Impact of Carbon Tax levy on Electricity Tariff in Thailand using Computable General Equilibrium Model

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Abstract
In recent years, issues of climate change and CO_2 mitigatation have become more and more important. Since the electric power generation is one of the key major greenhouse polluters. Measures and technologies to mitigate its emissions are of interest to most countries. This study aims to investigate effects and economic implications of levying carbon tax on electricity generation in Thailand by using the dynamic Computable General Equilibrium (CGE) model.
In this study, economic activities of Thailand were categorized into 40 sectors, with 49 commodities. Four scenarios were assumed: Business as usual (BAU), Low carbon tax rate (LT), 150 baht per ton CO_2 , Average carbon tax rate (AT), 450 baht per ton CO_2 , and High carbon tax rate (HT), 750 baht per ton CO_2. The result shows that, although the imposition of the high carbon tax rate can yield a greater impact on the economic growth, particularly for a short term, its effect is moderate. In addition, its impact on CO_2 is much more effective in a long term than a low tax rate. A tax rate of 150 baht per ton of CO_2 can reduce only 0.50% of CO_2 emission from the BAU case, and the rate is kept constant for the entire period of tax implementation. At a higher tax rate of 450 baht per ton of CO_2, it can reduce 2.2% of CO_2 emission from the BAU case, and it can reduce more in a longer term. The result also shows that, even with the high tax tariff, its impact on the economic growth is moderate, and the effect gradually declines over the years. It can slow down the economic growth by -0.14% from the BAU case on the first year of tax imposed and gradually reduces to -0.12% after a ten-year period.
In conclusion, it was found that an imposition of carbon tax tariff on electricity price to migitate CO_2 emission is possible, provided that a prudent policy to reallocate the tax to improve more efficient production must be deployed as a counter part of this tax regime.
Keywords: Computable General Equilibrium (CGE), carbon tax, electricity

1. Introduction

In modern society, electricity has become a major energy type essential to daily life of people in industry, communication, transportation, etc. Power is also a key factor in the economic development of industry and agriculture which are Thailand's main national outputs. Due to the continuous growth in the economy and population of Thailand, the demand for electric power has dramatically increased over the past two decades.
Although electricity provides a comfortable life style and economic improvement, it creates problems since conventional electricity generation requires carbon based fossil fuel. This emits CO2 which contributes to the global warming issue, a serious environmental problem. The CO_2 emissions have risen from 370 to nearly 395 ppm since 2000 (NOAA, 2013). This may well have contributed to an increase in flooding, storms, earthquakes and possibly new epidemics.
Therefore an awareness of environmental issues of electric power generation has increased since electricity is a key factor in economic growth. Several mitigations have been implemented in many countries, especially developed countries, with carbon tax, higher energy efficiency and renewable technology. Developing countries, such as Thailand, have now started to plan to implement renewable energy and cleaner technologies for better energy security and a cleaner environment. One dilemma of implementation is a higher power generation cost per unit, which induces shrinkage of the economy. Before the government decides what methods could be implemented it needs to take on board all the research studies about the situation of Thailand in order to choose appropriate solutions. This research answers the impact on the economy for implementation of carbon tax for various scenarios in Thailand.
Computable General Equilibrium has been a standard tool in empirical analysis over the last 25 years since data is easy to access and is useful for understanding economic interactions between markets and agents. Therefore

the CGE model has been applied widely in cost policy analysis in the fields of international trade, macroeconomics, public finance and energy-environmental issues. This research will use the recursive dynamic model presented in the CGE model which is able to predict future trends.

Research on energy and environment polices in Thailand has intensively studied power generation in terms of energy security, reduction of production cost and CO_2 emission for all scenarios. In the economy it is difficult to understand the interaction between market, price, international trade and agents and who benefit and who loose from policies implemented. Limmeechokchai and Suksuntornsiri (2007) used Input-output table analysis (IOA) to assess changes in fuel mix during power development planning for CO_2 reduction for each energy mix scenario. Previous research by Ram M. Shrestha and et al. (2004) studied CO_2 mitigation by using cleaner technologies on the supply and demand side management (DSM). The result of this research showed both a CO_2 and electricity price decrease.

