



## Climate Change and Energy Consumption Patterns in Thailand: Time Trends during 1988-2013

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Received: 27 August 2020

Accepted: 13 November 2020

DOI: <https://doi.org/10.32479/ijeep.10695>

### ABSTRACT

In traditional context, fossil fuel energy consumption is observed as non-renewable sources and contributing its major part for the energy source in the world economy. However, a new term under the title of renewable energy source is also examined and studied too. The focus of this paper is to investigate the impact of fossil fuel energy and renewable energy sources on the factor of climate change. For the measurement of climate change, overall six dimensions were added in the empirical analyses. The time period for the study was 1987 to 2013 and data was collected from World Development Indicator WDI. Findings for the regression analyses reveal that climate change in terms of CO<sub>2</sub> emissions from liquid fuel consumption (kt) or C<sub>1</sub> is directly influenced by both fossil and renewable energy, and same trend is found for CO<sub>2</sub> emissions (kt); C<sub>2</sub>. Meanwhile, the third indicator of climate change C<sub>3</sub> or CO<sub>2</sub> emissions (kg per 2010 US\$ of GDP) is negatively affected by renewable energy. Furthermore, C<sub>4</sub> (CO<sub>2</sub> emissions from gaseous fuel consumption [% of total]) is directly influenced by both of the energy sources in Thailand. Additionally, the trends in C<sub>5</sub> is found to be positively determined by both fossil fuel and renewable energy, while their negative and significant impact is observed for C<sub>6</sub>; CO<sub>2</sub> emissions from transport (% of total fuel combustion). Future research studies may consider the sub division of energy sources in both public and private sectors.

**Keywords:** Fossil Fuel, Renewable Energy, Climate Change, Carbon Emission, Thailand

**JEL Classification:** Q54, Q15, Q56, Q18

### 1. INTRODUCTION

For the increasing threat like global warming, carbon emission and its association with the energy consumption is among the most cited areas in the field of environmental economics (i.e. see the findings of Chang, 2010; Jeswiet and Kara, 2008; Ozturk and Acaravci, 2010; Shahzad et al., 2017; Shiyi, 2009; Zhang and Cheng, 2009). As per the findings of United Nations, the crucial factor to achieve the sustainable development in the world economy is the environmental quality (Pearce et al., 2013). For most of the reason, environmental quality is accepted as a basic human necessity which is now facing grave consequences (Kamran and Omran, 2018; Karmanov and Hamel, 2008; Pierzynski et al., 2005). Although economic growth and energy consumption are known as great channel for the transmission, yet the latter is observed as a key culprit for the environmental degradation. In

recent time, the issue of global warming and destruction of the ozone layers have also turned the researchers' attention towards natural environment. A lot of developed and emerged economies have been well known for the continuously utilizing the energy consumption, since the time of industrial revolution during 18<sup>th</sup> century (Barca, 2011; Fouquet and Pearson, 2012; Kander, 2002). Not only in overall economy but in sub-sectors, there is an experience of increasing consumption of energy. For this purpose, various countries are working to control the harmful effect of increasing energy consumption, but a huge threat is yet to be stopped.

The problem of climate change is a key challenge under sustainable development program. The reason is that increasing energy consumption and greenhouse gas emission has destroyed the social and economic life of the society (Jorgenson and Clark,

2016; Kim and Jeong, 2016; Ming et al., 2016). As stated earlier, in developed countries, energy consumption is an ongoing trend, but their key consumption sources are the households and similar other individuals (Rahman, 2019; Topcu and Tugcu, 2019). As observed in the literature, mainly there are two major sources of energy consumption. One is known as fossil fuel and other is observed as renewable energy source (Boyle, 2004; Johansson et al., 1993; Panwar et al., 2011; Rajabi and Mousavi, 2019; York, 2012). Although fossil fuel is among the traditional source to get the energy, yet it has been observed under the shadow of creating more challenges too. The environmental impact of fossil fuel is observed alike; air pollution and global warming. For the preservation of the natural environment, there is a growing concern to stop the negative influence of fossil fuel and its grace consequences. Research studied have provided a good understanding for examining the relationship between fossil fuel, economic growth and its environmental results through climate change (Mukhopadhyay and Forssell, 2005; Panwar et al., 2011).

