels of transportation can be represented by the number of vehicles and travel demand of vehicles which depend on population and GDP. The numbers of cars can be predicted from the car ownership model [5]. The growth of the car ownership is normally related to the growth of GDP. In this study, car ownership per capita can be estimated by using the following equation

$$NV = e^{a} GDP^{b} e^{(T^{t})} \times POP, \qquad (2)$$

where NV is the numbers of cars (vehicle), GDP is the gross domestic product at the 1988 constant prices (million baht), T is a time trend (T= 1 in 1989), POP is the population (person) and a, b and t denoted the coefficients in the model. The travel demand of the vehicle is an average distances that the vehicle has traveled in one year. It can be defined as the vehicle kilometer traveling (kilometer per year). The average distance travel of a sedan car used in this study is obtained from the study of Chanchaona, et al. [6], as shown in Table 2

Table 1 Average distance traveling of vehicles [7]

Vehicle type	Average Vehicle Kilometer Traveling (km/year)	
	Bangkok area	Provincial area
Sedan	15,634	14,071
Microbus & Passenger Van	20,947	20,947
Van & Pick Up	17,289	17,289
Motor tricycle	14,973	14,973
Urban Taxi	61,576	61,576
Fixed Route Taxi	19,257	19,257
Motor tricycle Taxi	33,012	14,071
Business Taxi	19,257	19,257
Motorcycle	5,627	5,627
Tractor	63,218	41,985
Fixed Route Bus	55,020	55,680
Non Fixed Route Bus	33,117	31,358
Private Bus	28,858	28,858
Small Rural Bus	-	41,985
Non Fixed Route Truck	31,102	65,242
Private Truck	29,608	57,022
Others	9,391	9,391

Normally, the types of fuel used in the road transport are classified into four main groups: gasoline, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG). The proportions of fuel used in vehicles are shown in Table 3.

Table 2 Fuel economy of the conventional vehicles by fuel typs

Vehicle Type	Proportion of Fuel Used by Vehicle (%)							
	Bangkok area				Provincial area			
	Gasoline	Diesel	LPG	CNG	Gasoline	Diesel	LPG	CNG
Sedan [a]	88.12	10.21	1.61	0.06	79.06	20.82	0.12	-
Microbus & SUVs [a]	15.98	83.94	0.08	-	9.52	90.40	0.08	-
Van & Pick Up [a]	5.68	94.29	0.03	-	8.24	91.70	0.06	-
Motor tricycle [a]	72.03	3.35	24.62	-	40.95	1.55	57.50	-
Urban Taxi [a]	22.67	0.26	73.29	3.78	79.56	18.40	2.04	-
Fixed Route Taxi [a]	96.65	0.04	3.31	-	97.45	2.55	-	-
Motor tricycle Taxi [a]	2.19	0.03	97.78	-	46.70	1.92	51.38	-
Business Taxi [a]	76.38	23.42	0.20	-	95.14	4.86	-	-
Motorcycle [b]	100.00	-	-	-	100.00	-	-	-
Tractor [b]	-	100.00	-	-	-	100.00	-	-
Fixed Route Bus [a]	-	99.94	0.06	-	-	98.05	1.95	-
Non Fixed Route Bus [a]	-	99.92	0.08	-	-	99.96	0.04	-
Private Bus [a]	-	100.00	-	-	-	100.00	-	-
Small Rural Bus [b]	-	-	-	-	-	99.89	0.11	-
Non Fixed Route Truck [b]	-	100.00	-	-	-	100.00	-	-
Private Truck [b]	-	100.00	-	-	-	100.00	-	-
Others [a]	0.26	99.74	-	-	5.38	94.62	-	-

Note [a] data from [4], [b] data from [6]

Fuel economy

Fuel economy is the average fuel consumption of a vehicle per vehicle-distance travel (liter/vehicle-kilometer). The fuel economy of vehicles is also obtained from the study of Chanchaona, et al and the estimation from this study, as shown in Table 3.