A large number of studies have used the CGE model to assess the economic impact in carbon reduction. In European countries a study developed the GRACE-EL model. Comprehensive information from the electricity sector contained in the database of GTAP v6, a multi-sector and recursive dynamic model was developed in order to develop policies that would achieve a 20% reduction in greenhouse gas emission. The conclusion was that holding down the price of emission and electricity would be a poor initiative for energy efficiency and technologies change (Gunner S. Eskeland and et al, 2012). In Asia the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) was developed by the National Institute for Environmental studies (NIEs) in Japan. It has been used in China for research on energy policies for non-fossil energy, energy efficiency improvement and emission control between years 2005 to 2050. The result of this contributed to Dai's thesis on the more serious issue that emission control has a negative impact on GDP and energy intensive sectors suffer more than energy efficient sectors. As a consequence, the demand for electricity declined (Hancheng Dai and et al. 2011). Tax and the increasing primary energy price were shown to have a direct impact on the price of electricity by using the standard CGE model to determine economic effect when increasing coal price for electricity generation.

According to the above, this research also aims to investigate the effect on the economy of Thailand if the carbon tax is imposed on electricity generated from fossil resources. This study applies the CGE model, which is developed from the standard model of Partnership for economic policy (PEP). This study only takes account of CO_2 emission in each scenario of different carbon tax rates and this study covers a period of 10 years from 2010 to 2020.

2. Method

The model is extended from the standard CGE model by PEP, which consists of one region, four sectors, and recursive dynamic model. In this study, the model was modified for one region, 40 activity sectors and 49 commodities (see table 1). The model contains four types of agents, household, firm, government and the rest of the world (ROW). It briefly describes the model's production and agents, as below.

2.1 Production

There are two types of nested production as shown in fig 1. This second-level nested production applies for all sectors in the model. At first level, activity output is determined by fixed coefficient aggregation of value added and aggregation of intermediated product. At the second level, the combination of value added which is composition of labor and capital is followed by Constant of Elasticity of Substitution (CES). The elasticity of substitution between labor and capital is set at rate of 1.5. Data for elasticity of substitution of production were adopted from original model.

2.2 Household

Household is one of final consumers. The household receives income from labor income, capital income and transfer from other agents. Savings of household is a linear function with disposable income, which means saving is a fixed proportion to income. Household demand is represented by the Stone-Geary Utility function subjected to budget constraint. It describes the demand of each commodity when income changes through income elasticity. There is a minimum level of consumption of each commodity, representing the quantitiy of demad at subsistancy level.

2.3 Government

Government collects various taxes from household and business. This study imposed carbon tax only on electricity generation. The carbon tax is assumed basing on the carbon price in the European market, which varies from 17.75 EUD/ton to 2.88 EUD/ton during 2009-2013 and equivalent to 714.26 Baht/ton to 115.90 Baht/ton (at the average exchange rate 1 EUD = 40.24 Baht in year 2012) (BOT, 2013) .Emission factor was adopted from the co_2 emission study by JGSEE (JGSEE, 2012). The government provides expenditures on public service and goods, which support social welfare.

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2.4 International transaction

This model assumes the small open economy, which means their policies could not alter world price or incomes. Like most other CGE models, elasticity of transformation (CET) is used to describe product distribution between domestic and international market subjected to revenue maximation problem. The Armington assumption (CES) is used to differentiate between domestic goods and imported goods. The elasticity of subsubstituiton in CET and CES function is set at the rate of 2.

2.5 *Dynamic parameter*

In this model, the future baseline is simulated through various exogenous parameters, which are population growth, government expenditure growth, expert growth and total investment growth. Throughout all years in all simulations, the population growth in Thailand is assumed at 0.5% from UN World Population project (UN,

Table 1. sector and commodities in the model and definition.

Sec	Activity	Sec	Activity	Com	Comodities	Com	Comodities
1	Paddy	21	Paper	1	Paddy	25	Chemical product
2	Corn	22	Ethanol	2	Corn	26	Gasoline
3	Cassava	23	Chemical	3	Cassava	27	Jet fuel
4	Cane	24	Refinery	4	Cane	28	LPG
5	Oil palm	25	Rubber	5	Oil palm	29	Diesel
6	livestock	26	NonMetal	6	livestock	30	Fuel oil
7	Chcoal	27	Iron	7	Chcoal	31	other refinery
8	Fishery	28	Metal	8	Fishery	32	Gasohol
9	Residue agriculture	29	Motor	9	other agriculture	33	Biodiesel
10	Coal	30	Machine	10	Coal and lignite	34	Rubber
11	Oil Gas	31	other industry	11	Crude oil	35	NonMetal
12	Mining	32	Electricity	12	Natural Gas	36	Iron
13	Food	33	Construction	13	Mineral	37	Metal
14	Palmoil	34	Trade	14	Food	38	Motor
15	rice	35	Rail transport	15	Palm oil	39	Machine
16	Starch	36	road transport	16	Rice	40	other industry
17	Maize	37	Water transport	17	Starch	41	Electricity
18	Sugar	38	Air transport	18	Maize	42	Construction
19	Textile	39	other transport	19	Sugar	43	Trade
20	Wood	40	service	20	Maolar	44	Rail transport
				21	Textile	45	road transport
				22	Wood	46	Water transport
				23	Paper	47	Air transport
				24	Ethanol	48	other transport
						49	service

