IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2022, 12(4), 10-14.

EJ EconJournals

Decomposition Analysis of Energy Consumption in Thailand, 1990-2020

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Received: 14 February 2022 **Accepted:** 16 May 2022 **DOI:** https://doi.org/10.32479/ijeep.13047

ABSTRACT

Thailand is a net energy importer that has steadily increased the demand for energy over the past several decades. But there has not been a systematic analysis of the energy demand change factors. Therefore, in this study, a decomposition analysis was applied to determine the major driving forces of the changes in energy use from the years 1990-2020. The analysis period covered a regional financial crisis known in Thailand as the "Tom Yum Kung" crisis in 1997-1998 and a global pandemic COVID-19 in 2020. The analysis results showed that the value-added of economic sectors is the most important factor in requiring more energy, while energy intensity is the most important factor in reducing energy consumption. Therefore, increasing the value-added of productions and enhancing the energy efficiency more stringent will lead to a decoupling of energy consumption against GDP and sooner peak demand of energy in Thailand.

Keywords: Decomposition analysis; Energy consumption; Economic structure; Value-added; Energy intensity; Thailand
JEL Classifications: C41, O14, P28, P51, Q43

1. INTRODUCTION

Like other emerging countries, Thailand's energy demand has been growing rapidly during the past decades. This causes critical challenges for Thailand such as energy security, environmental problems, and climate change. Since Thailand has a very limited energy resource, more than half of the energy supply is imported. In 2020, Thailand imported energy with 777 billion Thai Baht (accounting for 5.0% of gross domestic product [GDP]) which was reduced by 34.6% from the previous year, due to COVID-19 (Energy Policy and Planning Office, Ministry of Energy, 2021). Moreover, Thailand's indigenous resources; proved natural gas and oil will be depleted within 3.8 and 2.2 years, respectively (Department of Mineral Fuels, Ministry of Energy, 2020). Recently, Thailand's Prime Minister Prayut Chan-o-cha announced at COP26 that Thailand will accelerate greenhouse gas mitigation targets, joining global communities in keeping the global temperature rise below 1.5°C to tackle the climate crisis. Thailand aims to reach carbon neutrality by 2050, and net-zero greenhouse gas emissions by or before 2065. Therefore, it is an urgent issue for Thailand to utilize energy more efficiently and minimize its environmental effects. An investigation to find the causes of energy demand rise over the past decades is vitally needed.

The decomposition method is one of the favorite approaches to analyzing energy use, for example, Reitler et al. (1987), Park (1992), and Yilmaz and Atak (2010). This method is suitable for analyzing to know the key factors that are important to change in energy consumption. By this method, the country can implement appropriate policies and measures to increase energy security and reduce the environmental impact and climate change problems. Recently, Hariwan et al. (2021) adopted a decomposition method to assess the energy efficiency of the manufacturing industry sectors in Indonesia. This method identified the significant sub-sectors of the industry that affect energy demand. However, the study showed effects from only three main components: activity, structural, and energy intensity (EI). The combined effect between the three components was not investigated. Whereas this study tried to capture all effects including pairs of these main components and joint effect of the three components.

Decomposition analysis can be categorized into several techniques namely Index Decomposition Analysis (IDA), Structural Decomposition Analysis (SDA), and Production-theoretical Decomposition Analysis (PDA) (Kouyakhi and Shavvalpour, 2021; Yang et al., 2022). IDA was widely used to identify driving factors of energy consumption and CO_2 emissions in recent years (Li et al., 2021; Ozturk et al., 2021; Lu et al., 2022). The advantage of IDA is a time-efficient method, and it does not require highly detailed economic data (Wang et al., 2020). While the SDA approach is based on the input-output model in quantitative economics and the data requirement is relatively higher. Therefore, the application of IDA is more extensive compared to SDA (Zhang and Da, 2013). The PDA is considerably a new branch of decomposition analysis that is used to capture changes in an aggregate indicator within a framework of productive efficiency, which is different from IDA and SDA (Wang et al., 2018). Recently, there are attempts to incorporate IDA and PDA methods to investigate the decoupling between economic growth and CO_2 emissions, Liu and Feng (2021), and Yang et al. (2022).