In addition, renewable energy sources and their role in mitigating or lowering the uneven natural outcomes is widely examined in the literature. It is accepted that most of the economies in recent years are trying to shift their traditional or non-renewable energy sources to renewable ones (Elliott, 2000; Scheer, 2012). Meanwhile, the usage of renewable energy sources also requires a giant awareness for the local and international communities. In this regard, many economies which are known as “high income” have developed policies and adopted the relevant practices to promote the renewable energy sources (Topcu and Tugcu, 2019). For this purpose, these economies have increased their research and development share, feed-in-tariffs and providing the subsidies to different industries for using renewable sources (Topcu and Tugcu, 2019).

Both theoretical and empirical studies are showing their discoveries for energy consumption and climate change relationship. Han et al. (2019) the energy consumption carbon emission and its intensity in China. It is observed that for the Chinese economy, the key source of carbon emission is energy consumption. However, the urbanization in the country has contributed significantly towards the reduction of intensity for both carbon emission and energy consumption.

Waheed et al. (2019) aim to contribute the literature survey in the field of carbon emission, energy consumption, and economic growth. For attaining this objective, authors have observed the trends in targeted variables in developing and developed economies while providing the title of discussion for empirical conclusion, and modelling methods. Zhang et al. (2019) have explained that rapid rise in the construction industry of China has resulted in large amount of carbon emission and energy consumption. However, to reduce the level of carbon emission, it is important for work for the proper and reasonable utilization of energy specifically in construction sector.

Zhang et al. (2019) provides the contribution in the field of carbon emission and energy consumption while studying the agriculture sector of China. Meanwhile, authors have observed the overall

economic growth in the country during the time of 1996 to 2015. Authors have applied the ARDL method, VECM and impulse response techniques to examine the trends in targeted variables. Bianco et al. (2019) provides their research proposal for the consumption of electricity in terms of inequality, diversified typologies for the primary energy like natural gas, oil, coal, and carbon emission during the time of 2008 to 2016 in European Union (EU). For examining the trends of inequality between the countries, decomposition between and within entities based on the GDP per capita was investigated. Their findings show that GDP difference can provide a good understanding to know about the inequality trends in EU region. Nguyen and Kakinaka (2019) have worked for providing the fruitful recommendations for renewable energy consumption in lowering the issues for the climate change. However, to achieve this task, it is widely recommended to create a balance between economic growth and environmental degradation. In addition, their study has investigated 107 economies in the world during the period of 1990 to 2013 and provide some interesting facts. For example, in low-income countries, renewable source of energy consumption is positively linked to carbon emission while negatively with the output. On the other hand, high-income economies are observing a negative and significant association between carbon emission and energy consumption. Ninpanit et al. (2019) have examined the economy of Thailand. It is found that Thai economy is one of the most successful economies to implement export-led growth models. However, during the time of 1990 and 2015, there is triple increasing trend of carbon emission in the country. Authors found that Thailand economy is known as carbon exporting country.

As per the above discussion, this paper has investigated the role of fossil and renewable energy in determining the overall trends in climate change for the economy of Thailand. The remaining discussion of this papers covers the title like, discussion about the variables and methods in part 2, discussion of the results in part 3, and conclusion under part 4.