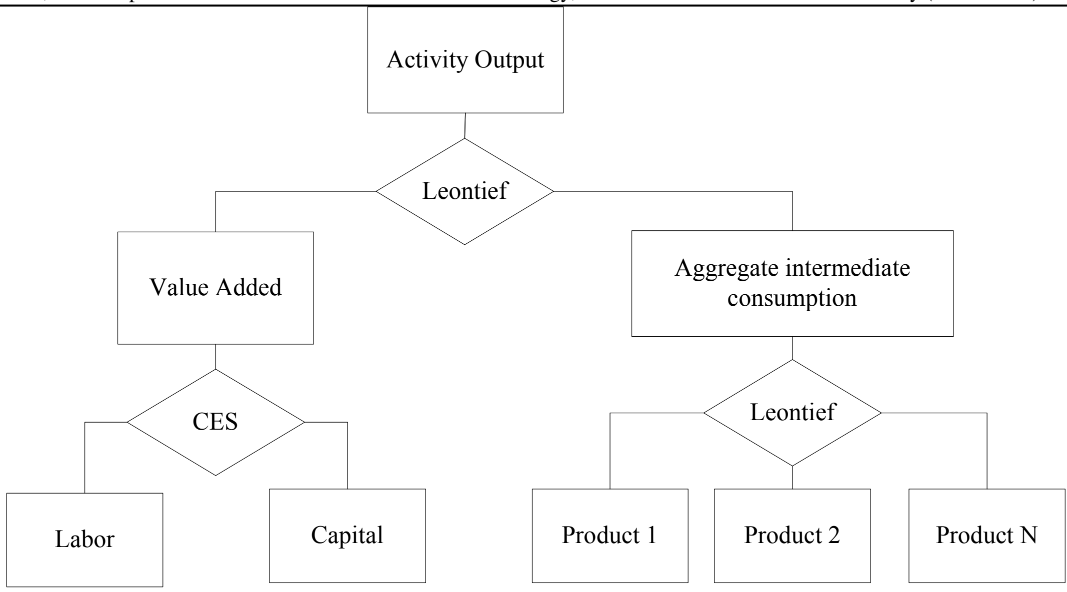

Figure 1. Nested structure of production

2008). The government expenditure growth adopted the average value of 5% from the study and forecasting parameter for Thai Long-Term Business [NIDA, 2007]. The same assumptions are made for export growth and total investment growth at rate of 5% and 10%, respectively. As a result of the dynamic parameters, the model could forecast trends of GDP growth path which is similar to average Thailand economic growth in the year 2000 – 2012. The annual Real GDP growth is about 4.3% and the inflation growth rate accounts for 2.2%. Furthermore, the elasticity of government income per GDP growth is close to actual value of 1.0.

2.6 Database

The database used in this study is based on 2010 social accounting matrix which was developed based on Input-Output table of 2005 (NESDB, 2010). The SAM 2010 was also used in the study of impact on macroeconomic of Thailand's underlying emission control (TGO, 2012).

2.7 Electric generation technology and carbon emission

In this study, technology of electricity generation is based on present situation and enegy mix in year 2010, which consists of natural gas (72.8%), coal (19.8%), oil (0.7%) of total primary fuel input for electric generation (DEDE, 2010).Then, the CO_2 is calulated from those energy mixes.

2.8 Scenario of Carbon tax

In order to study the effect of carbon tax on electricity generation, four scenarios including BAU scenario are analyzed by using this is used in this model is shown in the table 2.

Table CGE model. The BAU scenario assumes that there is no carbon tax policy introduced during study period. The other three scenarios are implied carbon tax rate, high (HT), average (AT) and low (LT) respectively. Carbon price which 2. Carbon price in four scenarios including base case

Scenario		**(baht/tonCO_2)**	
BAU	**LT**	**AT**	**HT**
0	150	450	750

3. Result

3.1 Macroeconomic Indicators

The influence of carbon tax scenarios on GDP is depicted in figure 2, which shows GDP change from BAU case in percentage change. As figure 2, the impact of its make GDP shrinking. In short term, the impact is more serious than long term value because in the long run the rising values of investment and export growth will continuously influence the expansion of GDP and these will offset the negative impace caused by the carbon tax. In low tax scenario, GDP shrinks about 0.028 – 0.018% from year 1 to 10. GDP will decline from BAU by 0.085% – 0.072% in average tax scenario. Finally, in high tax scenario, it is shown that GDP has a reduction from base line by 0.14% – 0.12%.

