Effectiveness of promoting energy efficiency in Thailand -- the case of air conditioners

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Effectiveness of Promoting Energy Efficiency in Thailand: the Case of Air Conditioners

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Abstract

This paper aims to identify the magnitude of energy efficiency improvement, which has been promoted through energy efficiency labeling and the Minimum Energy Performance Standard, and to compare this against the increase in the number of products and the average increase in cooling capacity. Air conditioners (ACs) are one of the major contributors to energy consumption in a household. To assess the magnitude of this factor, we developed a formula to decompose total energy consumption from ACs into the number of ACs, their average cooling capacity, and energy efficiency. In the case of ACs in Thailand, energy efficiency improvement has offset the increase in the average AC cooling capacity. However, energy consumption from ACs increases with the number of ACs.

Keywords: Energy Efficiency, Standard and Labeling, Thailand
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Abstract

This paper aims to identify the magnitude of energy efficiency improvement, which has been promoted through energy efficiency labeling and the Minimum Energy Performance Standard, and to compare this against the increase in the number of products and the average increase in cooling capacity. Air conditioners (ACs) are one of the major contributors to energy consumption in a household. To assess the magnitude of this factor, we developed a formula to decompose total energy consumption from ACs into the number of ACs, their average cooling capacity, and energy efficiency. In the case of ACs in Thailand, energy efficiency improvement has offset the increase in the average AC cooling capacity. However, energy consumption from ACs increases with the number of ACs.

Introduction

Thailand is the only country in Southeast Asia that has maintained an energy efficiency labeling program since the 1990s. In 1992, the Energy Conservation Promotion Act was promulgated. In the mid-1990s, Thailand began its labeling program for energy efficient products. This program was initiated by the Electricity Generating Authority of Thailand (EGAT). The World Bank and other donors supported the initial stage of this program. The impact of the program has been analyzed in several studies including by the World Bank (2006) and Asawutmangkul (2012). These studies show estimations of energy consumption reduction.

This paper aims to identify the magnitude of improvements in energy efficiency in energy consumption from air conditioners (ACs) and to compare this against the increase in the number of products in use and the increase in average cooling capacity. ACs are one of the major contributors to energy consumption in a household. To compare the magnitude of this factor, we developed a formula to decompose total energy consumption from ACs into the number of ACs, average cooling capacity, and energy efficiency. The first section outlines efforts to promote energy-efficient products in

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Thailand and discusses some previous studies on energy efficiency in Thailand. In Section 2, efforts for improving energy efficiency, such as energy efficiency labeling, the Minimum Energy Efficiency Standards (MEPS), and the High Energy Efficiency Standards (HEPS) for ACs in Thailand, are described. Section 3 presents the data sources, methodology, and results that explain the energy consumption from ACs.

Section 1. Energy Efficiency Policy and Programs in Thailand

The government of Thailand promulgated the Energy Conservation Promotion Act in 1992. This act covers energy conservation in factories, buildings, machinery, equipment, and materials. ACs are listed as one of the specific methods of building energy efficiency in Part 2 of the Act, which requires the government to create energy efficiency standards for various types of equipment. Part 3 of the Act covers energy conservation in equipment and machinery and the promotion of energy-efficient material. It also states that the government has the responsibility to set energy efficiency standards for equipment, machines, and materials. ACs are not mentioned as one of the scheduled items for which the government should set an equipment standard. The Energy Conservation Promotion Act was amended in 2007. In Part 3 of the amended Act, the government is required to create standards related to energy efficiency under the Thailand Industrial Standards (TIS).

In response to the Energy Conservation Promotion Act of 1992, the World Bank conducted a cooperation program from 1993 to 2000 with the Thailand Promotion of Electricity Energy Efficiency. In this program, compact fluorescent lamps and thin fluorescent lamps were promoted. In addition, energy efficiency labeling for electrical products, such as refrigerators and ACs, was introduced. Japan's Overseas Economic Cooperation Fund also supported the energy efficiency program in Thailand. Since 2000, the energy conservation label system has been operating, supported by the budget of the national government and EGAT.

In the labeling program, depending on energy-saving performance, products are classified into five levels, with Level 5 products having the highest level of energy efficiency. EGAT issues the labels to the manufacturers. Whether manufacturers attach labels or not is optional (it is not a mandatory program). As a result, from the beginning, lower-rating-level labels such as levels 1 and 2 have not been issued. Labels 3 and 4 were issued in the first few years. For refrigerators, label 3 was issued from 1995 to 1997 and label 4 was issued from 1995 to 1998. Regarding ACs, label 4 was issued from 1996 to 1998. Since then, only a level 5 label has been issued.