This study obtained data from several government agencies: the final energy consumption by sector from the Department of Alternative Energy Development and Efficiency, Ministry of Energy (DEDE, 2020), and data on sectoral value-added in constant prices from the Office of the National Economic and Social Development Council, the Office of the Prime Minister (Office of the National Economic and Social Development Board, 2020). In this study, an IDA was applied to determine the major factor causing the change in energy use from the years 1990-2020. The analysis period covered a regional financial crisis known in Thailand as the "Tom Yum Kung" crisis in 1997-1998 and up to a global pandemic COVID-19 in 2020.

2. SECTORAL ENERGY CONSUMPTION AND ITS VALUE ADDED IN THAILAND

2.1. Sectoral Energy Consumption

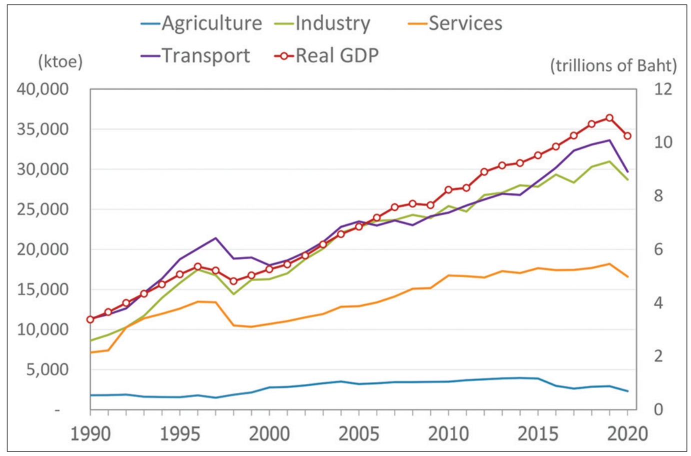
Final energy consumption in Thailand has increased continuously for the last 30 years with a compound annual growth rate (CAGR) of 3.57%, from 28,934 thousand tons of oil equivalent (ktoe) in 1990 to 77,340 in 2020, or 2.7 times. However, considering the 10 years during 1990-2000, 2000-2010, and 2010-2020, the CAGR of final energy consumption was 5.15%, 3.92%, and 2.25%, respectively (Table 1). This shows that energy consumption in Thailand has been growing at slower rates. The GDP of Thailand has grown with a CAGR of 4.05% for 30 years. While EI has shown a good sign that it has been reduced gradually with a CAGR of −0.46% during 1990-2020. Transport and industry sectors are the most energy-consuming sectors with similar growth as real GDP, while services and agriculture sectors are less energy-consuming sectors as shown in Figure 1.

Table 1: Compound annual growth rates of Thailand's energy consumption, GDP, and energy intensity during 1990-2020

Period	Energy consumption	GDP	Energy intensity
1990-2000	5.15%	4.53%	0.59%
2000-2010	3.92%	4.59%	−0.64%
2010-2020	1.21%	2.77%	−1.52%
1990-2020	3.57%	4.05%	−0.46%

Source: Author's calculation based on data from DEDE (2020) and Office of the National Economic and Social Development Board (2020)

Figure 1: Sectoral energy consumption and GDP.



Source: Author's calculation based on data from DEDE (2020) and Office of the National Economic and Social Development Board (2020)