Likewise, Consumers Price Index (CPI) under various carbon tax implement policy is presented in figure 3. In base case, the inflation rate has a declining growth rate in the future because it assumes that productivity of technologies improves when wage is constant. The effect of carbon tax induced in higher inflation rate.

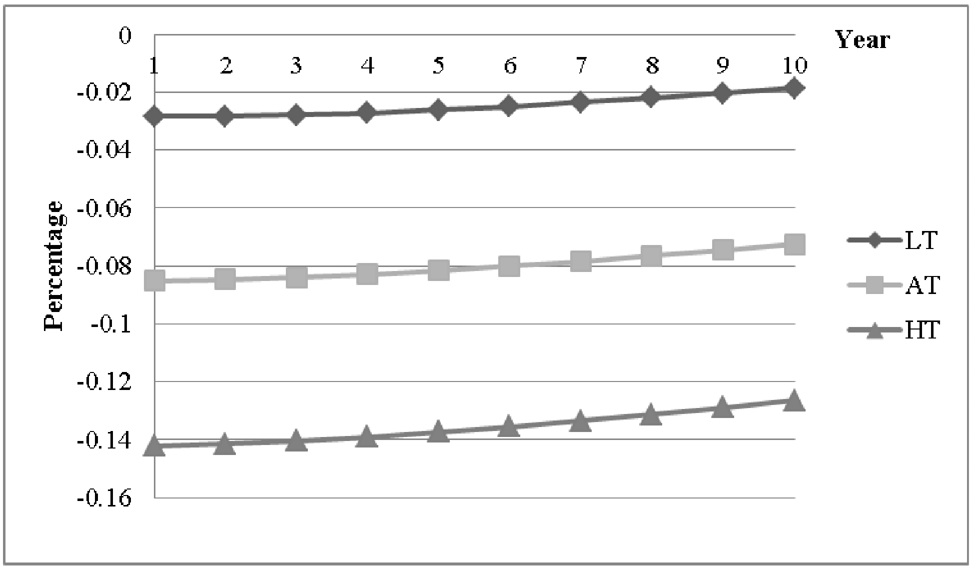

Figure 2. GDP in percentage change from BAU

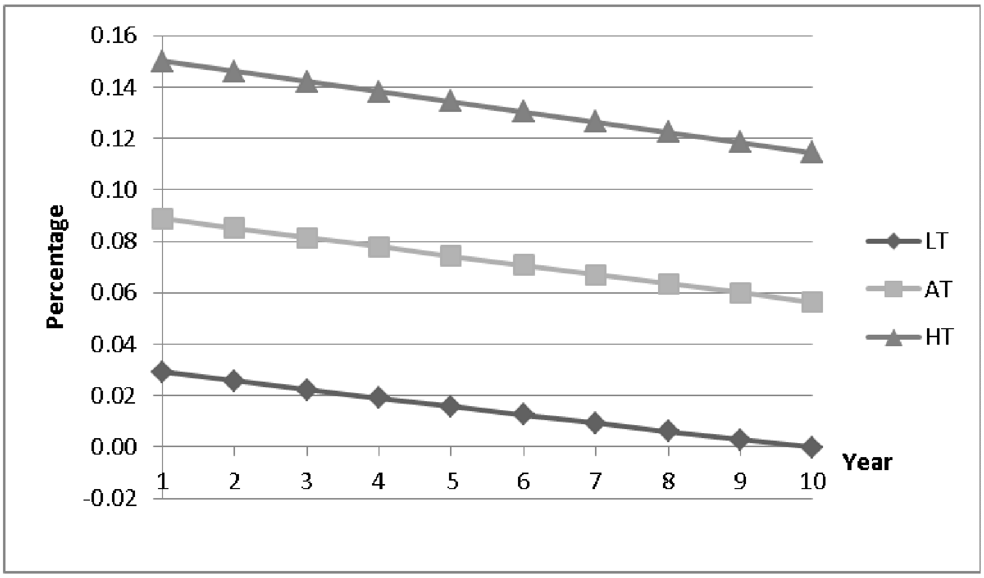

Figure 3. CPI in percentage change from BAU in various taxes secenarioes

In all scenarios, CPI has a higher magnitude of increasing in inflation rate in the earlier periodic and then decrease linearly. In low carbon tax, CPI increasse form 0.029 in the first period to 0.002 in the last period. For aveage tax, it is about 0.088% – 0.056% from BAU. In HT, the downward slope of magnitude of impact is about 0.004 in each year then it impact give about 0.15 to 0.114.