Table 3 Fuel economy of vehicle by fuel types [6]

Vehicle Type	Average Fuel Economy (liter/ vehicle-100 kilometer)							
	Bangkok area				Provincial area			
	Gasoline	Diesel	LPG	CNG *	Gasoline	Diesel	LPG	CNG
Sedan	8.5690	8.0257	10.3515 *	9.3402	8.7336	8.1235	10.0000	-
Microbus & SUVs	8.1235	7.2202	9.8134 *	8.8546	8.3195	8.2440	10.0501 *	-
Van & Pick Up	8.0515	7.3260	9.7264 *	8.7761	8.7413	8.2305	10.0000	-
Motor tricycle	8.3333	7.2907 *	7.1429	9.0833	8.3333	7.2907 *	7.1429	-
Urban Taxi	8.5985	7.5227 *	10.3872	9.3724	8.5985	7.5227 *	8.5985	-
Fixed Route Taxi	7.6923	6.7299 *	9.2925 *	8.3846	7.6923	6.6667	9.2925 *	-
Motor tricycle Taxi	8.0000	6.9991 *	8.7184	8.7200	5.6850	4.9738 *	8.7184	-
Business Taxi	8.5985	7.5227 *	8.5985	9.3724	8.5985	7.5227 *	8.5985 *	-
Motorcycle	4.0750	-	-	-	4.7551	-	-	-
Tractor	-	13.6612	-	-	-	13.6612	-	-
Fixed Route Bus	-	9.1659	12.6584 *	9.3663	-	9.1659	12.6584 *	-
Non Fixed Route Bus	-	9.5877	13.2409 *	9.7974	-	9.5877	13.2409 *	-
Private Bus	-	9.5420	13.1777 *	9.7507	-	9.5420	13.1777 *	-
Small Rural Bus	-	-	-	-	-	10.3199	14.3102 *	-
Non Fixed Route Truck	-	10.8696	-	11.1073	-	10.8696	-	-
Private Truck	-	12.5628	-	12.8375	-	12.5628	-	-
Others	7.2562 *	6.3492	-	7.1429	7.2562 *	6.3492	-	-

Note * Estimated by authors

Emission of vehicles

The emission of vehicle is the product of each type of the energy demand of the vehicles and their emission factors. It can be calculated as follows:

$$EM_{ij} = ED_i \times EF_{ij} \times GWP_j \times ECF \,, \qquad (3)$$

where EM_{ij} is the amount of the emission of substance j from fuel type i (kg CO_2 equivalent), ED_i is the energy demand of fuel type I (ktoe) which will be obtained from equation (1), EF_{ij} is the emission factors of substance j from fuel type i (kg/TJ), GWP_i is the emission conversion factors of substance j (kg CO2 equivalent/kg of substance), and *ECF* is an energy conversion factors (TJ/ktoe).

To estimate the environmental emissions of the energy consumption, the emission factors in this study are obtained from the Technology Environmental Database (TED). The considered emissions are the green house gases (GHGs), such as carbon dioxide (CO_2), nitrous dioxide (N_2O), and methane (CH_4). The emission factors in the TED module in LEAP are presented in the Table 4.

Table 4 Emissions factors used in the estimation [3]

Fuel Types of Sedan Car	Emission Factors (kg/TJ of energy consumed)		
	CO_2	N_2O	CH_4
Gasoline	68.65	0.6	20
Diesel	73.3	0.6	5
LPG	62.7	-	0.03
CNG	55.5	0.1	50

Global warming is an impact affecting the environment on the global scale. Normally, the quantities of GHGs can not be expressed or compared on a mass basis alone because of the differences in the properties and nature of gases. The Intergovernmental Panel on Climate Change (IPCC) presents global warming potentials (GWPs) for each individual GHG. The global warming potentials for each GHG are presented in Table 5.

Table 5 Global warming potential [8]

Substance	GWP (g CO_2/g substance)
CO_2	1
CH_4	62
N_2O	290

Scenarios
In order to analyze the potential of alternative scenarios to reduce the energy demands and the emissions in road transport, this study predicted the energy demands and the emissions of vehicle in road transport from 2005 to 2020 in the business as usual (BAU) scenario as the based case. For the alternative scenarios, it is assumed that in the future natural gas vehicle (NGV), hybrid cars and improved fuel economy of vehicle will be implemented.

