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Forecasting of Renewable Energy Demand and Supply of Thailand

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ABSTRACT

This paper presents the long-term energy consumption and renewable energy supply in Thai economic sectors; i.e. agriculture, construction and mining (ACM) sector, manufacturing sector, transport sector, household sector and service sector, by using both bottom-up MAED and top-down MESSAGE models. Three main scenarios, focused on energy demand and supply including energy-related CO_2 emission, with the base year of 2005 to 2030 have developed in this study which comprises Business-as-usual (BAU), energy efficiency (EE) and long-term national renewable energy development (REDP) scenarios. Under the BAU scenario, manufacturing sector have the main share at 38.38% of the energy consumption followed by transport, household, service, and ACM sector, respectively, while the EE scenario has the same trend with the BAU. Under the REDP scenario, with 8% share of renewable energy in final energy consumption, the share of biomass would increase with 0.01% compared with the BAU in 2030. Manufacturing and transport sector are the main targets for biomass applications in Thailand especially in biofuel production and steam generation or heating processes. This implies that if the world oil petroleum prices fall, the biofuel consumption would then decrease from fuel switching and the price subsidization from government in ethanol or biodiesel may still be required for keeping the biofuel proportion as in national REDP. Under the supply case, in 2573 found that Thailand will share the electricity from combined cycle power plants together accounted for 55.72%, followed by thermal power plants, coal and lignite power plants and renewable energy power plants accounted for less than 0.01. While the EE and REDP scenarios have the same trend with the BAU. In the case evaluation in CO_2 emissions from power generation. The year 2573 found that the combined cycle power plants accounted for 54.38% followed by thermal power plants and found that renewable energy power plants will reduce emissions of CO_2 0.002%. In case of renewable energy supply, domestic plantation is sufficient for overall biomass production under REDP. However, due to the limited land, research for higher yield and the agreement with neighborhood countries for plantation should be strongly considered for long-term biomass production.

Keywords: Long-term renewable energy demand and supply, MAED, MESSAGE, Thailand

1. INTRODUCTION.

Thailand has acquired more alternative energy resources to reduce oil import. The government has promoted and supported on biofuel consumption by blending with gasoline and diesel issued for gasohol, biodiesel (B2 and B5). During 2007, Department of Alternative Energy development and efficiency (DEDE) began to disseminate biofuel data and information in this publication. Commercial energy consumption, which comprises petroleum products, natural gas, coal & its products, and electricity, increased 1.6%, and new & renewable energy, including fuel wood, charcoal, paddy husk, and bagasse, increased 5.3%.

As an energy imported country, Thailand requires carefully examining of the relationships between energy and other implications in the long-term. This is necessary for assisting the government to decide the best pathways for country's prosperity. A number of long-term energy modeling studies have been conducted to examine the energy impacts in Thailand. However, they are solely focused on specific energy sectors, and specific analyses. This paper would examine the integrating technical, economic, environmental dimensions of energy sector development in Thailand based on renewable energy schemes.

2. METHODOLOGY

2.1 Energy demand model

To analyze the future development of the Thailand energy and electricity demand the computer program Model for Analysis of Energy and Electricity Demand (MAED) has been applied. The general approach of MAED relies upon the end-use methodology that was originally developed at IEJE of the University of Grenoble and known as MEDEE-2. Respecting the general structure of MEDEE-2, the International Atomic Energy Agency (IAEA) developed the present MAED model by introducing important modifications concerning the parameters required to be specified as input data, the equations used for calculating energy demand of some sectors, and some additional modules dealt with the analysis of hourly electricity consumption to construct the so-called load duration curve of the power system [1].

2.2 Energy supply model

Another purpose of this paper is to determine the most appropriate technological and resource configuration to meet long-term energy needs of the nation under a set of pre-specified constraints. There has, over the years, been significant effort at developing such models by energy researchers around the world. The main energy optimization models are Model for Energy Supply Strategy Alternatives and their General Environmental impacts (MESSAGE) and others, based on the principle of Reference Energy System (RES). For this research, the selected optimization model for MESSAGE. It was originally developed by the International Institute for Applied System Analysis (IIASA), and IAEA. The underlying principal of MESSAGE is the optimization of an objective function under a set of constraints that define the feasible option containing all possible solutions of the problem. This model is designed to formulate and evaluate alternative energy supply strategies consonant with a set of policies, for example, limits on fuel availability, energy trade, market penetration rates, and environmental profiles. [2]