Figure 4 represents percentage change from the base line of household's comsumption budget in each scenario. It shows that the higher carbon tax implies the higher loss in household's disposable income. As a result, every one hundred baht change in carbon price will give the negative impact on disposable income of household approximately 0.1 % of disposable household income.

From results of BAU, total government income growth account for around 4.3 % per year. The result of effect of carbon tax on total government income is that the government absolutely received more income when increasing carbon tax. In long term, percentage change from BAU in all scenarios is slightly dropped compare with the previous period since production activity declines as shown in figure 5. Likewise, due to the incraseing in taxes, the total government income will increase as well.

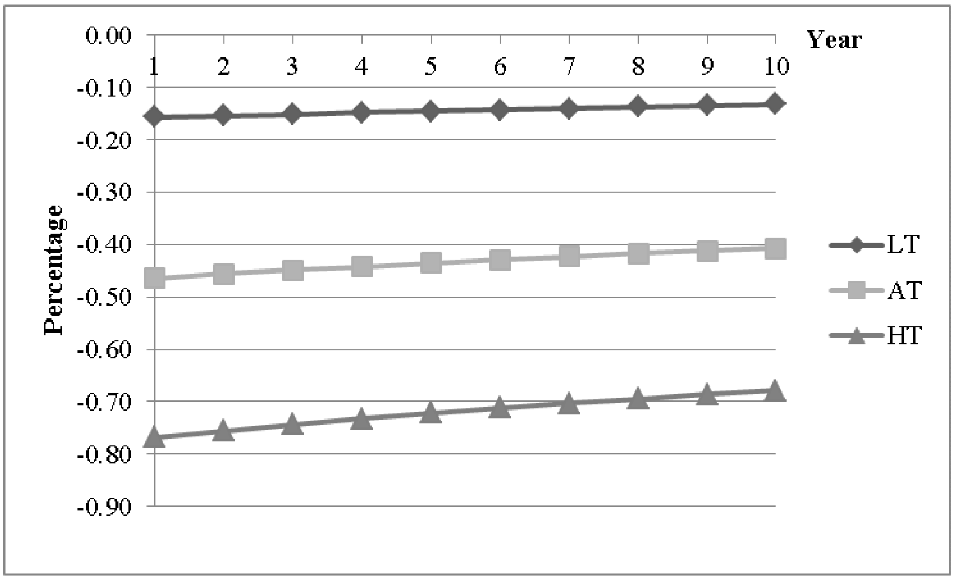

Figure 4. Comsumption budget of household in percentage change from BAU in various scenarioes

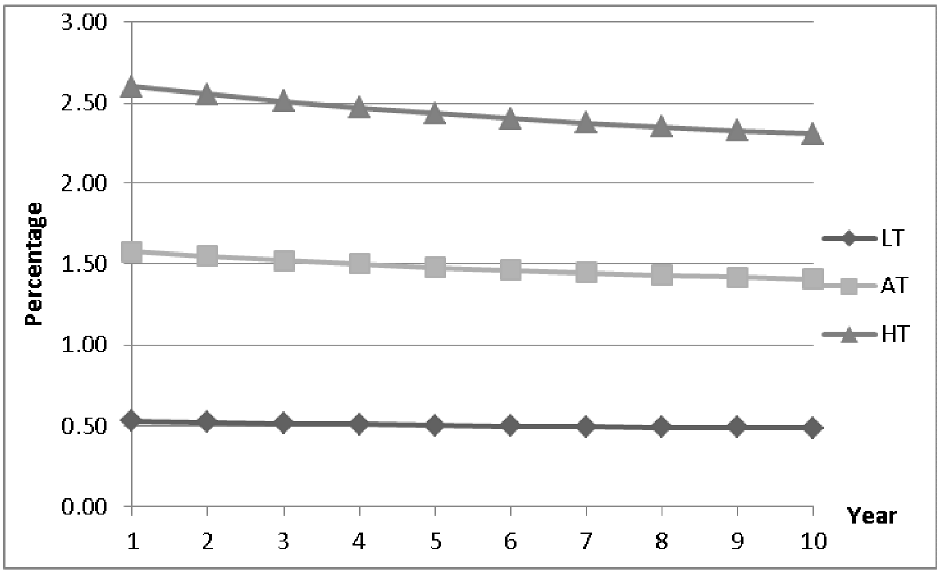

Figure 5. Total Government's income in percentage change from BAU in various scenarioes

3.2 Employment rate

According to lowered GDP influenced by carbon tax, employment rate will decline. As shown in figure 6, high carbon tax scenario induces an increase in unemployment at rate of 1.028% in base year. The more expensive carbon price becomes, the more the employment rate decreases. Likewise, the negative magnitude of decreasing rate in employment will be smaller compared with the previous year.

