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Decarbonizing Thailand: A Socio-economic Impact Study of Peak Emissions Before 2050

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Abstract

Paris Agreement has confirmed that all countries will hold the increase in the global average temperature to well below 2 degree Celsius above pre-industrial levels and to pursue the efforts to limit the temperature increase to well below 1.5 degree Celsius. Because there is a strong link between GHG emissions and economic development. That is to say, the increase of consumption will increase the standards of living too. Therefore, it is necessary for the researchers and policy makers to assess the socio-economic status that can maintain the GDP growth while reducing GHG emissions to mitigate climate change and safeguard the world. Thailand as a member of UNFCCC has pledged the Nationally Determined Contribution (NDC) stated that by 2030 GHG emissions in the country will be reduced by 20% compared to the business-as-usual (BAU) level. From the current stage, even if Thailand achieve its pledge in the Paris Agreement, the country is still far from the 2 degree Celsius target. Therefore, more ambitious measures are required and Thailand should pursue the peak GHG emissions at the earliest as a first step to make the country backing on track to achieve 2 degree target. By recognizing the important role of market-based mechanisms, this study uses computable general equilibrium model to assess the socio-economic impact of limiting GHG emissions in the target year 2020, 2030, and 2040 respectively compared to BaU. The result informed that achieving 2 degree Celsius target will cause Thailand cumulative GDP loss during 2010-2050 by 2.7% in Peak2020, 1.9% in Peak2030 and 0.9% in Peak 2050 respectively in 2050 compared to BaU. Peak emissions early will have more negative impact to Thai economy; however, carbon price as an economic external cost is increased to the highest level (9,072 THB / t CO2.eq) in Peak2040 scenario to keep Thailand backing on track. This can imply that the later peak emissions are observed, the higher cost is required to curve the emissions trajectory to meet emissions target in 2050.

Keywords : CGE model; socio-economic status; climate change; Thailand; peak emissions

Introduction

Climate change is a core problem that has radical effect to the world. With the current policy, greenhouse gas (GHG) emissions which are the main cause of climate change are projected to increase drastically. By not taking any mitigation effort, scientists forecasted that world temperature will increase up to 4.8 degree Celsius compared to pre-industrial level [1]. The creation in the Paris agreement in 2015, which was the latest attempt designed to tackle the climate change and avoid the increasingly warming of the Earth, made a considerable impact. According to the Paris Agreement, it has confirmed that all countries will hold the increase in the global average temperature to well below 2 degree Celsius above pre-industrial levels, while pursuing effort to limit warming to well below 1.5 degree Celsius [2].

Thailand, a highly vulnerable country to the impacts of climate change, is one of the most affected countries in the world; the effects include all of geography, economy and level of development burden. The increase in natural disasters such as tropical storms, floods and droughts annually has created the substantial economic loss. For example, severe flooding in monsoon season occurred in 65 provinces out of 76 provinces in 2011 has estimated the 46.5 billion USD economic loss and 815 people died; On the other hand, the level of precipitation throughout the country has decreased over the last fifty years in normal season. Thailand is experiencing its severe drought in 2020. According to the previous study by Thailand's Department of Disaster and Prevention [3], both flooding and drought will remain and the situation will worsen in the coming years. It is estimated at least 8 million people living in 59 provinces will be affected by the future flooding and drought. A study by the Organization for Economic Cooperation and Development (OECD) is also ranked Bangkok as the seventh most vulnerable port city in the world in terms of population exposed to coastal flooding [1]. Taking above climate change impact due to the increase in world temperature into account, this study used the Representative Concentration Pathways (RCPs), describing a process for creating various scenarios to project the plausible trajectories of the future GHG emissions [4]. Using RCPs as reference, there are multiple mitigation pathways that can tackle the main challenges confronting our global community and are likely to limit global world temperature to well below 2 degree Celsius compared to pre-industrial levels [5]. To achieve the Paris Agreement target, RCP 2.6 is the prominent scenario that has emissions concentrations about 450 ppm or emissions levels assumes zero in 2100 will be the most possible pathway to maintain the world temperature to well below 2 degree target. It is important to note that Thailand as a member of UNFCCC has pledged the Nationally Determined Contribution (NDC) stated that by 2030 GHG emissions in the country will be reduced by 20-25% compared to the business-as-usual (BAU) level. However, even if Thailand achieve their current 'Pledges' in the Paris Agreement – the kingdom is still far from the well below 2 degree Celsius target. Therefore, more ambitious measures are required and Thailand should pursue the peak GHG emissions as soon as possible to make the country backing on track to achieve 2 degree target. That's because the longer Thailand allow emissions to keep climbing, the harder it will be to prevent catastrophic warming. To make Thailand achieve 2 degree Celsius target, this study follows the RCP2.6 pathway that assumes our world in 2100 become net zero emissions. This study worked back to get the GHG emissions level in 2050. Using historical record of Thailand GHG emissions, this study then replicable Thailand GHG emissions in 2050 according to RCP2.6 trajectories. There are many studies that try to assess the sustainable pathway or try tackle the climate change. Previous study by [6] has shown the mitigation pathway toward NDC target in 2030, this study informed the socio-economic result of introducing new GHG mitigation technologies on key emissions sectors but the result could not show the peak emissions. The same happens to the previous study of [7] that tries to make Thailand a low-carbon country by 2050 with various pathways, this study focuses only on the old technology scenarios without showing peak emissions. Some also have studied on specific sectors, [8] assessed the economic impact in freight transport sector using the governmental policy in tackling the climate change [9] used the renewable energy as potential mitigation scheme to support Thailand achieving NDC target. But very few studies discuss about peak emissions. Even though there is a study by [10] that tries to show some of peak emissions scenarios among several scenarios on the Thailand economy and social welfare. But with the aims of the paper is different and model structure is also different, it makes this study lacking of specific information about the peak emissions in the designed target year and the result itself informs only general information. The detail discussion of the peak emissions and suggestion for policy analysis is limited. Therefore, the objective of this study is to assess the low carbon society in Thailand in aligning with the Paris agreement target. By doing so, this study sets 2 degree temperature of Paris agreement as a target for Thailand in assessing the various peak emissions scenarios and use RCP2.6 pathway to guide the GHG emissions trajectory at the end of target year. This study will then evaluate the socio-economic status, the emissions cost and sectoral analysis of each scenario of Thailand. Beside from this introduction section. Section 2 provides an explanation of the methodology. Section 3 presents the results and analysis and section 4 provides the conclusion of this study.