The World Bank (2006) estimated the effect of its energy efficiency program on total

energy consumption. It assumed the following in its estimation of the program: constant sales volume and average energy efficiency before and after the program. As part of the program, pilot Energy Service Company (ESCO) projects and demonstration projects for the improvement of energy efficiency of small and medium-sized enterprises were conducted. However, these pilot projects did not have significant impacts (World Bank, 2006). Compared to the assumed the virtual case where energy-saving performance was not improved, energy efficiency improvement of equipment saved 6,030 Gwh in 2004. Among them, lighting equipment, refrigerators, and ACs accounted for 25.8%, 42.9%, and 31.3%, respectively. The bank also projected that the amount of saved power would represent 13,117 GwH in 2010. Of that, lighting would contribute 20.1% and refrigerators and ACs would account for 39.6% and 40.1 %, respectively.

The Department of Alternative Energy Development and Efficiency (DEDE) – established in 2002, along with the Thailand Industrial Standard Institute (TISI) and other organizations—is responsible to set the MEPS and HEPS. DEDE has also conducted an energy efficiency labeling program for products other than electronic appliances. The program was started in 2007, targeting four products, the LPG stove, a variable speed drive, glazing, and insulating materials.

MEPS can be mandatory or voluntary. In the case of mandatory MEPS, products need to satisfy these standards when they are sold in the market. Products that do not satisfy the MEPS are not allowed to be sold. In the voluntary program, if a product satisfies MEPS, it can attach an endorsement-type label, defined as the TIS. Under the TIS, MEPS have been formulated for household refrigerators, room ACs, self-blasted lamps, double-capped fluorescent lamps, and single-capped fluorescent lamps. Both mandatory and voluntary MEPS are aimed at promoting the sales of energy-efficient products.

Under the TIS, MEPS for room ACs were developed in 2002 and became compulsory standards in March 2005. Furthermore, under the TIS, MEPS for refrigerators were created in 2004, becoming mandatory in December 2006.

While MEPS focus on reducing the demand of energy inefficient ACs, HEPS intend to stimulate the development and demand of higher energy performance products. As an ordinance of the Ministry of Energy, in March 2009, HEPS for eight products, including water heaters, window glass, chillers, electric kettles, refrigerators, ACs, fans, and rice cookers, were created.

Section 2. Institutional Change toward Improvement of Energy Efficiency of ACs

Regarding the share of AC household power consumption in Thailand, two estimates exist. Sangsawang (2010) estimated that ACs account for 6% of the power consumption

in the household sector. On the other hand, Vongsoasup (2010) estimated that ACs contribute 19% in the household sector, whereas commercial ACs account for 50–65%.

The World Bank (2006) estimated that, in 2004, the amount of energy saving through the improvement of energy efficiency of ACs reached 1,888 Gwh, which is equivalent to 70% of the refrigerator market. It also projected that the amount of power reduction by improvement of energy efficiency of ACs would reach 5,237 Gwh in 2010, exceeding the improvement in energy efficiency of refrigerators. Asawutmangkul (2013) estimated that the energy reduction from energy efficiency in various products would reach 16,635 Gwh, with ACs contributing 44% or 7,313.2 Gwh.

The two main methods established to improve energy efficiency of ACs are energy efficiency labeling and MEPS. Energy efficiency labeling was introduced in 1996 and mandatory MEPS were introduced in 2005, more than 10 years after the labeling program.

Energy efficiency labeling provides information on annual energy consumption, the energy efficiency ratio (EER), and the annual electricity charge. Annual energy consumption is calculated with the assumption that an AC is operated eight hours every day, and the annual electricity charge is calculated with the assumption of 3.28 Baht per watt.

The levels of energy efficiency labeling were revised in 2006 and again in 2011. In 2006, level 5 of the EER(in terms of Btu/hr/W) was revised from 10.6 to 11.0. In 2011, while the EER for ACs over 8000 watt cooling capacity was left as is, the EER for ACs at or below 8,000 watt cooling capacity was revised to 11.6. The revision in 2006 was decided after one manufacturer advertised that the energy efficiency level of their products reached beyond level 5 labeling. Therefore, there was the possibility that the advertisement will weaken the effectiveness of level 5 labeling.