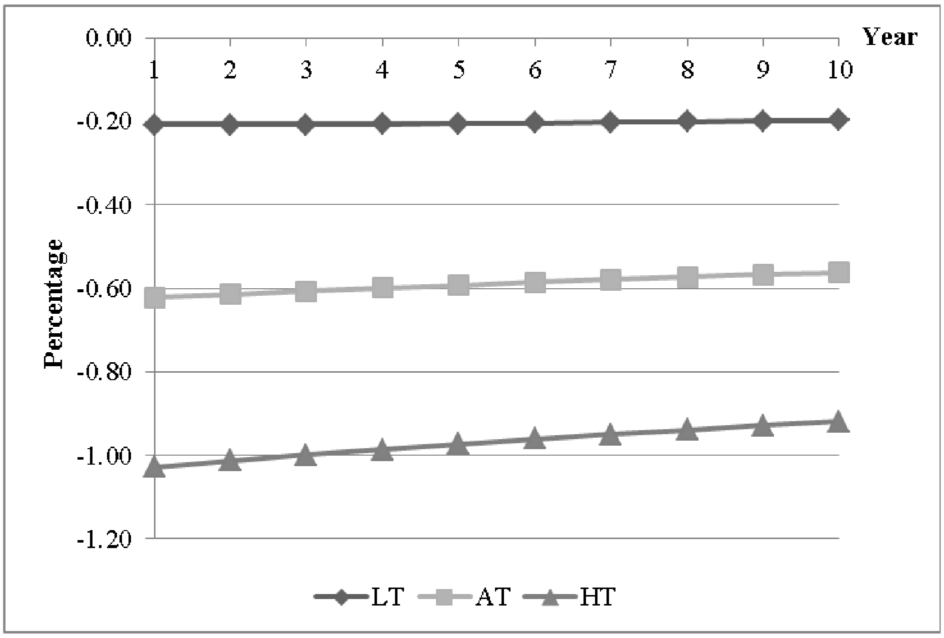

Figure 6. Labor demand change from BAU in percentage.

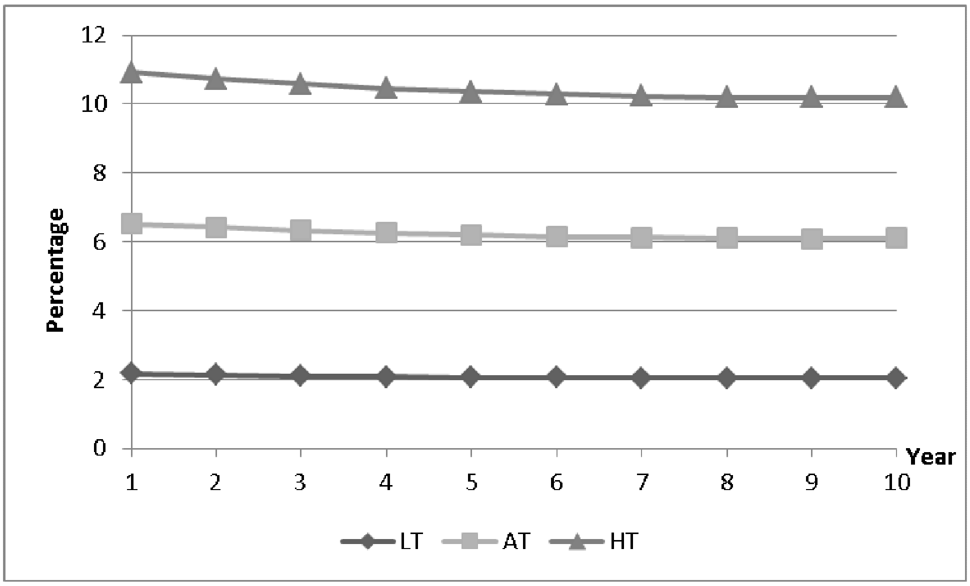

Figure 7 electrictity price change from BAU in percentage change.

3.3 Electricity price and consumption

The electricity price is directly influenced by carbon tax on electricity generation as shown in figure 7. The electricity price will be influenced by carbon tax on electricity generation. As a result, electricity price in all scenarios would increase. In the lowest price of carbon, the electricity price changes from BAU around 2.1 – 1.98 % by diminishing rate in the future. For the average price of carbon, the percentage change from BAU is higher than the lowest price of carbon account for 6.5 – 5.9 %. The electricity price rose around 10 % with the HT scenario.