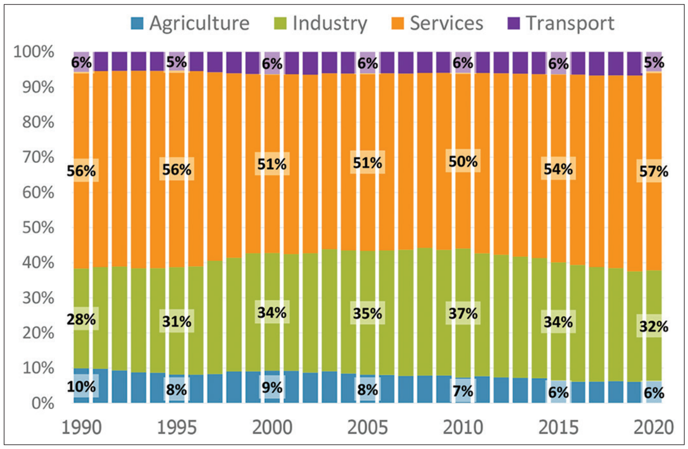
2.2. Share of Sectoral Value-added

GDP in 2002 constant prices between 1990 and 2020 was growing a bit higher rate than energy consumption with a CAGR of 4.05%, from 3,373 billion Thai Baht in 1990 to 10,247 billion Thai Baht in 2020. Considering 10-year period of 1990-2000, 2000-2010 and 2010-2020, CAGR of GDP were 4.53%, 4.59% and 2.77%, respectively (Table 1). The share of GDP by economic sectors was slightly changed during the last decade, the services sector has been dominating Thailand's economy. The services sector has the highest share of GDP, more than 50-57%. The industry sector shares about one-third while the transport and agriculture sectors share 2020 about 6% and 5% (Figure 2), respectively.

2.3. EI by Economic Sector

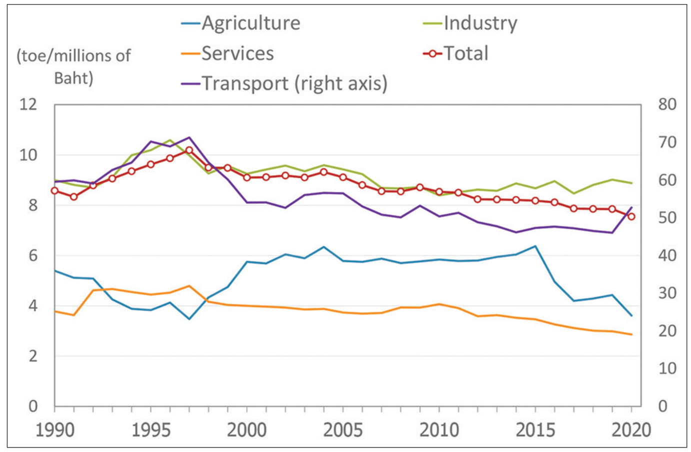
EI is one of the most important indicators to represent how much energy is consumed efficiently compared to production. The reduction of EI can be described by two changes. One is energy efficiency which energy use is lower while providing the same amount of production. The second is higher production or higher value-added with the same amount of energy use (Energy Policy and Planning Office, Ministry of Energy, 2011). EI during 1990-2020 is slightly improved with a CAGR of −0.46% (Table 1). However, this seems to be low when compared with a typical average improvement rate of 1.0%/year which should be the bottom line (Blok, 2005). Moreover, considering a target to achieve climate goals, an annual improvement rate of vehicle fuel economy should be 2.7%/year (Global Fuel Economy Initiative, 2013). These two confirmed that Thailand's energy efficiency improvement rate is quite far to achieve climate goals. EI during

Figure 2: Share of value-added by economic sectors



Source: Author's calculation based on data from Office of the National Economic and Social Development Board (2020)

Figure 3: Energy intensity by economic sectors



Source: Author's calculation based on data from DEDE (2020) and Office of the National Economic and Social Development Board (2020)

1990-2000 was increased with a CAGR of 0.59%, while the CAGR of EI during 2000-2010 and 2010-2020 was −0.64% and −1.52%, respectively (Table 1). The services sector has the lowest EI, and the trend is reducing continuously. The transport sector has the highest EI with a downtrend as shown in Figure 3.

3. DECOMPOSITION METHOD

The decomposition method is a popular method for analyzing the effect of the change from related factors. In this paper, we adopted the decomposition model in Park (1992) and Yilmaz and Atak (2010) to analyze Thailand's final energy consumption changes due to three factors: value-added, production structure, and EI.