Measurement methods and levels of MEPS for ACs were defined in the TIS standard in 2002. On March 11, 2005, MEPS became mandatory. The TIS also indicated that the MEPS from 2002 for specific ACs were scheduled to be revised upward in 2006. In 2010, the MEPS for the separated types of ACs increased to 9.6 Btu/hr/W (2.82 W/W), while those for both the window type and separated type of ACs below 8000 watt cooling capacity were unchanged at 9.6 Btu/hr/W (2.82 W/W). The MEPS for window type ACs between 8001 and 12000 watt cooling capacity were also unchanged at 8.6 Btu/hr/W (2.53 W/W).

Table 1　MEPS　(Units: W/W)

	Cooling Capacity	2002–2005	2006–2010	2010–
Window Type	Below 8000 W	2.53	2.82	2.82
	8000 W to12000 W	2.53	2.53	2.53
Separate type	Below 8000 W	2.82	2.82	2.82
	8000 W to 12000 W	2.53	2.53	2.82

Source : Compiled from TIS2134-2545 and TIS2134-2553。

In addition, the HEPS, which have been in place since 2009, were set at 3.22 for all ACs below 12000 W. The HEPS are supposed to be set at the top 20% in terms of energy efficiency in that reference year (Vonsoasup, 2012). If a product satisfies the HEPS, it can be attached with a voluntary certification label(endorsement type label).

On the other hand, the lower limit of the Level 5 energy efficiency rating from 1996 was 10.6 Btu/hr/W (= 3.12W/W). This was revised to 11.0 Btu/hr/W (= 3.22 W/W) in 2006. In December 2011, this was further revised to 11.6 Btu/hr/W (= 3.41 W/W) for ACs below 8000 W cooling capacity.

When HEPS was enacted, criteria of energy efficiency for Level 5 labeling was at the same level as the HEPS standard. However, after Level 5 was revised in 2011, the HEPS value was lower than the criteria for Level 5.

In developed countries such as Japan, the inverter AC is very common. To measure the energy efficiency of the inverter AC, Annual Performance Factor, which takes into account the intermediate load of the AC, began to be used in Japan. However, Thailand only uses the coefficient of performance, which is not adequate to evaluate the inverter AC. Thailand is now preparing to apply alternative evaluation methods.

Section 3　Dissemination of ACs and energy consumption

This section estimates the energy consumption of ACs based on AC sales data and the number of energy efficiency labels issued by EGAT from 1996 to 2011. In addition, it argues the impact of energy efficiency policy including energy efficiency labeling and MEPS.

In Thailand, the possession rate of ACs is still low. It is still the era of distribution of ACs . Table 2 shows AC penetration rates, in other words, the percentage of households that have at least one AC. Only 3.7% and 10 .6% of households had ACs in 1990 and 2000, respectively. This penetration increased to 19.8% in 2010. Moreover, in urban areas, the penetration rate reached 30.7% in 2010, whereas only 9.8% of the rural households had ACs. Looking at the penetration rate in Japan, 3.9% and 9.3% of the

households had ACs in 1968 and in 1972, respectively. This rose to 19.5% in 1976. Compared to Japan, the speed of penetration in Thailand is slow. AC penetration rates in Thailand are at the same level as those in the late 1970s in Japan.

Table 2　Penetration Rates of ACs（%）

	1990	2000	2010
National	3.7	10.6	19.8
Urban	15.3	24.8	30.7
Rural	0.9	3.7	9.8

Source: National Statistical Office (1992), (2002), (2012).

Table 3 shows the estimated number of ACs per 100 households. In 1990, there were 5.3 AC units for every 100 households. In 2000, the estimate was 16.6 AC units for every 100 households. Based on the total number of households in Thailand, the number of ACs was estimated at 0.652 and 2.635 million in 1990 and 2000, respectively.

Table 3　Number of ACs per 100 Households

	1990	2000	2010
National	5.3	16.6	n.a.
Urban	23.1	40.1	n.a.
Rural	1.1	4.9	n.a.

Note: Based on the data from the National Statistical Office (1992), (2002), the number of ACs per 100 households is estimated. Original data for 1990 included the number of households that had one, two, three, four, five, six, seven, and more than eight ACs. In addition, the data for 2000 included the number of households that had one, two, three, four, five, six, and seven or more ACs. For both years, the number of ACs per 100 households was estimated by assuming that the average number of households having more than seven ACs was eight.