## 2. VARIABLES AND METHODS

The methodological context of present research shows the time series data for all the variables over the last 27 years, starting from 1988 to 2013. One of the key reason to miss the latest years in the study is because of missing values from the data sources like WDI. Furthermore, as all the variables have got a secondary nature, therefore, descriptive technique is found to be a good approach to review, examine and discuss the data along with graphical presentations for the better understanding of the readers. For this purpose, initially descriptive measures like mean, standard deviation, and minimum-maximum are calculated through STATA-14 version. Addition to both central tendency and dispersion measures of the data, multiple regression method was applied.

$$\text{Climate change } (C_1) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \quad (1)$$

$$\text{Climate change } (C_2) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \quad (2)$$

$$\text{Climate change } (C_3) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \tag{3}$$

$$\text{Climate change } (C_4) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \tag{4}$$

$$\text{Climate change } (C_5) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \tag{5}$$

$$\text{Climate change } (C_6) = \alpha + \alpha_1 (\text{Fossil Fuel or F.Fuel}) + \alpha_2 (\text{Renewable Energy or R.Eng}) + \mu \tag{6}$$

Equations 1-6 shows an overall relationship between the variables of the study, considering the climate change as main dependent variable ranging from C<sub>1</sub> to C<sub>6</sub> (details under Table 1), while fossil fuel and renewable energy as main independent variables. Whereas error terms are included through the sign of μ, and coefficients with α, α<sub>1</sub>... α<sub>2</sub> respectively. The results for these equations are provided under Tables 2-4.

### 3. RESULTS AND DISCUSSION

This section covers comprehensive discussion for the key findings. As stated earlier, this research has calculated the descriptive results for two measures and energy consumption; named as fossil fuel and renewable consumptions. While overall six indicators (C<sub>1</sub>-C<sub>6</sub>) were added in the model to present the title of climate change. For energy consumption, fossil fuel mean score is three time higher than the renewable consumption, showing that majority of the Thailand economy is depending upon the traditional ways for the energy consumption in both public and private sectors, house hold consumptions and other commercial activities. For this reason fossil fuel consumption has higher deviation comparatively to renewable consumption of energy in the country. A maximum trend for fossil fuel is also higher and same case with it minimum trend during the last 27 years of observation, starting from 1987 to the end of 2013. For climate change, C<sub>1</sub> presents the mean value of 101000 which shows a higher average trend for the climate

change in terms of liquid fuel consumption which results in carbon emission in the natural environment. Whereas C<sub>2</sub> indicates carbon emission in kt scale with the mean score of 189000. Moving to the third indicator of climate change named as C<sub>3</sub>; CO<sub>2</sub> emissions (kg/2010 US\$ of GDP), average nick is 0.77 approximately over the recent four decades. Furthermore, C<sub>4</sub> reflects the average trend of 19.25 which provides the evidence that CO<sub>2</sub> emissions from gaseous fuel consumption (% of total) is showing its less than quarter contribution in overall carbon emission of Thailand. For C<sub>5</sub>; CO<sub>2</sub> emissions from gaseous fuel consumption (kt) have predicted a mean number of 25459.90. In the end, the mean value for C<sub>6</sub> or CO<sub>2</sub> emissions from transport (% of total fuel combustion) is 29.7334. All these findings are well presented in Table 2 and Figure 1:

The discussion of descriptive and correlation trends between the variable is leading towards the linear regression results. Overall empirical results are presented with Tables 3 and 4, where Table 3 shows the relationship of C<sub>1</sub>-C<sub>3</sub> with energy consumption sources, while Table 4 explains the causal impact of both of the energy sources on C<sub>4</sub>-C<sub>6</sub> respectively. Considering the influence of fossil fuel on climate change; carbon emission from liquid fuel consumption, and influence of renewable energy consumption on the same carbon emission, both have shown positive and highly