The calculation can be started by analyzing the EI at time t as shown in the following equation.

$$e_t = \frac{E_t}{P_t} \quad (1)$$

where e_t = energy intensity at time t
E_t = energy consumption at time t
P_t = total value-added in constant prices at time t

Then, total energy consumption in the period t can be calculated from the summation of the productions between sectoral value-added and EI for each sector m as follows:

$$E_t = \sum_{i=1}^{m} P_{it} e_{it} \quad (2)$$

where e_{it} = energy intensity of sector i at time t
P_{it} = value-added in constant prices of sector i at time t
m = economic sectors

If considering a change in a period, total energy consumption change between a base period ($t = 0$) and a later period ($t = n$) can be calculated as:

$$\Delta E = E_n - E_0 = \sum_{i=1}^{m} P_{in} e_{in} - \sum_{i=1}^{m} P_{i0} e_{i0} \quad (3)$$

Then, the right-hand side of Equation (3) can be alternatively written as:

$$\Delta E = P_n \sum_{i=1}^{m} a_{in} e_{in} - P_0 \sum_{i=1}^{m} a_{i0} e_{i0} \quad (4)$$

$$a_{it} = \frac{P_{it}}{P_t}$$

where
a_{it} = share of value-added in constant prices of sector i to the total value-added

It can be seen clearly in Equation (4) that the change in energy consumption depends on three variables: value-added (P_t), the EI of each sector (e_{it}), and production structure (a_{it}). Applying the principle of decomposition, we will get the formula as the following equation.

$$\begin{aligned}\Delta E &= P_n \sum_i a_{in} e_{in} - P_0 \sum_i a_{i0} e_{i0} \\ &= (P_n - P_0) \sum_i a_{i0} e_{i0} \\ &+ P_0 \sum_i (e_{in} - e_{i0}) a_{i0} \\ &+ P_0 \sum_i (a_{in} - a_{i0}) e_{i0} \\ &+ residuals(R) \quad (5)\end{aligned}$$

where residuals (R) can be further broken down into four combinatorial product terms of the three variables as follows:

$$\begin{aligned}R &= (P_n - P_0) \sum_i (e_{in} - e_{i0}) a_{i0} \\ &+ (P_n - P_0) \sum_i (a_{in} - a_{i0}) e_{i0} \\ &+ P_0 \sum_i (a_{in} - a_{i0})(e_{in} - e_{i0}) \quad (6) \\ &+ (P_n - P_0) \sum_i (a_{in} - a_{i0})(e_{in} - e_{i0})\end{aligned}$$

Table 2: Decomposition of energy consumption change during 1990-2020 (Unit: ktoe)

Components	1990-2000 (%)		2000-2010 (%)		2010-2020 (%)	
Output effect	16,132.3	(85.48)	27,094.9	(120.73)	17,186.9	(242.36)
Energy intensity effect	−265.0	(−1.40)	−2,510.6	(−11.19)	−3,687.8	(−52.00)
Structural effect	2,154.7	(11.42)	−380.5	(−1.70)	−3,655.3	(−51.54)
Joint effects of (1) and (2)	−147.8	(−0.78)	−1,422.9	(−6.34)	−902.3	(−12.72)
Joint effects of (1) and (3)	1,201.4	(6.37)	−215.6	(−0.96)	−894.3	(−12.61)
Joint effects of (2) and (3)	−130.7	(−0.69)	−78.7	(−0.35)	−767.8	(−10.83)
Joint effects of (1), (2), and (3)	−72.9	(−0.39)	−44.6	(−0.20)	−187.9	(−2.65)
Total	18,872.0	(100.0)	22,442.0	(100.0)	7,091.6	(100.0)