Materials and Methods

This research approach used one-year step recursive dynamic computable general equilibrium model (CGE model) of Thailand [6]. CGE model as the assessment model has been widely used for analysis of environmental policy related to national and global economy. The result of model can help inform policy makers of the costs, benefits and potential tradeoffs of environmental policies and climate change mitigation actions [11].

1. CGE model structure of Thailand

In CGE model, this study uses the Thailand input-output table as inflow data for intermediate demand, final demand and value added. The updated input-output table of Thailand was in 2010 [12], which originally comprised 180 sectors and assumed its compilation with based year in the Thailand NDC.. For simplicity of the model, the 180 original sectors have been aggregated into 29 sectors as show in **Table 1**. The CGE model structure of Thailand is also shown in **Figure 1** below.

1.1 Production sector

Production sector represents several levels of nested production. At each level, virtual firm production consists of 2 activities: activity using existing capital and activity using new capital. Each activity has different technologies: existing technology and advanced technology. Each activity produces commodities or services in line with the fixed yield coefficients and is assumed to maximize profits defining by the difference between revenue from the selling goods or services and the cost of factors and intermediate inputs using for production. Profits are maximized depending on a production technology. It is noting that the production using new capital has a same structure as the production using existing capital. The difference between production using existing capital and

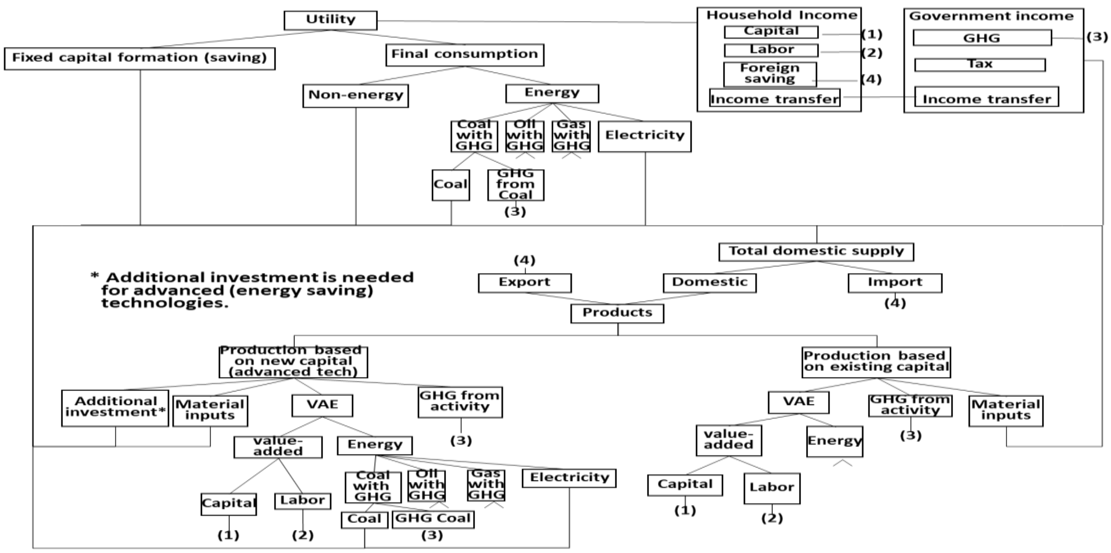

Figure 1 CGE model structure of Thailand to assess peak emissions

Table 1 Sector classification in CGE model

Non-energy sectors				Energy sectors
Agriculture	Water	Related products	Petroleum Refineries	Charcoal
Mining	Construction	Wood	Other Petroleum product	Coal
Food	Wholesales & retails	Services	Water transport	Petroleum
Textile	Railway	Other sectors	Air transport	Electricity
Paper and pulp	Public transport service	Non-Metal	Silo and warehouse	Gas
Petrochemical	Road freight transport	Metal and machinery	Post and telecommunication	

using new capital is that production efficiency, technology and other parameters from activities using new capital are improved compared with those under the existing capital. Compared to the production under existing capital, advanced technologies (for mitigating climate change) under new capital requires an additional investment.

1.2 Household sector

The representative household receives income from the primary factor endowments and lump-sum income transfer from the government. The household income is used for consumption and saving. The characteristic of household consumption is that it will maximize its utility by choosing the levels of consumption of commodities, subject to the constraints of its income and commodity prices they face. Each commodity's price should be equal to the marginal utility of the corresponding commodity. In this study, utility of household sector is defined from the non-energy final consumption and is assumed to be Cobb-Douglas function. Saving is equal to investment, and it is decided to meet the expected future economic growth in advance. Due to Thailand CGE model is included the feature of connection to the rest of the world as part of an open economy, foreign saving from international trade is also included in the household income.