Figure 1: Descriptive trends of energy consumption and climate

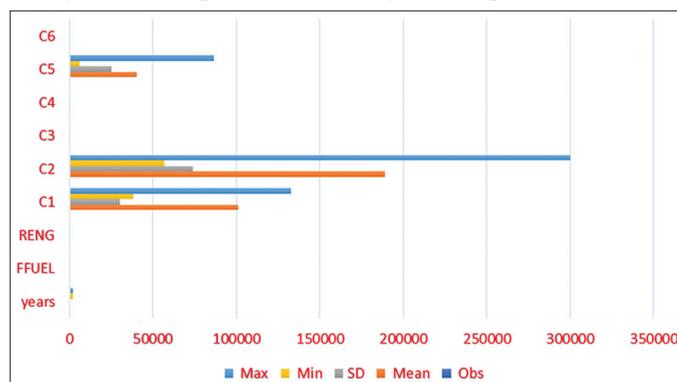


Table 1: Variables

Title of the variable	Nature of the variable	Abbreviations	Operationalization	Source of data
Fossil fuel energy	Independent I	F.FUEL	Fossil fuel energy consumption indicates the portion of the energy from the total energy consumption in terms of annual percentage measure (Janulis, 2004)	World Bank, World development Indicator
Renewable energy	Independent II	R.ENG	Renewable energy consumption (% of total final energy consumption on the country on annual basis (Shafiei and Salim, 2014)	World Bank, World development Indicator
Climate change	Dependent I	C <sub>1</sub>	CO <sub>2</sub> emissions from liquid fuel consumption (kt) (Lacheheb et al., 2015)	World Bank, World development Indicator
Climate change	Dependent II	C <sub>2</sub>	CO <sub>2</sub> emissions (kt) as calculated on annual basis	World Bank, World development Indicator
Climate change	Dependent III	C <sub>3</sub>	CO <sub>2</sub> emissions (kg per 2010 US\$ of GDP), measured on annual basis	World Bank, World development Indicator
Climate change	Dependent IV	C <sub>4</sub>	CO <sub>2</sub> emissions from gaseous fuel consumption (% of total) on annual basis	World Bank, World development Indicator
Climate change	Dependent V	C <sub>5</sub>	CO <sub>2</sub> emissions from gaseous fuel consumption (kt) in terms of annual values	World Bank, World development Indicator
Climate change	Dependent VI	C <sub>6</sub>	CO <sub>2</sub> emissions from transport (% of total fuel combustion) in annual values	World Bank, World development Indicator

**Table 2: Descriptive results for energy consumption and climate change (C<sub>1</sub>-C<sub>6</sub>)**

Variable	Years	FFUEL	RENG	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>
Obs.	27	27	27	27	27	27	27	27	27
Mean		75.578	24.567	101000	189000	0.777	19.255	40298	29.733
SD		7.969	5.274	30140.7	74254.9	0.097	5.937	25459.9	3.366
Min	1987	56.16	20.025	38085.5	56944.8	0.568	10.876	6193.56	24.655
Max	2013	82.057	35.51	133000	300000	0.893	28.889	86691.6	36.612

**Table 3: Energy consumption and climate change patterns (C<sub>1</sub>-C<sub>3</sub>)**

Section I: C <sub>1</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	1.707	0.403	4.35	0.000	***
RENG	3.849	0.294	13.09	0.000	***
_cons	-43.00	11.000	-3.90	0.001	***
Mean dependent var.	101000	SD dependent var.		30140.686	
R-squared	0.723	Number of obs.		27.000	
F-test	143.593	Prob > F		0.000	
Section II: C <sub>2</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	21.7039	7.282	2.970	0.005	***
RENG	20.572	4.944	5.143	0.000	***
_cons	-19.7	4.687	4.203	0.000	***
Mean dependent var.	189481.903	SD dependent var.		74254.879	
R-squared	0.872	Number of obs.		27.000	
F-test	81.960	Prob > F		0.000	
Section III: C <sub>3</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	0.005	0.003	1.62	0.117	
RENG	-0.011	0.004	-2.40	0.024	**
_cons	0.679	0.329	2.06	0.050	**
Mean dependent var.	0.777	SD dependent var.		0.097	
R-squared	0.934	Number of obs.		27.000	
F-test	168.753	Prob > F		0.000	
Akaike crit. (AIC)	-117.675	Bayesian crit. (BIC)		-113.788	

