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Energy Efficiency Improvement and CO_2 Mitigation in Residential Sector: Comparison between Indonesia and Thailand

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Abstract

This paper presents energy efficiency improvement and CO_2 mitigation in the residential sector between Indonesia and Thailand. The Long-range Energy Alternative Planning (LEAP) model was used to analyze future energy demand and CO_2 emissions during 2010-2050. This study applied the Demand Side Management (DSM) options to reduce CO_2 emissions in the residential sector by implementing energy efficiency improvements such as efficient lighting, cooking, cooling and entertainment devices. The results indicate that in the business as usual (BAU) scenarios between 2010 and 2050, for Indonesia the energy demand will increase from 18147 ktoe in 2010 to 36044 ktoe in 2050. By adopting these scenarios, energy will be saved by 27.6% of total energy demand in 2050 while cumulative CO_2 emission can be reduced by 16% of overall CO_2 emissions in 2050. For Thailand, the energy demand will increase from 1879.1 ktoe in 2010 to 3167.8 ktoe in 2050. The energy will be save by 15.5% of total energy demand in 2050 and cumulative CO_2 emission can be reduced by 13.36% of overall CO_2 emission in 2050.

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Keywords: LEAP model; Energy Efficiency; CO_2 mitigation; Residential Sector.

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1. Introduction

Electricity is a basic energy to supply energy in each sector. The electricity production is undesirable emission and environmental effects. The existence of carbon emissions can lead to climate change. Climate change is a global issue that started to be a topic of conversation in the world since 1992. Law No. 6 1994 was ratified by Indonesia in the convention on climate change. It needs to maintain a stable concentration of greenhouse gases (GHGs) and objective of the convention GHGs in the atmosphere thus ensuring food security and sustainable development [1]. The meeting resulted in the Kyoto Protocol regulating GHGs emissions due to human activities so that its concentration in the atmosphere is stable and does not harm the earth's climate system. This protocol contains an obligation for developed countries called Annex I countries to reduce emissions by 5% from1990 levels during 2008-2012 [2]. While developing countries are entering into the Non-Annex I countries, they are not obliged to reduce emissions such as Indonesia and Thailand. In Asia several countries were developed low carbon Asia research projects. The program will be run in accordance with the country regulation for an Asia and national action plan for reducing CO_2. Therefore, the objective of this study is to prepare for the sustainable development in the residential sector which are energy consumption and CO_2 emitting in Indonesia and Thailand. In this study, the LEAP model, developed by Stockholm Environment Institute, is employed to estimate energy demand and CO_2 emissions in addiction to asses CO_2 mitigation from four mitigation measures, the option considered includes: (1) efficient lighting devices, (2) efficient cooking devices, (3) efficient cooling devices and (4) efficient entertainment devices.

2. Energy use and CO_2 mitigation in Indonesia and Thailand

Energy is important for living. Many people need energy to fulfil the energy demand. Every year primary energy production and consumption increased because energy demand also increased. Energy production refers to form of primary energy as crude oil, natural gas, coal, waste, electricity and combustible renewable. In 2010, the primary energy production in the world produced by 12.8 million kg of oil equivalent and 12.5 million kg of oil equivalent was consumed [3]. Oil mining in Indonesia has probably peaked and decreased, that it had to improve energy resource and develop new plant. Oil is dominated in the energy production mix by 52%, followed by gas by 29%. Indonesia's energy consumption has been grown by 7% per year and the electrification rate is around 60% [4]. The final energy supply dominated by fossil fuel by 75% share in the final energy consumption. Then the utilities of new and renewable energy had not been optimized. Due to its high production cost, there are subsidy policies on liquid petroleum gas (LPG) and fuel oil [5].

In 2011, primary energy supply in Thailand was about 128,092 ktoe with an average growth rate of 6.74% per year. The final energy consumption by economic sectors, transportation, industrial, residential and agriculture by 70,562 ktoe with an average growth rate of 5.35% per year [6]. The most energy consuming sectors are transport, industry and residential sectors, respectively. In the residential sector, energy consumption was 11,040 ktoe and accounted for 15.6% of final energy consumption in 2011. The low carbon scenario in the residential sector, named "Thai style comfortable", includes efficiency improvement of lighting, heating, cooking, cooling, entertainment, and other system [7]. In Thailand, CO_2 emissions in the residential and building sectors were estimated about 7222 kt-CO_2 in 2011 at 5.35% average annual growth rate. It increased due to improvement of electricity activities for advanced technology [8].