Business as usual (BAU) scenario
In the BAU scenario, the number of vehicles is forecasted based on GDP. The based year is 2005. The travel demand can be calculated from the number of vehicles, average distance travel, as presented in Table 1, and the average fuel economy of each vehicle type, as presented in Table 3. In this scenario, the present efficiency of vehicle and the pattern of energy utilization of vehicleare unchanged from 2005 to 2020. The ongoing projects are not implemented and the environmental emissions are evaluated by using TED in the LEAP model.

Natural gas vehicle (NGV) scenario
In recent years, the Thai government tries to promote and implement the utilization of compressed natural gas (CNG) in the road transport. The CNG can be used in spark ignition (SI) engine, gasoline engine, and compress ignition (CI) engine, diesel engine. The CNG equipments are installed in the SI engine called bi-fuel engine and installed in the CI engine called diesel dual fuel (DDF) engine. In 2003, the PTT Public Co, Ltd., created the project of NGV in road transport vehicles in Bangkok Metropolitan area. In this project, the PTT is providing and supported the initial cost of CNG conversion equipment for vehicle which applied for the project. In this study, the NGV scenario considers the substitution of bi-fuel engine for SI engine such as sedan car, urban taxi, and substitution the CNG dedicated engine for CI engine such as fixed route buses, van and pickup in the Bangkok Metropolitan area. The penetration rate of NGV from 2005 to 2020 follows the 2005 plan of the PTT.

Hybrid car (HYB) scenario
A hybrid car is a new technology of passenger cars, which is the most efficient used-energy vehicle in road transportation. It presents the significant reduction of the fuel consumption and the emissions comparing to the conventional vehicles in the similar sizes of the vehicle. Nowadays, the hybrid car is used in several advanced countries, such as in the United Stated, the European Union, and Japan, particularly in urban areas, in order to reduce the emissions. In the hybrid cars scenario, we assumed that the hybrid cars will be substituted for the new conventional sedan with a market penetration rate of 15% of new sedan saturated in 2015. The period of the scenario starts from 2005 to 2020. The fuel economy of hybrid vehicle is 4.6954 liter gasoline/vehicle-100 kilometer [9].

Fuel economy improvement (FEI) scenario
The fuel economy is one of the important factors to reduce the energy demands and the emissions in road transport. Therefore, many countries, such as United Stated and Japan, used the fuel economy standards as the mechanisms in the energy conservation plan. There are three main methods for determining vehicle fuel economy standard. The first is a minimum standard value system, which all of

vehicles covered by this system should exceed standard values. The second is an average standard value system, which the average values of all vehicles covered by this system should exceed standard values. The third is called a maximum standard value system. Under this system, targets are set based on the value of the most energy-efficient vehicle in the market at the time of the value setting process. Currently, the most popular minimum standard value system in the world is the minimum energy efficiency standard, such as in U.S.

In this study, we assumed that Thai government will implement the minimum fuel economy standard programme to reduce energy demands and emissions. With this programme, the fuel economy of sedan and pickup should exceed the minimum fuel economy standard, as shown in Table 6.

Table 6 Fuel economy of new sedans and pickups in FEI scenario [9]

Vehicle Type	Average Fuel Economy (liter/vehicle-100 kilometer)	
	Gasoline	Diesel
Sedan	6.9013	-
Van and Pickup	-	5.8608

Results and Discussion

Business as usual scenario

From the forecasting models, the prediction presents that the number of vehicles increases from 27.0 million vehicles in 2005, to 30.8 million vehicles in 2010, to 36.4 million vehicles in 2015 and to 42.6 million vehicles in 2020 accounting for 3.5% annual growth rate, as presented in Table 7.

