The Association Between CO_2 Emission and Temperature in Thailand

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ABSTRACT

The important source of carbon dioxide (CO_2) emission is identified to be energy usage, which the demand is gradually increasing. Currently, many people are exposed to increasing temperatures, which affects to health, environment, and quality of life. Moreover, there are many worries about its continuously increasing trend. This work is interested in studying the association between the annual CO_2 emission and the annual mean temperature in Thailand. At a confidence interval of 90%, a statistically significant association between the annual CO_2 emission and the annual mean temperature was observed. The appropriate predictive equation represented that the CO_2 emission at 0.481 M ton increased the annual mean temperature by about 1°C. The results are useful for planning the reduction of CO_2 emissions in Thailand. Fascinatingly, the largest source comes from electricity production, and the most significant energy type is finished oil. Therefore, they should be controlled as the priority. Integrated methods are considered as more efficient strategies for the CO_2 crisis.

INTRODUCTION

Awareness raising about carbon dioxide (CO_2) emission occurs in many countries around the world. Especially the 192 countries joined the Kyoto Protocol in 2005. These are committing industrialized and transitive economic countries that can afford to decrease greenhouse gas (GHG) emissions according to accepted individual targets (United Nations Climate Change 2023). CO_2 is a major greenhouse gas as the cause of far-ranging adverse health and environmental effects (U.S. Environmental Protection Agency 2023).

Thailand is a large CO_2 emission source, releasing up to 263 Mton in 2018, most of it was from fuel combustion (Energy Policy and Planning office 2023). Presently, the Thai government has a long-term target to decrease greenhouse gas emissions by 20% by 2030, as compared with 2005. This was submitted in October 2021 under the Paris Agreement (Ministry of Energy 2011). The amount of CO_2 is related to climate change by trapping heat in the atmosphere (Picano et al. 2022). There are many potential health risks of CO_2 exposure, such as inflammation, bone demineralization, kidney calcification, decrease in more-level cognitive abilities, endothelial disorder, and oxidative stress (Tyler et al. 2019, Breeze Technologies 2020). As well known that multiple advantages will be obtained from the reduction of CO_2 emissions, such as saving the environment and protecting people's health. Moreover, large and immediate economic co-benefits are obtained, which can help to reduce a lot of costs for mitigating air pollution and environmental crisis (Grantham Research Institute 2017).

This research aims to study the association between the annual CO_2 emission and the annual mean temperature in Thailand. In addition, quantifies the main economic sections and energy types related to CO_2 emission. Their applications need to be considered, planned, and managed properly.

MATERIALS AND METHODS

The secondary data consisting of the annual mean temperature, the total energy usage, and the emission of CO_2 were obtained from the Energy Policy and Planning Office (EPPO), Ministry of Energy, Thailand. The year 2009-2022 were selected as the study period. After that, a single linear regression analysis was used to assess the association between the annual CO_2 emission and the annual mean temperature in Thailand with the enter method. Lastly, the proper predictive equation was developed to predict the annual mean temperature from the CO_2 emission volume in Thailand.

RESULTS AND DISCUSSION

Thailand Overview Situation

Thailand's temperature trend: It is noteworthy that the annual mean temperature trend fluctuated strongly all the time (Fig. 1). Thailand's average temperature is now

around 27.2°C warmer than its temperature in 2009 equals 27.4°C. It has continuously increased by about 0.2°C in this study period, which will result in people being exposed to dangerous heat. There are warnings that every 1°C of warming higher than normal level will affect area drought and labor productivity, including a reduction of economic growth by approximately 1.3% per year (Duan et al. 2022). It is predicted that the Thai temperature will reach up to 1 degree Celsius in 2092, approximately 70 years later. Anxiously, unawareness of the CO_2 emissions will lead Thailand to approach many serious problems shortly.

