

CHAPTER 1

INTRODUCTION

1.1 Rationale

In modern society, electricity has become a major energy type essential to the 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. As Figure 1.1, it shows electricity consumption between year 2004 and 2012 which have an upper trend in secondary axis [1]. The primary axis shows GDP [2]. It shows that the relationship of GDP and electricity consumption has the same direction especially; Hamburger crisis in year 2009, the consequences were a little decline in GDP and electricity consumption. Similar, flooding in Thailand in year 2011 gives a negative impact on GDP and electricity consumption.

Although electricity provides a comfortable life style and economic improvement, it creates problems since conventional electricity generation requires carbon-based fossil fuels, which emit CO₂ and contributes to the global warming issue, a serious environmental problem. The CO₂ emissions have risen from 370 to nearly 395 ppm since 2000 [3]. This may well have contributed to an increase in flooding, storms, earthquakes and possibly new epidemics.

An awareness of environmental issues due to electric power generation. 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.

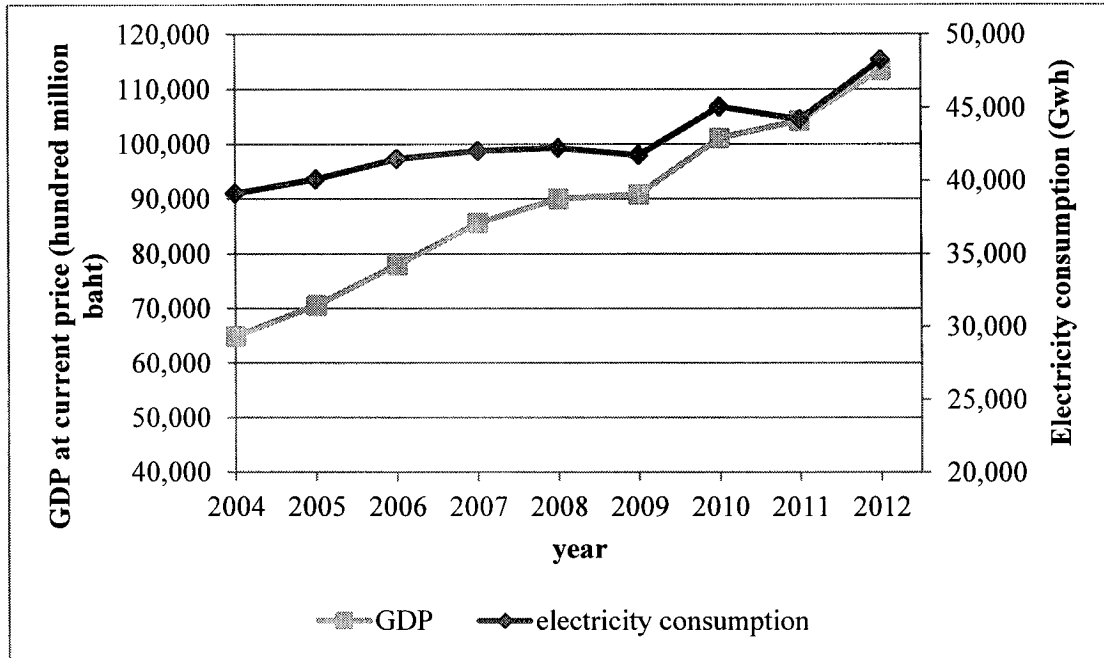


Figure 1.1 Electricity consumption and GDP during years 2004 to 2012. [1, 2]

Over the last 25 years Computable General Equilibrium has been a standard tool in empirical analysis 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.

1.2 State of the Problem

In order to deduce CO₂ emissions from electricity, the taxation was implemented on electricity generation activity at a constant rate during the study period. Its impact on the economy must be assessed in advance to alleviate economic damage and give a guideline how to reduce CO₂ emission. Furthermore, the sectorial impact is investigated to decrease negative impact.

1.3 Situation of Electricity generation and CO₂ emissions in Thailand

For this study, the database was based on year 2010 in which it describes the situation of electricity generation and CO₂ emissions emitted by electricity generation in the base year of the study.

1.3.1 Electricity Generation in Thailand in year 2010

Total electricity generation is about 159,518 GWh, which comes from the total of the generation system 25,094 MW. The electricity generation is categorized by type of energy sources that connect to CO₂ emission as shown in Table 1.1 [4].

1.3.2 CO₂ emissions from electricity generation sector

The CO₂ emitted by the electricity generation sector in year 2010 from the Energy Statistics of Thailand accounts for 90.79 Million tons. It is mainly generated from natural gas, approximately 57.99 Million ton CO₂. The total CO₂ emission generated by electricity generation during year 2004 to 2010 is depicted in Figure 1.2.

1.4 Objective

This study aims to assess the macroeconomic impact of tax policies on electricity generation, since electricity price will definitely rise and have an effect on the economy. Furthermore, the benefit to the environment is measured in terms of CO₂ emission reduction in each scenario. The study investigates this policy in the short term and long term and assumes the technology structure is the same as the base year.