**Table 4: Energy consumption and climate change patterns (C<sub>4</sub>-C<sub>6</sub>)**

Section I: C <sub>4</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	2.200	0.360	6.10	0.000	***
RENG	2.609	0.545	4.79	0.000	***
_cons	-211.107	40.415	-5.22	0.000	***
Mean dependent var	19.255	SD dependent var		5.937	
R-squared	0.733	Number of obs.		27.000	
F-test	32.938	Prob > F		0.000	
Akaike crit. (AIC)	142.134	Bayesian crit. (BIC)		146.022	
Section II: C <sub>5</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	9205.333	1428.111	6.45	0.000	***
RENG	10608.659	2157.977	4.92	0.000	***
_cons	-916000.000	160000.000	-5.72	0.000	***
Mean dependent var.	40298.021	SD dependent var		25459.938	
R-squared	0.772	Number of obs.		27.000	
F-test	40.664	Prob > F		0.000	
Akaike crit. (AIC)	589.492	Bayesian crit. (BIC)		593.380	
Section III: C <sub>6</sub>	Coef.	SE	t-value	P-value	Sig.
FFUEL	-1.207	0.138	-8.73	0.000	***
RENG	-1.332	0.209	-6.38	0.000	***
_cons	153.653	15.501	9.91	0.000	***
Mean dependent var.	29.733	SD dependent var.		3.366	
R-squared	0.878	Number of obs.		27.000	
F-test	86.232	Prob > F		0.000	
Akaike crit. (AIC)	90.385	Bayesian crit. (BIC)		94.273	

\*\*\*P&lt;0.01, \*\*P&lt;0.05, \*P&lt;0.1

significant influence. However, under the achieved results, higher positive impact of renewable energy is observed while lower positive impact is observed through fossil fuel consumption in Thailand. Both of the independent variable are justifying that there

role in increase the carbon emission from liquid fuel consumption during 1987-2013, on average basis. Overall value of coefficient of determination R<sup>2</sup> reflects a change of 72.3% in carbon emission through both of the energy sources.

For the second indicator of carbon emission which is known as  $CO_2$  emissions (kt), both factors of fossil and renewable energy utilization are showing a direct impact, hence causing an upward shift in carbon emission in terms of kt. However,  $C_2$  is more influenced by fossil fuel ( $b = 21.70$ ), as compared to renewable energy ( $b = 20.57$ ). This effect provides the justification that higher consumption of fossil fuel is more vulnerable to the economy of Thailand, compared to some new energy sources like wind, solar, air etc. In terms of explained variation,  $R^2$  is 87.2, F-test is 81.96 which is significant at 5%, hence values of coefficients for both of the energy sources and constant are not equal to zero.

The role of energy consumption in climate change is also demonstrated and measured through  $CO_2$  emissions (kg per 2010 US\$ of GDP) or  $C_3$ , for which findings are provided in the third section of Table 3. It is stated that consumption of fossil fuel is putting a direct impact on  $C_3$ , yet this impact is statistically insignificant as both t-value and p-value are below the threshold point of 1.96% and 10%. It finds that no evidence to defend the relationship between fossil fuel energy consumption and carbon emission in terms of KG per 2010 US dollars of gross domestic product in Thailand. On the other hand,  $C_3$  is negatively affected by renewable energy ( $b = -0.011$ ,  $SE = 0.004$ ,  $t = -2.40$ ,  $P = 0.024$ ). All of these results are justified and accepted for describing the role of renewable energy as a determinant of  $C_3$  of Thailand region.

The influence of two of the leading sources of energy consumption on remaining three climate change indicators ( $C_4$ - $C_6$ ) is presented in Table 4. For  $C_4$ , both fossil fuel and renewable energy sources have shown an alarming output, indicating an increasing trend. It means that higher consumption of fuel from traditional and some new sources is leading to the more carbon emission  $CO_2$  emissions from gaseous fuel consumption (% of total). Similar result is found for the renewable energy which shows a coefficient of 2.60, indicating a unit change in the value of renewable energy sources, causing a positive change of 2.60 in  $C_4$ , on average during the last 27 years of the research. F-test is highly significant, reflecting the fitness of the coefficients and their marginal effect on dependent variable, whereas  $R^2$  is 73% approximately, meaning a higher variation in  $CO_2$  emissions from gaseous fuel consumption (% of total) because of both of the energy sources.