Trends in Thailand's energy usage and CO_2 emission: The energy usage and the total CO_2 emission have the same trend as presented in Fig. 2. It indicates that the energy usage

is related directly to the CO_2 emission. Excluding 2020, they were reduced a bit, which resulted from The Thailand Energy Efficiency Plan 2018 - 2037 (EEP 2018). The EEP 2018 has many mitigation measures to reduce energy usage (Department of Alternative Energy Development and Efficiency 2015).

The calculation of CO_2 emissions per capita is around 3.75 tons per capita in Thailand in 2022 (based on the number of populations at 66,090,475 persons. (National Statistical Office 2022). As compared with the top thirty countries in 2011 stayed in the range of 32.47 – 7.51 tons per capita, and the low-middle-income country was average at 1.77 tons per capita. This pointed out that Thai people release a higher CO_2 level than the typical middle-income country, up to
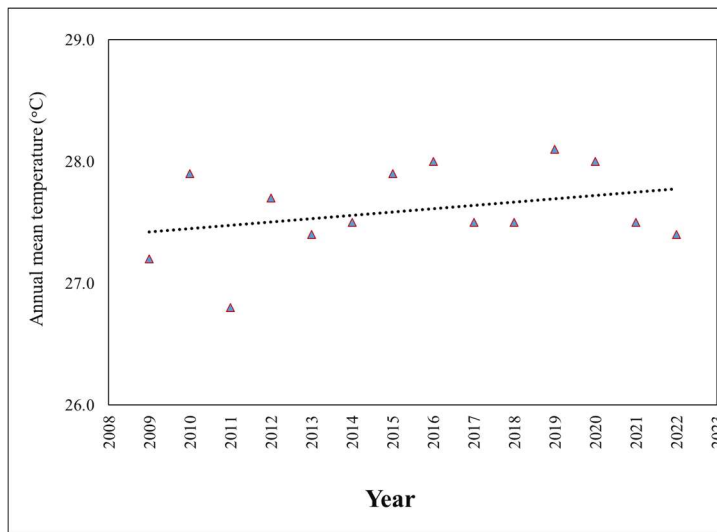

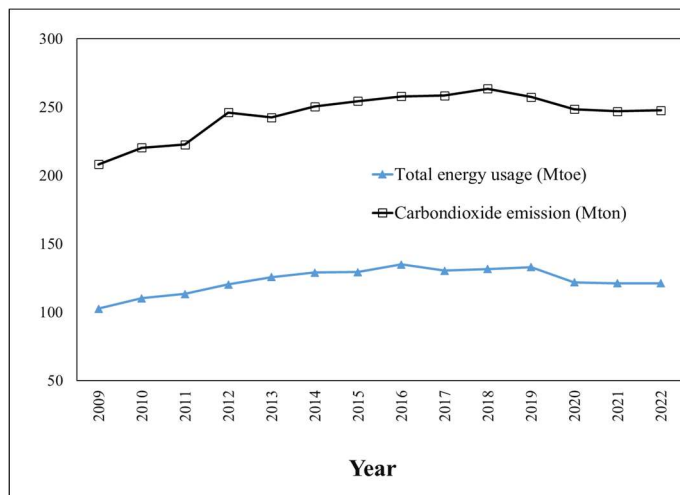Fig. 1: The annual mean temperature of Thailand between 2009 and 2022.

Fig. 2: The total energy usage and the CO_2 emission in Thailand.

2.12 times, which the Thai government should be aware of limiting CO_2 emissions (Amin 2011).

The Association Between the CO$_2$ Emission and the Mean Temperature

The simple linear regression result: Analysis of variance (ANOVA) was used to illustrate the association between the CO_2 emission and the mean temperature (Table 1). The P value less than 0.10 means that there is a significant association at 90% confidence intervals. Nevertheless, it shows a low R square value because it may have even noisy or high variable data. Therefore, the application of the obtained equation to predict the future annual mean temperature should be careful.