Increase of electricity price has significant impact on electricity consumption by all agents. Figure 8 shows the impacts in each scenario from Base line. As a result, every one hundred baht charge in carbon per ton for electricity generation would impact on total electricity consumption about 0.44 % and the impact would reduce going forward. As noticed, in long term, the consumption of electricity has a declining trend in high tax scenario since a higher price of electricity will lower most product activities.

3.4 CO_2 emission

As a consequence of total electricity consumption decline, the negative percentage of CO_2 emission in Figure 9 shows carbon reduction from BAU. This percentage change rate increases in all scenarios, reflecting that the whole production activities will be lowered when carbon tax is imposed on electricity sector.

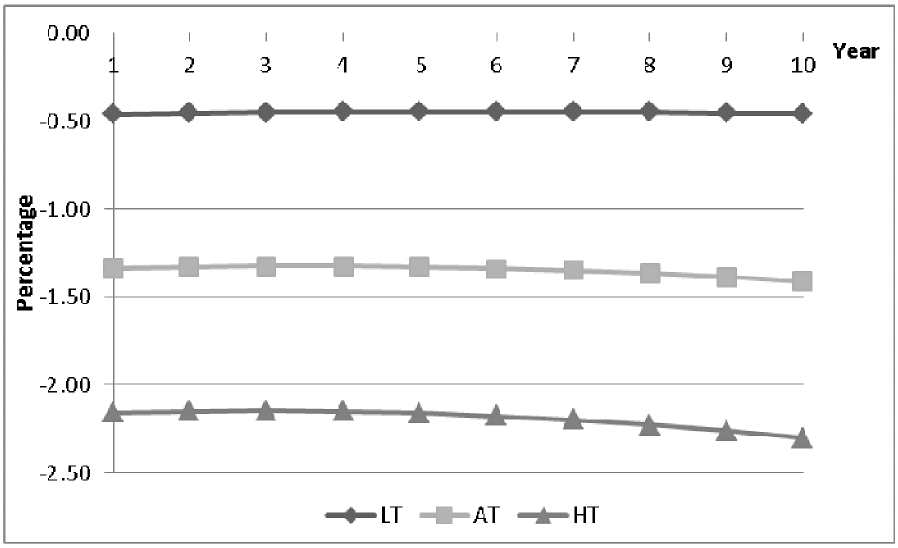

Figure 8. Electricity consumption change in percentage change from BAU.

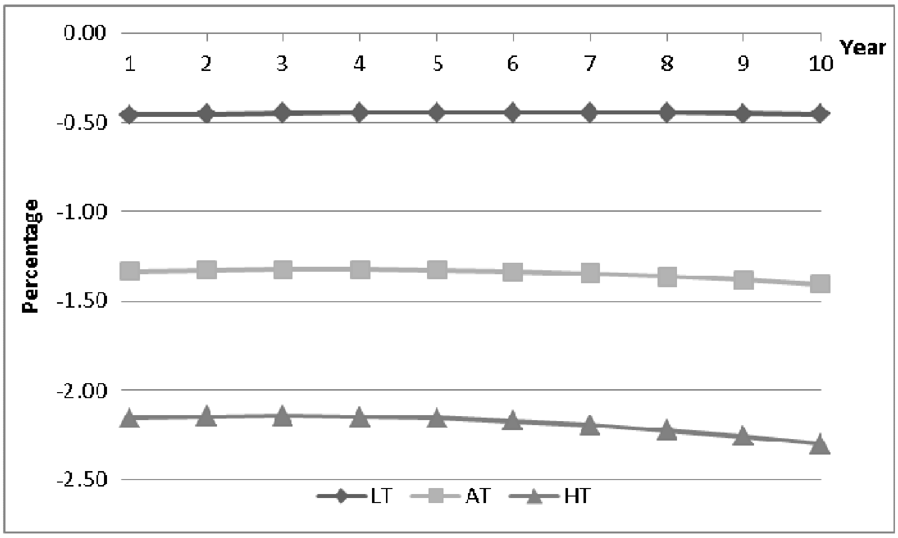

Figure 9. CO_2 emission change in percentage change of BAU

4. Discussion and Conclusion

By imposing carbon tax tariff on electricity cost, it was found that, at the low tax rate (LT), the percentage change in CO2 emission reduciton is almost constant during 10 years at approximately 0.5%. The effect is significantly different for the average tax (AT) rate and the high tax (HT) rate, particularly for HT, which deduction of CO_2 is much more effective in a lonter term.