Figure 1 shows the number of energy efficiency labels issued by EGAT and domestic unit sales of ACs. As mentioned in Section 1, only the level 5 energy efficiency label was issued after 1999. The number of Level 4 issued labels was 20,000 in 1996 and 10,000 in 1997 and 1998. The unit sales of ACs severely dropped in 1997–1998, during the Asian economic crisis, and in 2009, during the recession triggered by the Lehman shock. In addition, the issuance of energy-saving labels decreased in 2007 and 2008. This was due to the revision of the criteria for Level 5 labeling at the end of 2006.

According to the estimation of the energy-saving effect from the World Bank (2006), mentioned in Section 1, the bank assumed that the number of Level 5 labels would be 0.92 million in 2010, whereas the actual number turned out to be 2.22 million. Therefore, it can be presumed that there has been a greater reduction of energy consumption than the World Bank (2006) expected.

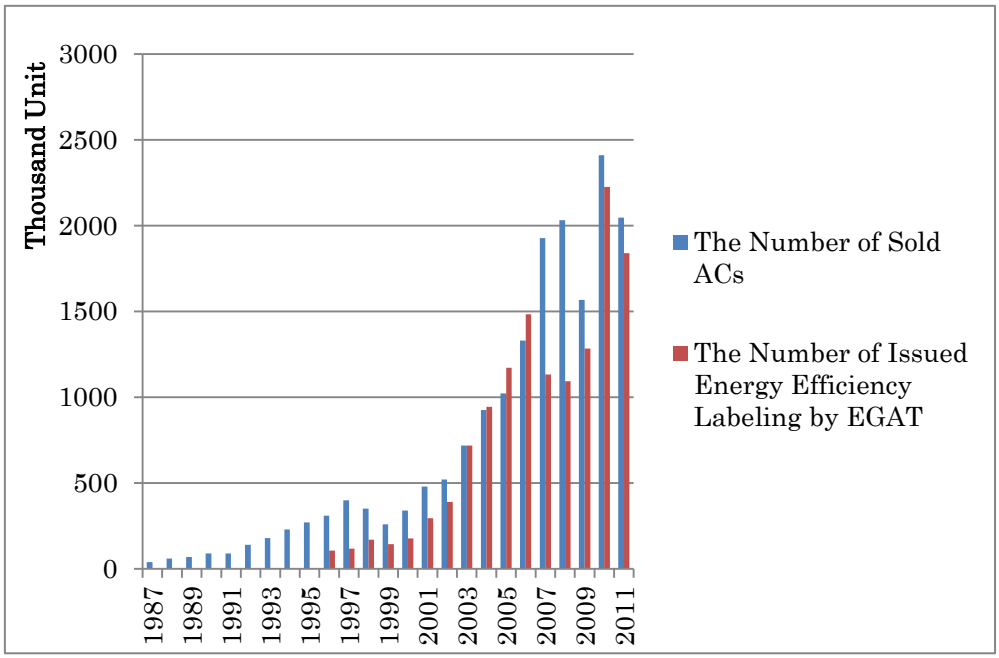
Comparing domestic unit sales and the number of energy efficiency labels issued, the share of energy efficiency labeling was about 30% of sold units in the initial years. Gradually, this share increased. During 2004–2006, the number of energy efficiency labels issued exceeded the number of ACs sold in Thailand. There were three reasons for this. The MEPS were defined in 2002 and became mandatory in 2005. As a result, manufacturers might stop the production of ACs with lower energy efficiency ratings. Another reason might be the fact that the consumer awareness of energy efficiency labeling increased as it became common for manufacturers to attach energy efficiency labeling. This was also verified in a consumer awareness survey by JETRO (2011). When consumers were asked, on a seven-point evaluation, of the importance of energy efficiency labeling in their purchase of an AC, 67.7% chose "very important" and 23.4% chose “important.” In total, as per the evaluation, more than 90% of consumers considered energy efficiency labeling when purchasing an AC. The third reason was the Level 5 labels was issued by EGAT, based on the request of manufacturers, before they actually sold their product. Manufacturer might have overestimated the volume of sales of ACs with Level 5 labels.