1.3 Government sector

In Thailand CGE model, it assumes that the government will collects taxes, including carbon tax, labor tax, finished goods tax and import tax. The government then spends its revenue (collected taxes) on public services, such as infrastructure building which are provided to the whole country, and on the goods and services that are sometimes provided to the households for free of charge or at low prices.

1.4 Connection with rest of the world

This CGE model assumes a small open economy. The implication of small economy is that its activities do not affect world price or incomes. Export and import prices are exogenous and the relationship between export and domestic supply is assumed CET function and the relationship between import and domestic goods is assumed Armington's assumption.

1.5 Dynamic CGE model

Since static model can represent economic status only in base year, this study uses recursive dynamic model to do iterative calculation and simulate the next year status based on the previous year data. There are two driving forces of economic growth in this recursive dynamic model: 1) the technology change which assumes the efficiency improvement is exogenous and the same numbers for all scenarios, and 2) the increase of capital and labor factor inputs which assumes the capital stock is updated using investment and depreciation. Installed capital cannot be moved to any sectors, but new capital can be installed in any sectors. The distribution of new capital into sectors is subject to maximize the profit. Labor is updated using population growth rate as per governmental forecast.

2. Scenarios of this study

As mentioned in the introduction, this study derived Thailand GHG emissions trajectory in line with RCP2.6 pathway. Since Thailand public policy is focusing on the long-term policy specifying 2050 as a target, this study follows such the guideline. Four scenarios are constructed; one is baseline scenario and the remaining three scenarios show the peak emissions in different period.

2.1 Business as Usual (BaU) : situation goes by as usual. Society has no concern on the environmental issue and there is no limit for GHG emissions.

2.2 Peak 2020: BaU+ limit GHG emissions by introducing GHG tax. GHG emission in Thailand will peak in 2020

2.3 Peak 2030: BaU+ limit GHG emissions by introducing GHG tax. GHG emission in Thailand will peak in 2030

2.4 Peak 2040: BaU+ limit GHG emissions by introducing GHG tax. GHG emission in Thailand will peak in 2040

Results and Discussion

1. GDP is reduced by 0.9% to 2.7% among the Peak scenarios during 2010-2050

Introducing the peak emissions scenarios, **table 2** shows cumulative GDP loss during 2010-2050 is -2.7% in Peak 2020, -1.9% in Peak 2030, and -0.9% in Peak 2040 compared to BaU respectively. The GDP loss is occurred due to the introduction of carbon tax to control the emissions, carbon tax enhances the cost of production and demand drops in response to the increased output price. Peak2020 shows higher cumulative GDP loss compared to other scenarios. This is due to that Peak2020 using carbon tax to control emissions has a higher marginal production cost earlier in production sectors related to GHG emissions. Hence, this made uncompetitive price of products and services to consumers in Peak2020. Another interesting result is that GDP loss in target year in 2050 which recorded about 6.4% in all peak scenarios of this study is lower than the low-medium upper bound of 12% GDP loss in target year of the study by [10]. The lower GDP loss in this study is due to there are some mitigation effort installing in transport sectors.