2.3 Long-term energy scenarios

This paper proposes three alternative long-term scenarios, namely, (i) Business-as-usual (BAU), (ii) Energy efficiency (EE) scenario with 5% higher energy efficiency improvement in manufacturing, transportation and household sector, (iii) long-term national renewable energy development plan (REDP) scenarios with 4.8% manufacturing sector and 1.9% transportation sector. All three scenarios, BAU, EE, and REDP are based on different sets of technologies, constraints and policies

2.4 Data

The main data for BAU, EE, and REDP comprise energy demand, technologies, technological constraints, environmental profiles, and policy regulations. MAED requires data on economy, demography, energy consumption [3], [4], [5], [6] and [7]. While MESSAGE requires data [8] on technological efficiencies, technical life time, investment cost, fixed cost and related activity and capacity boundaries. These parameters are required in the MESSAGE in order to optimize the energy investment decisions by finding the least-cost supply solution in long-term.

2.5 RES specification

The RES development is the core requirement for energy impact analysis. RES represents the current energy flows in the country from extraction, conversion, transmission and distribution, to final conversion for end users. The RES of Thailand – developed in this paper consists of 5 energy forms, namely, resources, primary energy, secondary energy, final energy, and end-users. The RES has 66 technologies in the system. The demand analyzed in this study includes 5 mainly economic sectors, which are industry, agriculture, transport, household and service sector. The main energy types and technologies in this RES are based on Thailand's 2005 energy balance. The updated technological data, this RES is likely to show all of the latest energy technologies in the energy system. It also separates the economic sector into the sub-sectors, for example, industry is separated into light industry and heavy industry, reflecting relative intensiveness of energy consumption of these two sub-sectors.

3. RESULTS AND DISCUSSION

3.1 Business-as-usual scenario

3.1.1 Final energy demand by energy form

The final energy demand by energy would increase from 62.36 Mtoe in 2005 to 154.34 Mtoe in 2030 in BAU scenario. This is approximately increased with 6.15 % per year annual average growth rate. In 2030 the results also suggest that motor fuels would have the main share with 42.70% of total final energy demand by energy form, this is followed by fossil fuels at 23.24%, electricity at 20.31%, modern biomass at 7.36% and traditional fuels with 6.06% of final energy demand by energy form, respectively, as shown in figure 1.

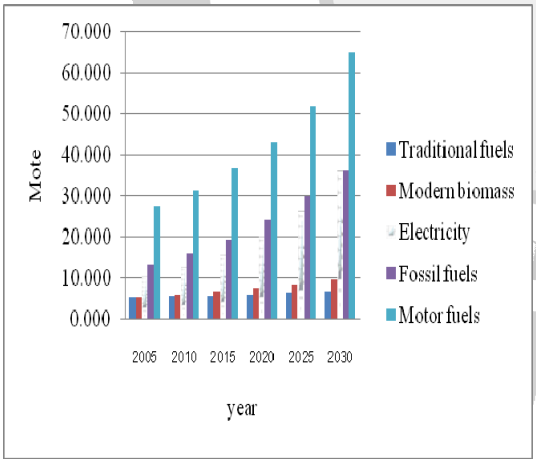

Fig. 1 Final energy demand by energy form in BAU scenario; 2005-2030

3.1.2 Final energy demand by sector

The final energy demand by sector would increase from 62.36 Mtoe in the year 2005 to 154.34 Mtoe in 2030 in BAU scenario. This is approximately increased with 6.15 % per year annual average growth rate. In 2030 the results also suggest that manufacturing sector would have the main share with 38.38% of total energy consumption, this is followed by transportation sector with 34.26%, household sector with 12.99%, service sector with 7.24% and ACM (agriculture, construction and mining) sector with 6.78% of final energy demand by sector, respectively, as shown in figure 2.