The predictive equation model of the annual mean temperature from the CO_2 emission in Thailand was represented using Eq.1 as follows:

The annual mean temperature (°C) = 0.481 The total CO_2 emission (M ton) ...(1)

Particularly, the CO_2 emission rising around 0.481 Mton led to the increase in annual mean temperature by 1°C (Tables 2 & 3).

The results pointed out that Thailand would require the reduction of CO_2 emissions. According to the Paris Agreement of 2015 committed to trying to decrease GHG enough to limit warming to lower than 2 degrees by 2100 (Wike 2019). Nordhaus (2017) found that the social cost of carbon management was about 31 dollars per ton of CO_2 in

Table 1: The ANOVA results.

Parameter	Sum of squares	Df	Mean Square	F value	P value
Regression	0.388	1	0.388	3.602	0.082
Residual	1.292	12	0.108		
Total	1.680	13			

Table 2: The appropriate analysis of the predictive equation.

R	R square	Adjusted R square	Standard error of the estimate
0.481	0.231	0.167	0.328

Table 3: The coefficients of the predictive equation.

Parameter	Unstandardized coefficients		Standardized coefficients	t value	P value
	B	Standard error	Beta		
Constant	25.008	1.368		18.275	0.000
Total CO_2 emission	0.011	0.006	0.481	1.898	0.082

2010. It is estimated the huge boundary costs for managing and mitigating carbon in Thailand that is the end-of-pipe (EOP) method. Moreover, a lot of hidden costs are spent and lost, such as images of tourists, quality of life, etc. Thus, preventive measures are more appropriate, such as CO_2 source reduction, emission minimization, etc. Additionally, there was a study about the advantages and disadvantages of a carbon tax for reducing and managing CO_2 emissions (Prasad 2022).

The Emission of CO$_2$ Divided by Economic Sections and Energy Types

Following the result, the largest CO_2 portion released from electricity production rose to the maximum record at 99 Mton in 2016. In 2023, the total annual Thai electricity net production by all-scale electric power plants of approximately 16,003 GWh from various energy sources consisting of natural gas (51%), coal (16%), renewable energy (14%), water energy (4%), and oil (1.4%) (Ministry of Energy 2023).

Both the transportation and industry sections are quite in the same values (Fig. 3). Interestingly, the decrease in CO_2 emission of the industry section was in 2022 because of the COVID-19 delay. In contrast, the transportation section had an increasing CO_2 emission level.

Nowadays, the governor encourages increasing renewable and alternative energy (waste to energy, heat, wind, biogas, biomass, solar energy) by 20% instead of fossil energy by 2030 (International Renewable Energy Agency 2017). This policy may benefit the country by providing the following effective and practical measures for the reduction of CO_2 emissions.

Consideringly, CO_2 emissions are categorized by energy types (Fig. 4). Most CO_2 emissions were from the use of finished oil by about 36.62-41.91%. In the present day, the finished oil is used for various purposes in Thailand, such as electricity production, transportation, and several industries. Unsurprisingly, it is the largest source of CO_2 emission. Additionally, there was a rising trend from 2009 until the present, which had a temporary decrease only in 2020 and 2021 during the Covid crisis.