Table 7 Number of vehicles from the forecasting models in the BAU scenario

Vehicle Type	Number of Vehicles (vehicles)			
	2005	2010	2015	2020
Sedan	3,301,075	4,060,263	5,275,496	6,815,269
Microbus and Pickup	597,654	650,619	717,351	792,571
Van and Pickup	4,532,422	5,548,862	7,023,256	8,739,347
Motorcycle	17,360,525	19,200,326	21,927,490	24,655,073
Motortricycle	2,589	2,715	2,971	3,477
Urban Taxi	95,990	5,597	173,690	238,058
Motortricycle Taxi	37,620	32,125	25,254	20,538
Fixed Route Taxi	8,675	9,443	10,453	11,532
Business Taxi	2,878	3,265	3,793	4,354
Fixed Route Bus	77,168	78,138	77,693	75,762
Non Fixed Route Bus	25,312	29,190	34,165	39,629
Private Bus	10,252	11,963	14,214	16,677
Small Rural Bus	19,531	18,173	15,421	12,367
Non Fixed Route Truck	118,639	149,301	202,803	280,127
Private Truck	631,995	677,614	724,344	760,379
Tractor	102,286	101,817	98,038	92,017
Others	78,642	73,232	62,093	50,090
Total	**27,003,253**	**30,772,639**	**36,388,529**	**42,607,268**

In BAU scenario, for the energy demands, the prediction result presents that the total energy demand of road transport in the BAU scenario increases from 20,776 ktoe in 2005 to 34,386 ktoe in 2020, accounting for 3.4 % annual growth rate over 15 years. For the environmental impact, CO_2 emissions and others GHG emissions in terms of CO_2 equivalent (CO_2 eq) would increase from 80,147 thousand tons of CO_2 eq in 2005 to 146,876 thousand tons of CO_2 eq in 2020, as shown in Table 8.

Table 8 Energy demands and emissions of vehicles in the BAU scenario

Year	2005	2010	2015	2020
Energy Demands (ktoe)	20,776	24,627	29,150	34,386
Emissions (thousand tons of CO_2 eq)	80,147	98,024	119,967	146,876

Alternative scenarios

According to PTT plan, the prediction from the models presented the energy demands in NGV scenario would increase from 20,776 ktoe in 2005, to 34,365 ktoe in 2020. For the emissions, the prediction shows that the emissions of vehicles would be increased from 80,147 thousand tons of CO_2 eq in 2005 to 125,588 thousand tons of CO_2 eq in 2020, as illustrated in Table 9. From the results, the prediction show that the conventional transport fuel (gasoline, diesel and LPG) could be substituted by an alternative domestic fuel (CNG) by 1,032 ktoe in 2010, 1,894 ktoe in 2015 and 1,900 ktoe in 2020 in NGV scenario, accounting for 4.2%, 6.5% and 5.5%, respectively. For the environmental impact, the emissions could be reduced by 19.7% in 2010, 20.4% in 2015 and 14.5% in 2020 in the NGV scenario.

Table 9 Comparison of energy demands and emissions between BAU scenario and NGV scenario

	Energy Demand (ktoe)				Emissions (thousand ton of CO_2 eq)			
Scenarios	2005	2010	2015	2020	2005	2010	2015	2020
BAU Scenario								
LPG	343	464	624	838	19,069	25,766	34,646	46,513
Gasoline	6,644	7,946	9,595	11,498	19,250	23,020	27,799	33,313
Diesel	13,772	16,194	18,899	22,007	41,790	49,184	57,447	66,948
CNG	16	23	31	43	39	54	75	102
Total	**20,776**	**24,627**	**29,150**	**34,386**	**80,147**	**98,024**	**119,967**	**146,876**
NGV Scenario								
LPG	343	105	172	447	19,069	5,844	9,528	24,828
Gasoline	6,644	7,767	9,289	11,186	19,250	22,502	26,911	32,407
Diesel	13,772	15,713	17,766	20,790	41,790	47,930	54,447	63,743
CNG	16	1,055	1,926	1,943	39	2,502	4,571	4,610
Total	**20,776**	**24,640**	**29,152**	**34,365**	**80,147**	**78,778**	**95,456**	**125,588**

The energy demands and the emissions of all scenarios are shown in Table 10. The hybrid car scenario would be able to reduce energy demand of vehicle in road transport accounting for 0.4%, 0.8% and 1.0% comparing to the BAU scenario in 2010, 2015 and 2020, respectively; whereas, the fuel economy improvement scenario would be able to reduce energy demand accounting for 0.6%, 3.5% and 5.7% in 2010, 2015 and 2020, respectively.