The impacts of carbon tax tariff are the strongest in the first period of implementation, and then it gradually declines in a longer term. It can affect to high price of electricity which decrease labor demand in the market because of lower consumption. The level of lowering to a total activity output is dependent on how high a tax rate is imposed. The household sector gets less income from its earning due to decrease in demand of labor forces from the households. This affects to household's consumption budget. Contrasingly, under the high tax rate AT scenario, a total income of the government increases, accounts for 1.5%, while the income of the household sector decreases for 0.5%. Since the increase of the government's income grows faster the decrease of the househould's sector, it is very important how the government spends for this extra income. Under this study, we assumed that the increase income of the government is spent for investment in next year for all sectors. This is to makes sure that the collected money from the carbon tax is recycled to stimulate more production with better production efficiency in the following years, to maintain the demand of commodities in the market and it can induce less cost in production for the following years. As a result, the CPI of each scenario of carbon tax declines in a long term. It implies that comsumers' welfare can increase in a long term even the carbon tax policy is imposed.

It is a crucial of this study, which show that, by adopting a sound financial management, one can avoid any unfavourable negative of carbon tax regimes through re-invest in more productive techlogies such as energy efficiency improvement at the end-end level. This implies that if a carbon tax is imposed, a counterpart of sound financial mechanisms for the green policy for energy and production's efficiency improvement must also be implemented in order to minimize the negative impacts of the carbon tax. In this study, we assume a fix constant carbon tax rate throughout a time period (10 years). In practical way, the government can deploy a non-fix constant rate of the tax, such as a low rate at the beginning period and a high rate at the end of the period, or vice versa. It will give some freedom for the government to control any disruption of the economic development due to the negative impact of the carbon tax policy.

By conclusion, this study shows that the implementation of carbon tax on electricity for a developing country like Thailand is possible, provided that a prudent policy for re-cycling of the carbon tax for improving production in a long term is necessary to avoiding any strong unfavourable negative impact on the economic development.

Recommend for further studies

Due to the rigidity of the Social Acounting Model (SAM), which based on input-output model, the electricity generation technologies are assumed to be fixed over the period of this study, which does not reflect reality. A further study on how to modify an intermediate input table to represent new advance technology changes in electricity generation structures in the future is necessary to study on policy implementation on green electricity production by re-cycling of carbon tax to investment in those new technologies. In addition, the application of CES model for energy-economics analysis can be more effective, if more detailed data are obtained to formulate nested and other related production functions, which can represent for primary inputs of each activity of production, can be formulated.

References

Asia-Integrated Model Team (AIM), (2011, June). AIM/CGE [basic] manual, AIM traning workshop 2011.

Bank of Thailand (BOT). Euro zone Exchange rate in year 2012, Available at: http://www.bot.or.th/Thai/Statistics/FinancialMarkets/ExchangeRate/_layouts/Application/ExchangeRate/ExchangeRateAgo.aspx. [Accessed: 2 September 2013].

Bernard Decaluwé, André Lemelin, Véronique Robichaud and Hélène Maisonnave, (2012, May). THE PEP STANDARD COMPUTABLE GENERAL EQUILIBRIUM MODEL SINGLE-COUNTRY, RECURSIVE DYNAMIC VERSION, Partnership for Economic Policy (PEP).

Bernard Decaluwé, André Lemelin, Véronique Robichaud and Hélène Maisonnave, (2012, April). A user guide , Partnership for Economic Policy (PEP).

Bundit Limmeechokchaia, Pawinee Suksuntornsiri, (2007). Assessment of cleaner electricity generation technologies for net CO2 mitigation in Thailand, Renewable and Sustainable Energy Reviews 11, pp 315–330

Dai, H., Masui, T., Matsuoka Y., Fujimori, S.,(2011). Assessment of China's climate commitment and non-fossil energy plan toward 2020 using hybrid AIM/CGE model, Energy Police 39, pp 2875-2887

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, (2010). Electric Power in Thailand.

Govinda R. Timilsinaa and Ram M. Shresth, (2006). General equilibrium effects of a supply side GHG mitigation option under the Clean Development Mechanism, Journal of Environmental Management 80, pp 327–341.

Joint Graduate School Energy and Environment (JGSEE), (2012, August). Study of activity data and Emission factor form fossil fuel in electric generation of Thailan: Final report.

National Economic and Social Development Board (NESDB), (2010). 2005 Input-Output table. Available at: http://www.nesdb.go.th/Default.aspx?tabid=97 [Accessed: 2 September 2013].

National Institute of Development Adminstration (NIDA), (2007). The Study and forecasting parameter for Thai Long-term Business.

Thailand Greenhouse Gas Management Organization (TGO), (2012, September 15). THAI-CGE Manual: Study of impact on macroeconomic from carbon emission deduction policy in Thailand, THAI-CGE traning workshop 2012.

United Nations (UN), (2008). World Population Prospects, The 2008 Revision Population database.