It is followed by natural gas and coal, respectively. Markedly, there is a bit of difference between both. Mostly, the use of coal released CO_2 lower than the use of natural gas, except for 2021. This is the consequence of the increase in electricity consumption and the start of economic recovery after the Covid crisis. At the end of the graph (2015 - 2022), the CO_2 emission from natural gas had a small reduction. On the other hand, the distribution from coal depicted the high fluctuated values. This is because of uncertain occurrences
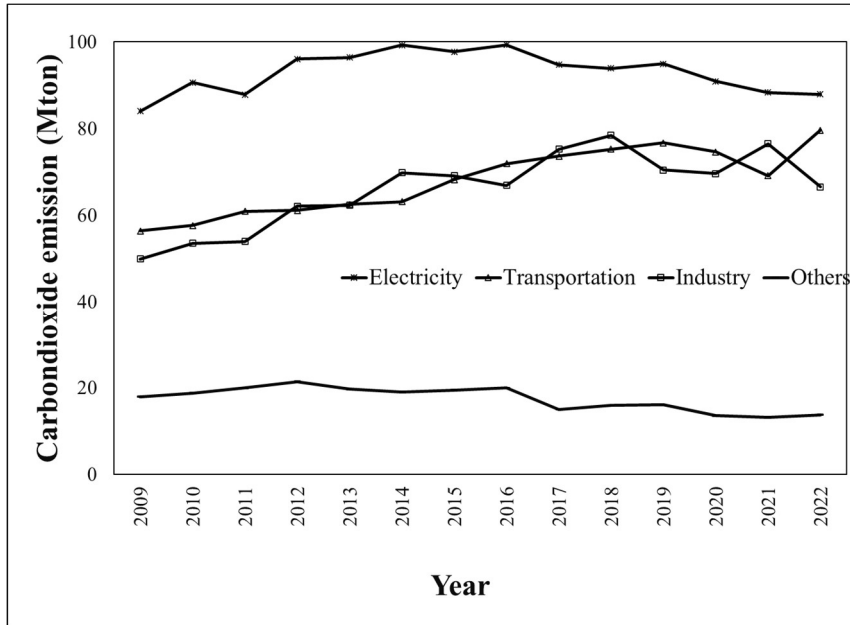
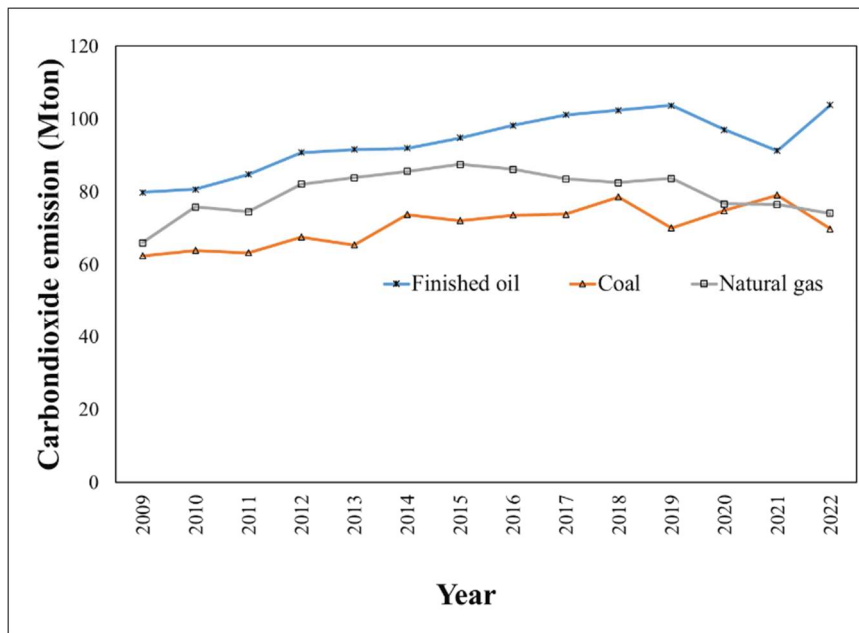Fig. 3: The annual CO_2 emission divided by economic sections.

Fig. 4: The annual CO_2 emission divided by types of energy.

such as the Covid crisis, the Russia-Ukraine war, the energy crisis, etc.

CONCLUSION

The trend of annual mean temperature was presented to continuously increase between 2009 and 2022 in Thailand. The CO_2 emission is related directly to energy usage. Also, the statistical result indicated that the volume of CO_2 emission has a significant association with the annual mean temperature. The CO_2 emission at 0.481 M ton led to the rise of annual mean temperature by 1°C. In addition, the highest quantity of CO_2 was generated from the electricity production process. In the future, it will require a continuous

increase to a higher level. Interestingly, finished oil is the most important energy type of CO$_2$ emission, approximately 36.62-41.91%. Thus, the use of finished oil should be reduced and used properly.

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