In 2004, almost all ACs sold in the market were affixed with Level 5 energy efficiency labeling. This no longer fulfilled the intention of the labelling. This contributed to the revision of the criteria of Level 5 labeling in December 2006, which became effective in 2007. In 2007 and 2008, ACs that did not satisfy the criteria of Level 5 labeling were sold with old label or without label. The percentage of Level 5 issued labels to total unit sales was less than 60%. The hottest season in Thailand is April. Manufacturers usually put out new models two or three months before April. In that year, they did not have much time to meet the new criteria for Level 5 labeling as it takes about two years for a manufacturer to design a new model, procure parts, and assemble the AC. As a result, 40% of the ACs were sold without the revised Level 5 labeling in 2007 and 2008.

In the previous section, we compared the lower limit value of Level 5 labeling and the HEPS. The HEPS are supposed to be set to cover the top 20% of the models in terms of energy efficiency. The HEPS were the same as the criteria for Label 5 labeling during 2009–2011. In this period, the ratio of Level 5 labeled ACs to total unit sales was more than 80%. The HEPS are too low for their original purpose to promote

higher-energy-efficiency ACs.

Figure 1　Number of Domestic Unit Sales and Issued Labels for ACs



Source: From Data compiled by the Electrical and Electronics Institute (Thailand) and JETRO Bangkok Center (2004).

Among the number of issued energy efficiency labels, the number of inverter ACs represented 1.79% in 2006 and increased to 6.65% in 2011 (Vongsoasup, 2012). In Thailand, the inverter AC penetration rate is still low. However, its market share is gradually increasing.

Changes in the energy consumption from ACs sold each year can be decomposed into operating time per unit, cooling capacity per unit, energy efficiency, and number of ACs.

$$\text{Total Energy Consumption from AC} = \text{Operating hours per unit of AC} \times \text{the Number of ACs} \times \text{cooling capacity per unit of ACs} \times \text{Reciprocal of Energy Efficiency Rate}$$

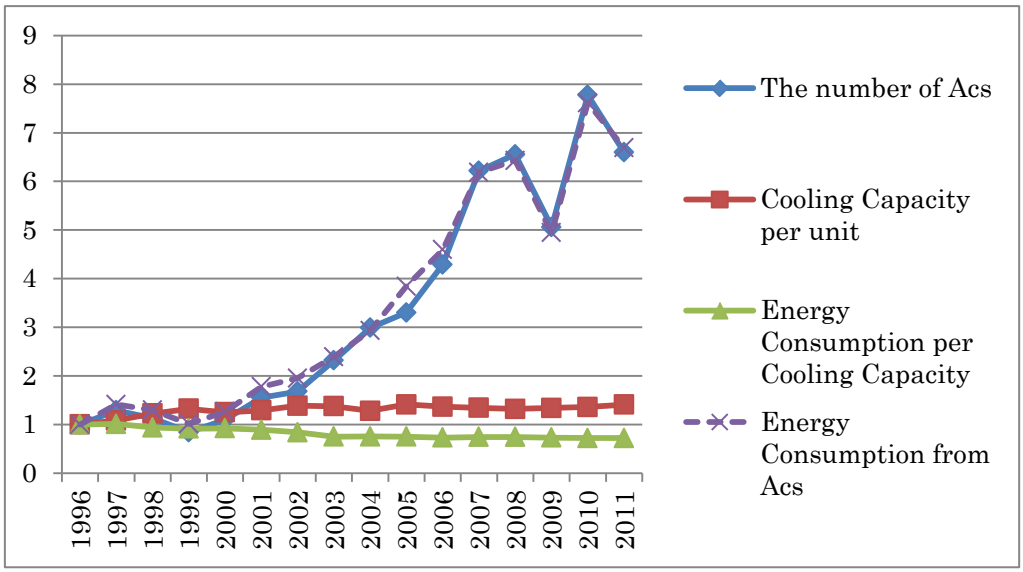
$$= \text{Operating Hours per unit of AC} \times \text{the Number of ACs} \times \left(\frac{\text{Total Cooling Capacity}}{\text{the Number of ACs}}\right) \times \left\langle\frac{\text{Energy Consumption}}{\text{Cooling Capacity}}\right\rangle$$

To calculate an index that explains the contribution of these factors to total energy consumption, we assume the following for missing data.

1) We assume that the average operating hours have been constant because we do not have data on average operating hour for every year.
2) For non-labeled ACs before 2003, EER is assumed to be 7.4, per the World Bank's (2006) estimation of energy efficiency of non-labeled ACs in 1995. In addition, based on 2007, we assumed 10.8 as the median of the criteria of label 4 (10.6 to 11.0).