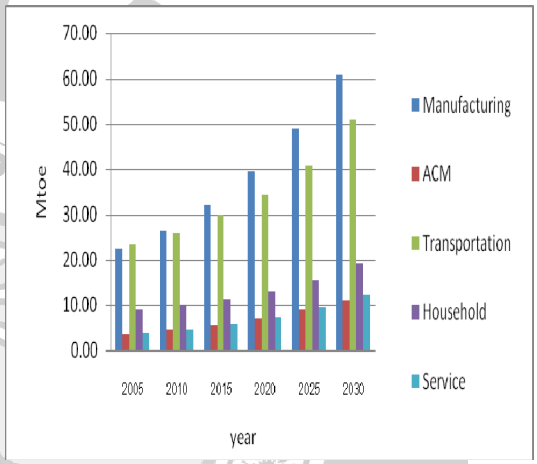

Fig. 2 Final energy demand by sector in BAU scenario; 2005-2030

3.1.3 Electricity demand by sector

The Electricity demand by sector would increase from 10.42 Mtoe to 36.18 Mtoe in 2005 and 2030, respectively. The average annual growth rate of the electricity demand by sector increases by 10.30% per year. In 2030, the manufacturing sector would have the highest shares in electricity demand by sector, accounted for 48% of total electricity demand by sector, while the service sector with 29%, household sector with 18%, transport sector with 4% and ACM with 1% of electricity demand by sector, respectively, as shown in figure 4.

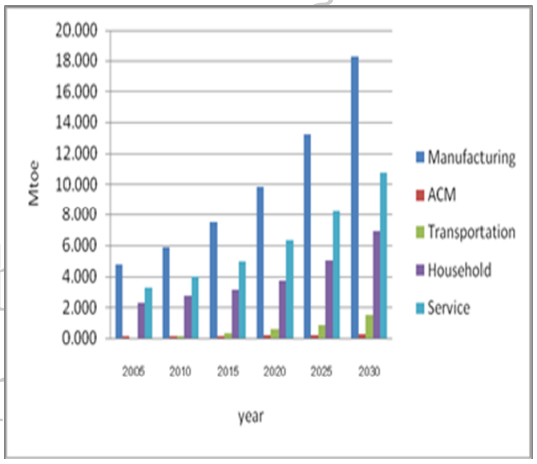

Fig. 3 Electricity by sector in BAU scenario; 2005-2030

3.2 Energy efficiency scenario

The final energy demand would increase from 62.36 Mtoe in 2005 to 148.70 Mtoe in 2030 in EE scenario. This is approximately increased with 5.77% per year annual average growth rate. From figure 4 and 5 in 2030, presents the comparisons between each scenario in term final energy demand by energy form, final energy demand by sector. The results show fossil fuels and modern biomass EE scenario decrease fossil fuels BAU scenario from 36.16 Mtoe to 34.67 Mtoe, modern biomass BAU scenario from 9.72 Mtoe to 9.34 Mtoe. This is approximately decreased with 0.17% per year and 0.16% per year annual average growth rate. In manufacturing sector of EE scenario decrease from BAU scenario from 60.87 Mtoe to 59.01 Mtoe. This is approximately decreased with 0.13% per year annual average growth rate. In transportation sector motor fuels EE scenario decrease motor fuels BAU scenario from 65.27 Mtoe to 62.74 Mtoe. This is approximately decreased with 0.16% per year annual average growth rate and transportation sector of EE scenario decrease from BAU scenario from 51.08 Mtoe to 48.55 Mtoe. This is approximately decreased with 0.21% per year annual average growth rate. In household sector EE scenario decrease tradition fuels, modern biomass, electricity and fossil fuels BAU form 6.99, 9.72, 36.18 and 36.16 Mtoe to 6.74, 9.62, 35.62 and 36.01 Mtoe respectively. This is approximately decreased with 0.15% per year, 0.04% per year, 0.06% per year and 0.02% per year annual average growth rate and household sector of EE scenario decrease from BAU scenario from 19.13 Mtoe to 18.01 Mtoe. This is approximately decreased with 0.24% per year annual average growth rate.