The relevant climate change issue for Indonesia is become among the most important carbon emitters from energy consumption [9]. Thailand also facing challenge in energy-environment-economy development in the context of limited energy resources availability and global climate change. The CO_2 emission from energy consumption during 2000-2010 increased from 263.42 Mt-CO_2 in 2000 to 433.99

Mt-CO_2 in 2010 for Indonesia, and 188.35 Mt-CO_2 in 2000 to 295.28 Mt-CO_2 in 2010 for Thailand [3]. CO_2 mitigation in the residential sector considered includes substitution of fluorescent lamps, compact fluorescent lamps and LED for incandescent lamps, improvement of refrigeration and air conditioning efficiency, and substitution of LPG stove for kerosene stoves [10].

3. Methodology

A study of energy planning and polices is prepared by forecasting energy demand in the Business as Usual (BAU) case, and calculate energy supply required to meet energy demand. The residential sector was analysed with efficiency improvement of appliances. The methodology of the research study can be best described as follows: (i) data collection (statistical reports, reviews of research papers, official government plan, and online database), (ii) development of energy models for the residential sector by using LEAP, (iii) formulate energy efficiency scenario, (iv) comparative study of scenarios, and (v) evaluation of CO_2 emissions.

The residential sector consists of 4 service categories, which are lighting, cooking, cooling and entertainment. The services are provided by service categories. This study considers the mitigation potential in the residential sector. The model would select types of appliances in order to satisfy the service demand and minimize the energy consumption of scenarios including energy efficiency improvement.

In the residential sector, four mitigation measures are efficient lighting devices, efficient cooking devices, efficient cooling devices and efficient entertainment devices. The proposed efficient technology are to obtain energy saving and CO_2 mitigation during 2010-2050. Regarding the proposed penetration rate of particular technologies as follows:

Lighting system
Lighting is the most important end use to reducing energy consumption in the residential sector. The options considered include: (i) conventional lighting appliances, which is fully replaced in 2030, and (ii) compact Fluorescent Lamp, which will share 4 about 20% and 50% of total lighting in 2030 and 2050, respectively.

Cooking system
Conventional cooking appliances are fully replaced with high efficiency appliance corresponding to particular service type in 2030.

Cooling system
Refrigerators and air conditioners are the target for efficiency improvement, since their electricity use is growing rapidly. The options considered include: (i) efficiency improvement of refrigerators, and (ii) efficiency improvement of air conditioning systems.

Entertainment g system
Television appliances are fully replaced with high efficiency appliance corresponding to particular service type in 2030.

4. Result and discussion

4.1. Energy Demand in BAU Scenario

The increasing energy demand in the BAU scenario of Indonesia is presented in Fig. 1(a) total energy demand increased from 18147.7 ktoe in the base year to 36043.6 ktoe in 2050. The energy demand will

increase about 50% in 2050 when compared with the base year. In Thailand, total energy demand was 1879.1 ktoe in 2010 and will increase to 3167.8 ktoe in 2050, Fig. 1(b) it increases about 41% when compared with base year. The energy demand in Indonesia is higher than Thailand because its population is larger than Thailand. In 2010 population in Indonesia was about 237.6 million with 60.9 million households and it will increase to 423 million with 108.5 million households in 2050. In 2010 the population in Thailand was about 66.4 million with 22.8 million households and it will increase to 74.9 million with 38.4 households in 2050.

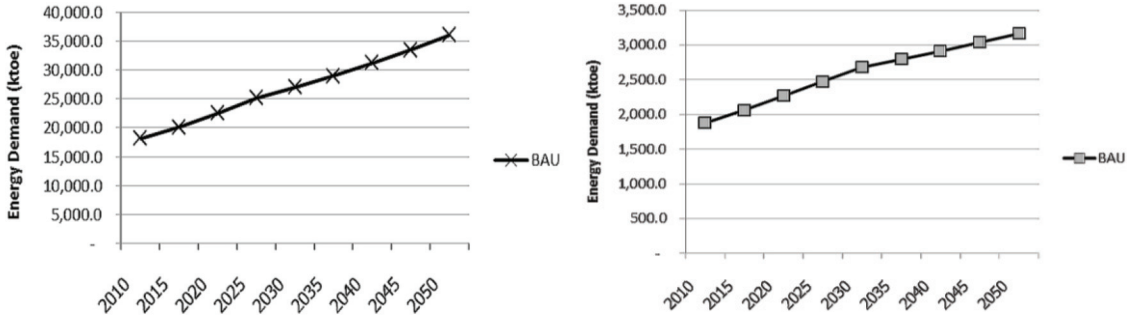

Fig. 1. (a). energy demand BAU scenario in Indonesia; (b) energy demand BAU scenario in Thailand