For the emissions, the prediction presented that the hybrid car scenario, would be able to reduce the emission, accounting for 0.4%, 0.8% and 0.9% in 2010, 2015 and 2020, respectively. The fuel economy improvement scenario would be able to reduce the emissions of vehicle, compared to the BAU scenario, accounting for 0.4%, 2.5% and 4.0% in 2010, 2015 and 2020, respectively

Table 10 Comparison of energy demands and emissions in the BAU scenarios

Scenarios	Energy Demands (ktoe)				Emissions of Vehicles (thousand tons of CO_2 eq)			
	2005	2010	2015	2020	2005	2010	2015	2020
BAU Scenario	20,776	24,627	29,150	34,386	80,147	98,024	119,967	146,876
NGV Scenario	20,776	24,640	29,152	34,365	80,147	78,778	95,456	125,588
HYB Scenario	20,776	24,534	28,929	34,053	80,147	97,642	119,053	145,487
FEI Scenario	20,776	24,485	28,131	32,425	80,147	97,606	116,924	141,008

Conclusion

By using the forecasting models, this study examined the number of vehicles, the energy demands and the emissions in road transport in Thailand from 2005 to 2020. The results presented that the number of vehicles in road transport is 27.0 million vehicles in 2005 and increases to 42.6 million vehicles in 2020, accounting for 3.5% annual growth rate. Due to the increasing of the vehicles in road transport, the energy demands will increase from 20,776 ktoe in 2005 to 34,386 ktoe in 2020, accounting for 3.4% annual growth rate. The emission in terms of CO_2 equivalent in the transport sector would increase from 80.1 million tons of CO_2 eq in 2005 to 146.9 million tons of CO_2 eq in 2020.

Based on the scenario analysis, the prediction models presented that, in the NGV scenario, CNG could be substituted for conventional fuel by 1,032 ktoe in 2010, 1,894 ktoe in 2015 and 1,900 ktoe in 2020. The emissions in this scenario would increase from 84.15 million tons of CO_2 eq in 2005 to 125.7 million tons of CO_2 eq in 2020. In comparison to the BAU scenario, this scenario could be reducing the emissions by 19.7% in 2010, 20.4% in 2015 and 14.5% in 2020.

In addition, in the hybrid scenario, energy demand would increase from 20,776 ktoe in 2005 to 34,053 ktoe in 2020, accounting for 3.3% average annual growth rate and the emissions will increase from 80.1 million tons of CO_2 eq in 2005 to 145.5 million tons of CO_2 eq in 202. This scenario could reduce energy demands by 0.4%, 0.8% and 1.0% in 2010, 2015 and 2020, respectively, and could reduce CO_2emissions by 0.4%, 0.8% and 0.9% in 2010, 2015 and 2020, respectively.

In the fuel economy improvement scenario, energy demand would increase from 20,776 ktoe in 2005 to 32,425 ktoe in 2020, accounting for 3.0% average annual growth rate. The emissions in this scenario are 80.1 million tons of CO_2 eq in 2005 and 141.0 million tons of CO_2eq in 2020. This scenario could reduce energy demands by 0.6%, 3.5% and 5.7 % in 2010, 2015 and 2020, respectively, and could reduce CO_2 emissions by 0.4%, 2.5% and 4.0% in 2010, 2015 and 2020, respectively.

Thus, the FEI scenario has the highest potential to reduce energy demand in road transport, accounting for 5.7% in 2020, whereas, the NGV scenario has the highest potential to reduce the CO_2 emissions, accounting for 20.3% in 2015 and 14.4% in 2020.

According to the results of this study, therefore, the fuel economy improvement scenario has the highest potential strategies to reduce the energy demands comparing to the hybrid car scenario. However, to reduce the emissions and to substitute the conventional fuel with domestic energy sources, the NGV scenario should be implemented.

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