Figure 4: Decomposition of annual energy consumption change

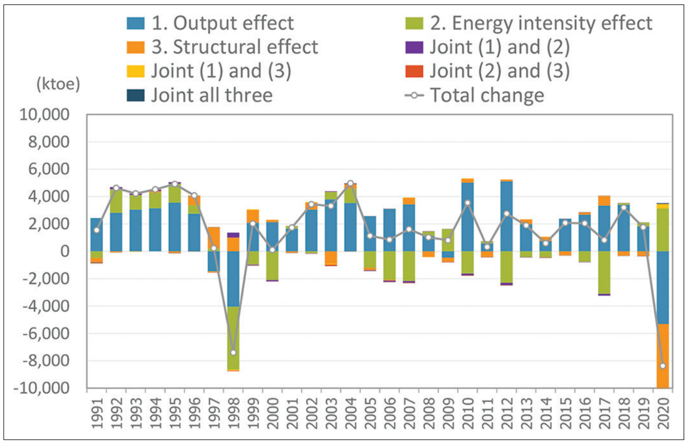
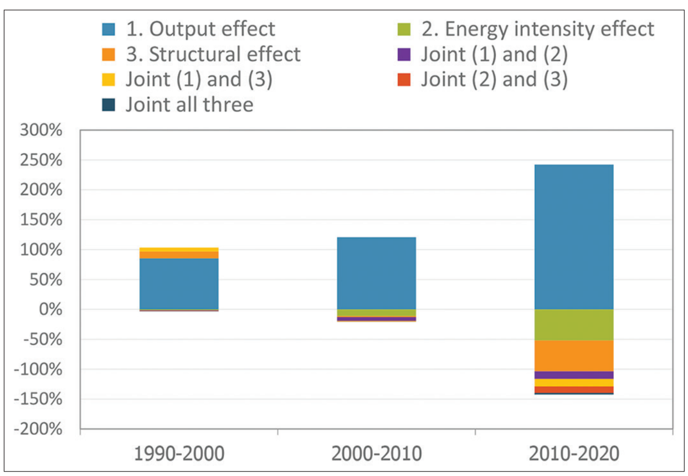


Figure 5: Decomposition of energy consumption change during 1990-2020



where the first term is the joint effects of changes in output and EI; the second term is the joint effects of output and structural change; the third term is the joint effects of EI and structural change, and the last term is the joint effects of all three variables.

4. RESULTS AND DISCUSSION

4.1. Decomposition of Annual Energy Consumption Change

The results of the decomposition analysis identified the effect of variables on the final change in energy consumption each year in Thailand as shown in Figure 4. In most cases, the value-added will increase energy use, while the EI tends to decrease, especially after 1997-1998 when the financial crisis occurred and in 2020 when COVID-19 occurs. For the economic structure variable, the effect is uncertain, making energy increase or decrease with smaller changes. For the joint effects of variables are rather small. The joint effect between the value-added factor and the EI was the highest among the other joint effects.

4.2. Decomposition of Energy Consumption Change during 10-Year Periods

To see the effects of various variables in the longer term more clearly, the final energy change analysis is done every 10 years from 1990 to 2020, i.e., divided into periods 1990-2000, 2000-2010, and 2010-2020. Analysis results decomposition over 10 years makes it clear that the effect of production output or value-added, led to a significant increase in energy consumption, accounting for 85.5%, 120.7% and 242.4% of the energy increases in the period 1990-2000, 2000-2010 and 2010-2020, respectively, as shown in Table 2 and Figure 5. The effect of EI on energy reduction was minimal in 1990-2000, −1.4%, and increased in the years 2000-2010 and 2010-2018, −11.2% and −52.0%, respectively. While the structural effect in the years 1990-2000 was the most at 11.4% and resulting in −1.7% and −51.5% decrease in energy consumption in the years 2000-2010 and 2010-2020, respectively. For most of the joint effects, the changes are small in the range of −12.7-6.4%, and most of the joint effects reduced energy use, except for the joint effect between value-added (1) and economic structure (3) where the increase in energy consumption in the years 1990-2000 was 6.4%.

5. CONCLUSIONS

It can see clearly from the results of the decomposition analysis of Thailand's final energy consumption in the years 1990-2020, that energy consumption highly depends on its production outputs for all 10-year periods (except during the crisis years), while the EI and structure of the economy have negative effects during the last ten years, 2010-2020. The EI of Thailand had been slightly improving during the last 20 years, after the financial crisis. While the structural change still has no trend during the periods of study, expect only 2020 that is affected by COVID-19 resulting in energy demand reduction.

The findings of this study can help policymakers to focus more on energy efficiency since the improvement during the last 30 years was not at the level that we need to meet the climate goal, particularly for the industry and transport sectors. More stringent energy efficiency measures will ease Thailand to decouple between energy consumption and economic growth sooner and wider. Since the economic structure of Thailand has rarely changed, the impact of the country's economic structure on energy consumption is still small. Thailand's economy must urgently change the production structure to a more energy-efficient and higher value-added businesses.

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