4.2. Total Energy Demand in the Residential Sector

The BPPT (The Assessment and Application Technology Agency) in Indonesia project [11] has provided roadmap of energy saving technologies such as substitution of LPG for kerosene, gas and efficient electric appliances. Removal of kerosene and incandescent lamp with high efficient lighting appliances as CFL, LED, and improved air conditioners, refrigerators and TV, all of these will save energy by 25% in 2030 when compared with the BAU. In the energy efficiency scenario savings will be about 27.6% when compared with the BAU in 2050.

In Thailand, efficient cooking devices can save up to 20% of energy demand in the residential sector in 2030 [12]; in the modern building scenario with efficiency improvement of appliances savings will be about 45% in 2050 (BAU: 19729 ktoe, Efficiency Scenario: 11758 ktoe) [7]. The measures are almost the same with BPPT such as switching from traditional biomass/wood and kerosene to efficient cooking stoves. In the energy efficiency scenario of Indonesia, savings in 2050 will be about 15.5% when compared with the BAU. The total energy demands in both countries are presented in Fig. 2.

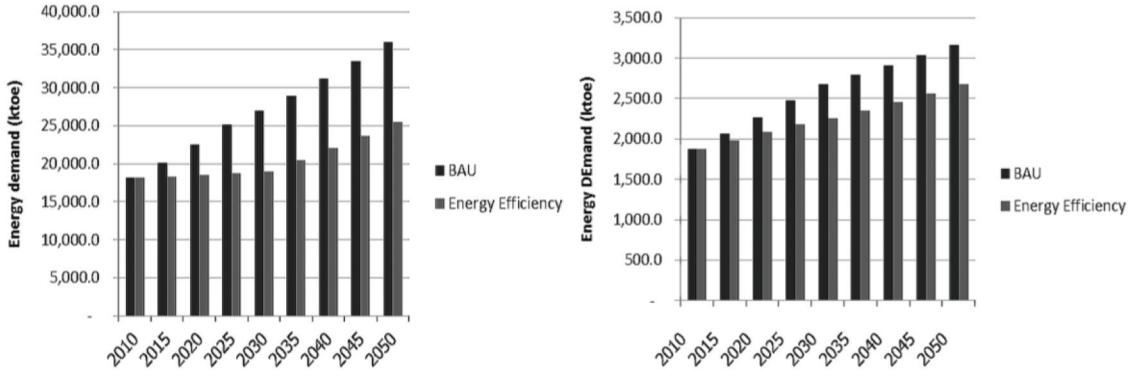

Fig. 2. (a). total energy demand in Indonesia; (b) total energy demand in Thailand.

The energy efficiency scenario shows that electricity access will increase in 2050 (see Fig. 3). In Indonesia the electricity utilization will be increased by 43.82% from 2010-2050 in the BAU scenario. In Energy efficiency scenario the cumulative electricity access will increase about 12.42% when compared with the BAU scenario, from 124.7 TWh in 2010 to 189.9 TWh in 2050., In the BAU scenario, the electricity access in Thailand will increase by 40.68% from 2010-2050. In energy efficiency scenario the total electricity access will increase about 12.9% when compared with the BAU scenario, from 12.5 TWh in 2010 to 17.7 TWh in 2050. The Electricity access in Indonesia is increase faster than Thailand because in 2020 the electrification in Indonesia will be 100% [11].