Table 2 Cumulative GDP loss and GHG reduction by 2050 compared to BaU in 3 peak scenarios

	Peak 20	Peak 30	Peak 40
Cumulative GDP loss	-2.7%	-1.9%	-0.9%
Cumulative GHG emission reduction	-33%	-24%	-12%

2. GHG emissions and GHG price

All peak scenarios GHG emission reduction in 2050 is 2.7 times more than that in BaU **(Figure 2 (a))**. As shown in Table 2, cumulative GHG emissions in Peak2020, Peak2030 and Peak2040 are lower by 33%, 24% and 12% respectively compared to BaU. In sectoral emissions, the emissions are reduced tremendously in metal and machine sector which require large amount of energy input for the production. Emissions in non-metal sector especially cement sector that requires high energy input and by product itself generate high emissions is also reduced significantly. Another key finding is that emissions from coal mining is reduced by 14 times in all peak scenarios in 2050 compared to 2010. This complies with the use of coal is dropped due to carbon tax made it expensive. Carbon tax in **Figure 2b** using to control emissions is highest in Peak2040 in 2050, which records 9,072 THB/tCO2eq, this is because of Peak2040 is adopting the carbon limit lately so that the carbon tax increase at high rate to maintain the Peak2040 under 2 degree target. This imply that the later peak emissions are met, the higher cost is required to curve the emissions trajectory to meet emissions target in 2050.

3. Sectoral output

The result in Table 3 shows that Peak 2020 will have the highest cumulative output loss in energy and non-energy industry sectors compared to BaU. As for the statistical reference value, cumulative output loss of 30% which equals to 63 trillion THB has been observed in energy sector in Peak2020 and 11% which equals to 65 trillion THB has been observed in non-energy industry sector in Peak2020 compared to BaU. In sectoral analysis, cumulative production loss of energy sector especially in coal sector that contains high carbon content will drop significantly by half in Peak2020 during 40 years period compared to BaU. Thanks carbon price that helps transform the country to become low-carbon economy. Agriculture and services sectors which are classified as non-energy sectors affect less from these peak emissions scenarios.

(a) (b)

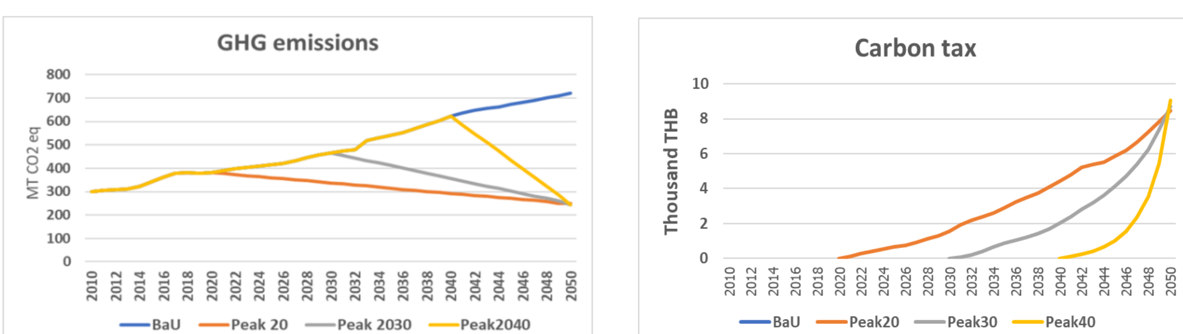

Figure 2 (a) GHG emissions during 2010-2050 and (b) carbon tax during 2010-2050

Table 3 Cumulative output loss during 2010-2050 compared to BaU

Year 2050		Scenarios		
		Peak 2020	Peak 2030	Peak 2040
Sectors	Energy	-30%	-23%	-12%
	Industry	-11%	-6%	-3%
	Agriculture	1%	1%	0%
	Service	-1%	0%	0%

Conclusion

Achieving 2 degree Celsius target will cause Thailand GDP loss observed highest in Peak2020 compared to BaU. Meanwhile, economic structure change can be observed since Thailand will transform to low carbon society in 2050. Carbon price, as an economic external cost, is increased to the highest level (9,072 THB / t CO2.eq) in Peak2040 to keep Thailand on Paris agreement track. In this analysis, since introduction of low carbon technologies such as renewable technologies is limited, the GDP loss and reduction potentials in 2050 among the cases are not different significantly. It is recommended for the future work to introduce various technologies to differentiate the reduction potential in 2050.

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