The fifth indicator of climate change is entitled as  $C_5$ ;  $CO_2$  emissions from gaseous fuel consumption (kt) and effect of both of the energy sources on it is presented under section II of Table 3. As experienced from the coefficients of both of energy sources, highly positive and significant impact is recorded. It means that higher consumption of fossil fuel is leading to more carbon emission and same is the case with the renewable energy consumption. It reflects that economy of Thailand is under serious threat because of increasing carbon emission, hence declining tendency in climate quality. This effect will continue until there are some serious steps from the policy makers and environmental regulation authority.

In the third section of Table 4, climate change impact of fossil and renewable energy is examined for  $CO_2$  emissions from transport (% of total fuel combustion). As per the findings, the results under section III are entirely different from the earlier

coefficients. It is observed that both fossil and renewable energy is causing a decline in  $CO_2$  emissions from transport (% of total fuel combustion), hence lower  $C_6$  or climate change impact. This argument is highly significant at 1% with the good explanatory power and model fit indices.

## 4. CONCLUSION

The potential and adverse impact of the increasing energy consumption on climate change needs an effective investigation and strategic decisions for the betterment of planet earth. This study has observed the trends in increasing energy utilization from the two main sources, fossil and renewable, and their environmental results through change in climate with increasing carbon emission. A series of statistical analyses were conducted for exploring the relationship between dependent and independent variables over the 27 years of study period. However, before describing a marginal effect of energy sources on climate change indicators, descriptive look has given a substantial knowledge to analyze, understand, and explore the data points with their average score and deviation from the mean respectively. It is extracted from the average trend that energy consumption from all the fossil fuel sources is three times more than the average trend of renewable energy utilization in Thailand. For climate change indicators, a mixed trend is examined in all six measures, ranging from  $C_1$  to  $C_6$ .

Addition to the above discussion of the results, current research has a range of contributions. For example, one the significant addition in the literature of carbon emission and climate change from the context of Thailand is completely missing. In this way, this study has contributed a good theoretical work for the readers and other stakeholders. The empirical investigation of Thailand economy in terms of climate change and consumption of energy showed a significant empirical evidence for the policy makers and country administrative to expand their strategical analyses for the controlling of harmful effect of increasing environmental consequences. Additionally, focusing on the core findings of the study from the context of energy consumption and climate change, it is clearly stated that higher consumption of the energy from fossil fuel sources are causing more environmental issues, comparatively to some renewable energy sources. This result would be considered as a most meaningful evidence to put more attention towards the creation of new sources of the energy in the country. As per the detailed review, most of the economies in the world are trying to move from non-renewable energy sources to renewable ones. These are China on the top, India, and Pakistan. These countries and their governments are trying to impose the taxes like "carbon-taxes" just to force their industries for the lower consumption of old energy sources. In this way, present research highly suggests for the policy makers to consider and implement the same policy in the Thai economy for the betterment of climate changes. By using the stated findings of this research, it may be expected that future trends for the climate change due to increasing energy consumption patterns may reasonably be revised.

However, various limitations are also highlighted under this study. For example, an overall energy consumption pattern from fossil and renewable sources were added in the study to effect their

environmental trend. For upcoming studies, the trends for such energy consumption can be investigated through more specific patterns like fossil fuel energy consumption in public sector offices, private sectors, and educational institutes. At second, this study has not observed the time trends for the energy consumptions on the value of climate change indicators. Therefore, future research may investigate the t-trend and d-trend for analyzing the relationship between energy consumptions and climate change. Besides, the trends for the energy consumption can be investigated with the moderating effect from the economic growth which is also observed as a missing part in the literature of environmental economics and sustainable development in the region of Thailand. Lastly, in terms of originality/value this research would be an acceptable contribution while examining the climate change.

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