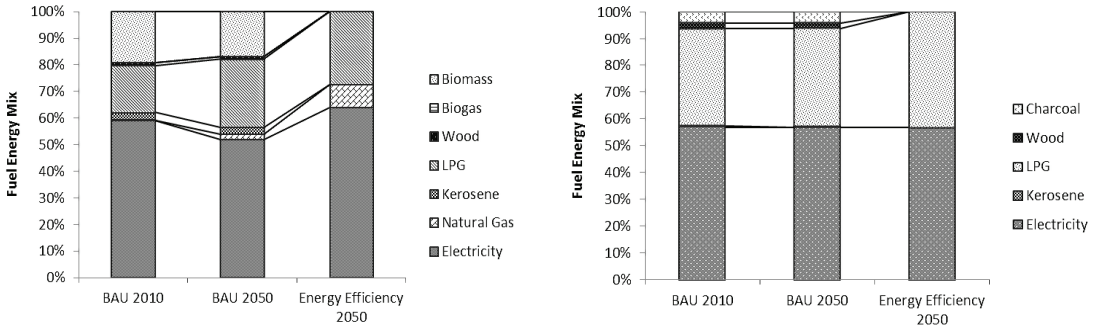

Fig. 3. (a). fuel energy mix in Indonesia; (b) fuel energy mix in Thailand

4.3. CO_2 Emission

The Total CO_2 emission result can be presented in Fig. 4(a) for Indonesia and Fig. 4(b) for Thailand. In Indonesia in the BAU scenario, energy demand comes from cooking, cooling, entertainment, and lighting devices. CO_2 emissions of electrified and non-electrified residential are accounted by 12.6 million tons in 2010 and is expected to increase to 33.9 million tons in 2050. CO_2 emissions will be increased by 2.5 times during 2010-2050. In the energy efficiency scenario, CO_2 emissions will be increased by 17%, in 2050, to 28.2 million tons. The cumulative CO_2 emissions reduction during 2010-2050 will be about 16% when compared with the BAU scenario. In the residential sector in Thailand, CO_2 emission was about 1.9 million tons in 2010 and will increase to 3.3 million tons in 2050. In the energy efficiency scenario, CO_2 emissions will increase to 2.7 million tons, and accounted for 16.91%, in 2050. Cumulative CO_2 emission reduction will reach 13.36% when compared with the BAU scenario from 2010-2050.

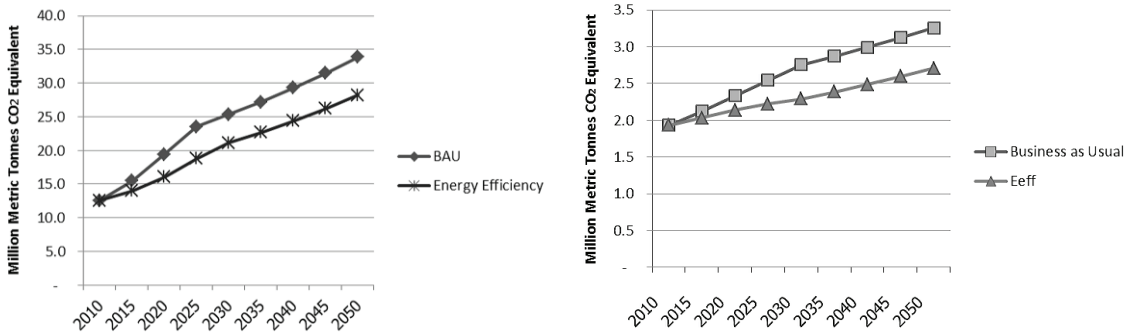

Fig. 4. (a). total CO_2 emission in Indonesia; (b) total CO_2 emission in Thailand

5. Conclusion

Energy consumption in Indonesia and Thailand residential sector, urban electrification for households and energy efficiency scenario was modeled by using the LEAP model. As a reference, a Business as Usual scenario (BAU) was also formulated to forecast the growth of energy demand without increasing electrification rates. Results show that in 2050 in the BAU scenario Indonesian and Thailand energy demand will be accounted for 36043.6 ktoe and 3167.8 ktoe, respectively. The LEAP model also suggested that increasing and decreasing energy demands are due to electrification and efficient appliances implementation in the residential sector. In the energy efficiency scenario the total electricity access in Indonesia will increase about 12.42% when compared with the BAU scenario, from 124.7 TWh in 2010 to 189.9 TWh in 2050. Similar with Indonesia, in energy efficiency scenario the total electricity access will be increased by 12.9% when compared with the BAU scenario, from 12.5 TWh in 2010 to 17.7 TWh in 2050. Implementing energy efficiency appliances can save energy about 27.6% for Indonesia and 15.5% for Thailand in 2050.

In Indonesia, during 2010–2050 the cumulative emissions in the energy efficiency scenario will reach 839.5 million tons CO_2. In the BAU scenario, without electrification and improvement of energy efficiency appliances, the cumulative CO_2 emission would reach 997.3 million tons. The cumulative CO_2 emission reduction will reach 16% when compared with the BAU scenario from 2010-2050. In Thailand during 2010–2050, the cumulative CO_2 emissions in the energy efficiency scenario will reach 94.7 million tons. In the BAU scenario without electrification and improvement of energy efficiency appliances, the cumulative CO_2 emission would each 109.3 million tons in the BAU scenario. The cumulative CO_2 emission reduction during 2010-2050 will reach 13.36% when compared with the BAU scenario.

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