Figure 2 shows the decomposition index of energy consumption from ACs sold in each year. The base year is set at 1996. Unit sales of ACs dramatically increased over time. This number increased more than nine times from 1999 to 2010. Energy efficiency also improved by about 30% from 1996 to 2011. Meanwhile, cooling capacity increased by 40%. Energy efficiency improvement offset the increase in cooling capacity per AC unit. However, total energy consumption from ACs increased dramatically as a result of the increase in the number of units sold in the market.

Figure 2　Decomposition Index of Energy Consumption from ACs Sold Each Year

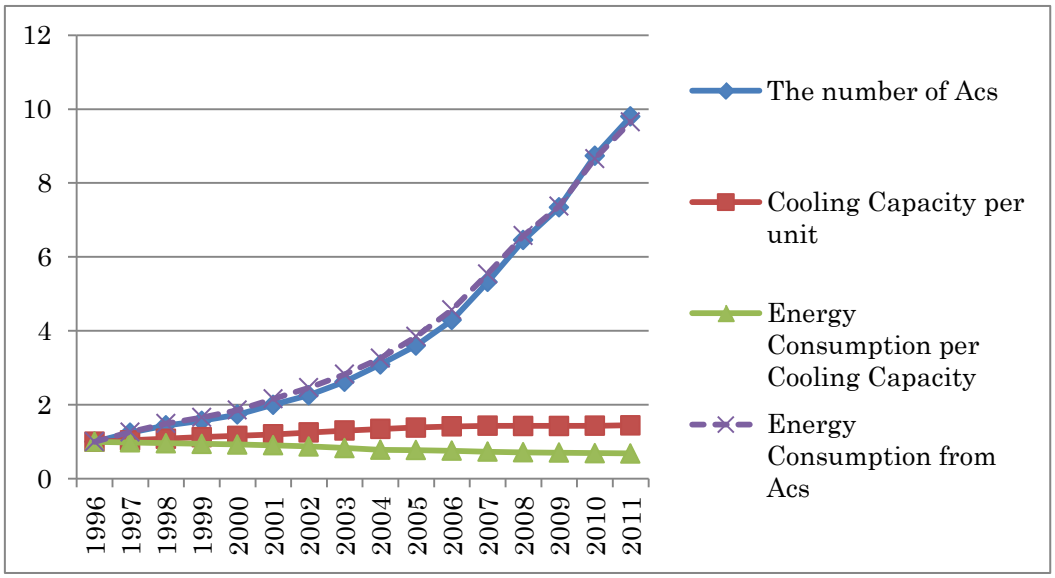


Source：Compiled by authors.

To estimate total energy consumption from ACs, we need information on the durability of ACs. The JETRO Bangkok Center (2004) estimated that the durability of an inside AC unit is 9.24 years and that of an outdoor unit is 8.85 years, based on a survey of small workshops dismantling ACs. On the other hand, using the number of ACs per 100

households in 1990 and 2000 and the unit sales of ACs, mentioned in Section 2, an AC is disposed after 9.02 years on average. Under the assumption that the durability of an AC is 9 years, the index, which explains the contribution to total energy consumption from the stock of ACs, is estimated as shown in Figure 3. The base year is set at 1996. The increase in energy efficiency (reduction in energy consumption per cooling capacity) is greater than 30%. Thus, energy efficiency improved. However, the reduction of energy consumption only offset the increase in cooling capacity. As the number of ACs increased, the energy consumption also increased.

Figure 3 Decomposition Index of Energy Consumption from Stock of ACs



Source: Compiled by Authors.

Conclusion

Thailand has begun efforts to improve energy efficiency, including the promotion of energy-efficient lighting, refrigerators, ACs, and other equipment since 1990s. In fact, consumers are well aware of energy efficiency labeling. Manufacturers also have been eager to put such labels on their products. AC energy efficiency has also significantly improved. However, the number of ACs has also increased rapidly. Thus, energy efficiency improvement has been offset by the increase in average cooling capacity of ACs. However, energy consumption from ACs also increases along with increase in the number of ACs.

If energy efficiency had not improved in Thailand, energy consumption from ACs would have been 1.4 times what it was in 2011. Most developing countries are in the process of diffusing energy consuming equipment including ACs. Taking into account the

durability of these products, energy efficiency improvement is crucial to preventing climate change and to reducing the continued investment in the power sector. Developing countries need to start an MEPS program and energy efficiency labeling as soon as possible.

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