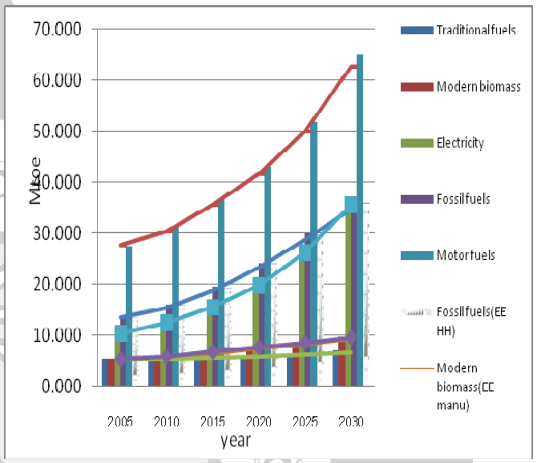

Fig. 4 Final energy demand by energy form in EE scenario; 2005-2030

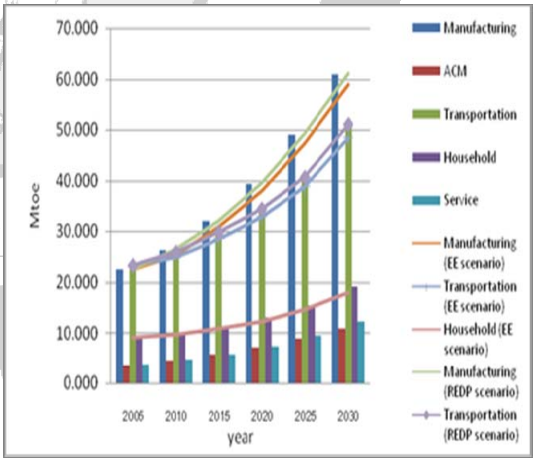

Fig. 5 Final energy demand by sector in EE scenario; 2005-2030

3.3 Long-term National Renewable Energy Development Plan scenario

The final energy demand in REDP would increase from 62.36 Mtoe in 2005 to 154.52 Mtoe in 2030. This is approximately increased with 6.16% per year annual average growth rate. From figure 5 and 6 presents in 2030, the comparisons between each scenario in term final energy demand by energy form and final energy demand by sector. In manufacturing sector of REDP scenario increase from BAU scenario from 61.05 Mtoe to 60.87 Mtoe. This is approximately increased with less than 0.01% per year annual average growth rate, the results show modern biomass REDP scenario increase modern biomass BAU scenario from 9.72 Mtoe

to 10.05 Mtoe and fossil fuels decrease from 36.16 Mtoe to 30.01 Mtoe. This is approximately increased with 0.13% per year and decrease with 0.02% per year annual average growth rate and transportation sector of REDP scenario increase from BAU scenario from 65.27 Mtoe to 65.28 Mtoe. This is approximately increased with less than 0.01% per year annual average growth rate.

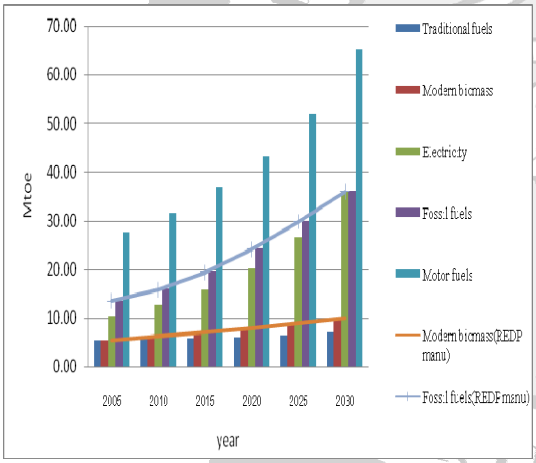

Fig. 6 Final energy demand by energy form in REDP scenario; 2005-2030

3.4 Expected Electricity production

From the supply using MESSAGE in BAU scenario, this requires a Discount rate for adjusti ng the exchange is 10% and considers without load region during of 2005-2030 years. From figure 7 presents power generation systems in th e year 2005 produced 15,596.73 MWyr producti on increased in the year 2030 to 46,793.17 MW yr. This is approximately increased with 8.33% per year annual average growth rate. In 2573 ma in power system from combine cycle power plants produce 31,694.2 MWyr, followed by. is t he thermal power plants 17,988.8 MWyr, coal and lignite power plants 2,979 MWyr cogenerati on power plants 2,841.3 MWyr, fuel oil power plants 972.1 MWyr, hydro power plants 644 M Wyr, electricity imports 887.4 MWyr, gas turbin e power plants produce 266.4 MWyr, renewable energy power plants 0.5 MWyr, respectively, of the power generation

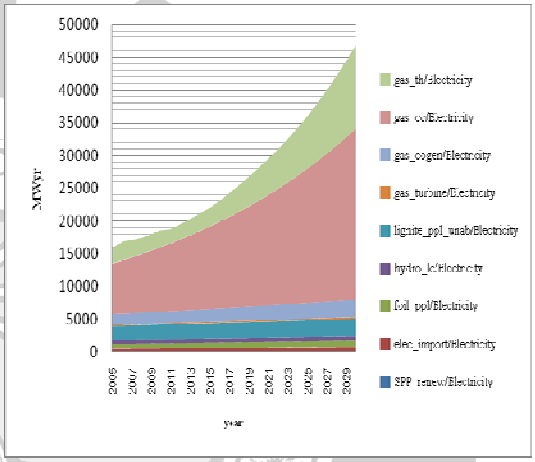

Fig. 7 Expected Electricity production; 2005-2030

3.5 CO_2 emission

Emissions of CO_2 increased from the year 2548 from 76.58 Mtons-CO_2-e to 213.56 Mtons-CO_2-e. In 2573 CO_2 emissions from combine cycle power plants together with the maximum 116.14 Mtons-CO_2-e, followed by coal and lignite power plants 26.39 Mtons-CO_2-e, thermal power plant 51.59 Mtons-CO_2-e in 2573, cogeneration power plants 11.29 Mtons-CO_2-e, fuel oil power plants 6.70 Mtons-CO_2-e, gas turbine power plants 1.44 Mtons-CO_2-e and renewable energy power plants 0.01 Mtons-CO_2-e in 2573, as shown in figure 2.

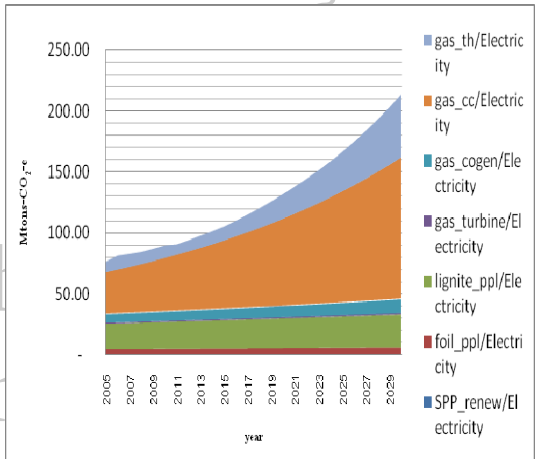

Fig. 8 CO_2 emission; 2005-2030

4. CONCLUSIONS

This study focuses on the forecast of energy demand and supply in Thailand during long period, from 2005 to 2030, by using MAED and

MESSAGE with three scenarios; the BAU, Energy efficiency and long-term national renewable energy development scenarios. The re sults from all scenarios are in the similar trend o f energy demand from 2005 to 2030 in BAU sce nario. In the year 2030, the manufacturing sector would have the highest shares in energy consumption followed by transport sector, service sector, household sector and agriculture-construction-mining sector respectively, and the main power supply sector would have the highest shares from combined power plants followed by thermal power plants, coal and lignite power plants, cogeneration power plants, fuel oil power plants, hydro power plants, electricity import, gas turbine power plants and renewable energy power plants, CO_2 emission from combine cycle power plants together with the maximum, followed by thermal power plants, coal and lignite power plants, cogeneration power plants, fuel oil power plants, gas turbine power plants and renewable energy power plants.

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REFERENCES

[1] International Atomic Energy Agency. (2006) Users' Manual for Version MAED-2, International Atomic Energy Agency, Vienna, Austria.
[2] International Atomic Energy Agency. (2007) Users' Manual for MESSAGE, International Atomic Energy Agency, Vienna, Austria.
[3] DEDE. (2005) Thailand Energy Situation 2005, Department of Energy Development and promotion, Ministry of Energy, Bangkok, Thailand.
[4] DEDE. (2005) Electric Power in Thailand 2005, Department of Energy Development and promotion, Ministry of Energy, Bangkok, Thailand.
[5] DEDE. (2005) Oil and Thailand 2005, Department of Energy Development and promotion, Ministry of Energy, Bangkok, Thailand.
[6] DEDE. (2005) Thailand Energy Situation 2005, Department of Energy Development and promotion, Ministry of Energy, Bangkok, Thailand.
[7] NESDB. (2005) The NESDB has reclassified the GDP by industry to be followed the Thailand Standard, National Economic and Social Development Board, Bangkok, Thailand.
[8] Integriertes Ressourcen Management (IRM-AG). (2007). "Interim Report Developing the Greater Mekong Subregion Energy Strategy", Asian Development Bank, Vienna, Austria