1.5 Scope of research work

1.5.1 This study implements this tax policy on the supply side of the power generation sector.

1.5.2 The period of this study is ten years from the base case.

Table 1.1 Electricity generation categorized by type of energy source [4]

| No | Energy sources | GWh | percentage |
|----|--|---------|------------|
| 1 | Natural gas | 109,454 | 68.6 |
| 2 | Coal and Lignite | 28,207 | 17.7 |
| 3 | Fuel oil | 997 | 0.6 |
| 4 | Hydro power | 5,537 | 3.5 |
| 5 | Co-generation and gas engines of firms | 15,136 | 9.5 |
| 6 | Others (renewable, thermal) | 28 | 0.1 |
| | Total | 159,359 | 100 |

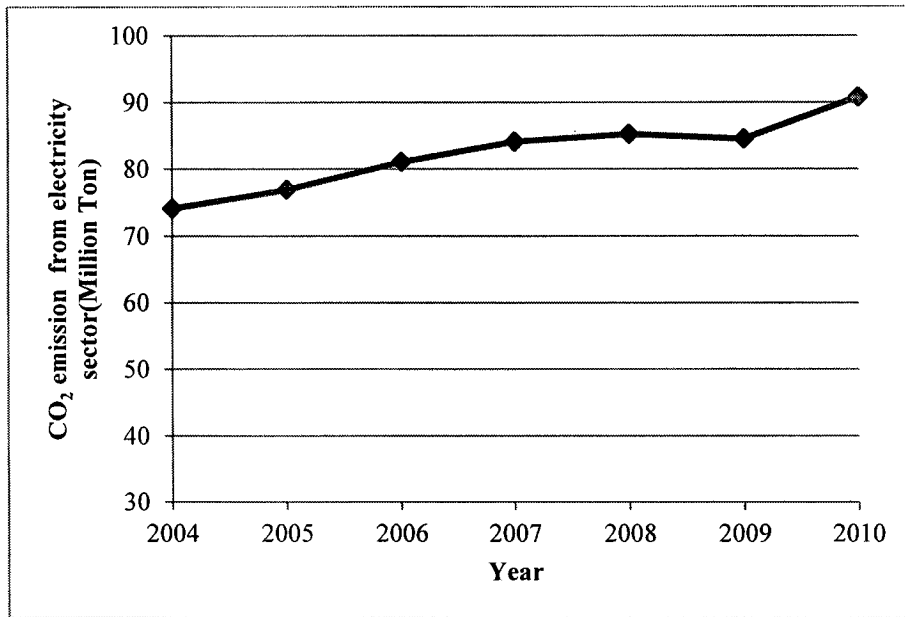


Figure 1.2 CO₂ emissions generated from electricity activity in Million tons [5]

1.5.3 This study assumes that there has been no change in technology structure during the study period.

1.5.4 The study does not include externality costs of electricity generation in determining the impact on the economy of Thailand.

1.5.5 CO₂ emissions are calculated according to electricity output activity.

1.6 Literature review

Computable General Equilibrium has been used widely for the economic analysis of the impact of policies in developed and developing countries. It is basically a top-down model which is able to examine feedback effects between markets caused by policy-induced changes. It describes normally non-energy sector through smooth production function. But it represents a combined top-down and bottom-up model, taking into consideration evolving production technology, to assess the impact of energy policy with changing technologies. It is called hybrid model.

Govinda R. Timilsina (2006) considered the general equilibrium effects of a supply-side GHG mitigation option and the substitution of thermal power with hydropower in Thailand [6]. This model could be considered a hybrid model as mentioned above. It found that it would increase economic welfare in Thailand. The model disaggregated into 21 production sectors of which 6 are energy sectors. The production behavior of each sector is represented by a nested constant elasticity of substitution (CES) production

function. This model divides electricity sector into seven subsectors based on technologies used for electricity generation, Hydro, Internal combustion power generation technology, Coal-, Oil- and gas fired steam turbine technologies, oil- and gas-fired combined cycle/gas turbine technology. The model adopted elasticity of substitution from existing studies such as Bohringer and Rutherford (1997), Naqvi (1999) and Zhang (1997). In order to evaluate substitution impact, output of electric generation is exogenous variable and electric generated from other technologies is endogenous variable, which are adjusted by model simulation. Not only welfare but also the others macroeconomic effects are exhibited. Exports are decreased whereas imports are increased. As a consequence, demand of fossil fuel would significantly decline especially, coal and gas then output of these sectors also decrease compared with baseline.

Even in a developing country (Pakistan), there was a CGE research in year 1998 by Farzana Nagvi. It introduced a computable general equilibrium model of the Pakistan: economy in 1998 [7]. Using input-output table contains 131 commodities which are produced by 128 industries, the model used the Stone-Geary function to describe the household utility function. The model allows changes in relative energy prices to affect household energy consumption depending on share of energy products in households' luxury and subsistence level expenditures. It represents the production structure of each sector, refinery industry, Electricity supply, agricultural industries. In production structure, it basically consists of Constant Elasticity Substitutions and Leontief function. It analyzed short run effect of a policy thus the model does not have a theory of investment so it is considered a statistic CGE model.

In China, there has been researched on coal price-electricity price adjustments using the CGE model. The result found that a rising electricity price caused increasing production costs of different sectors [8]. It shows that the output of the whole society declines while the electricity price rises. GDP consequently drops. In the scenario simulations, it is assumed coal price increases by various percentages. According to a rising coal price, the coal electricity price rises because the electricity price should be increased to retain the profit level of the electric power sector. Hancheng Dai (2011) [9], studies non-fossil energy planning up to 2020 using Integrated Model computable general equilibrium model developed by the National Institute for Environmental Studies (NIES) which is different from Y.X He et.al (2010). The latter model focuses on GHG and develops various scenarios, with different set up parameters, energy supply by non-fossil

energy, capital productivity improvement, capital change, population and labor productivity. The result found that the total electricity consumption in 2020 will rise by around 2.6 times that in 2005. It could be noticed that Electricity generated by subcritical steam turbine diminish dramatically when a scenario is applied that is more strict on GHG. The simulation shows CO₂ price becomes additional burden on the manufacturing which makes cost of the energy per unit output increasing and activity levels in economy fall down.

The effects of alternative generation of electricity on economies has garnered wide interest. Chae Young Lim, et al. (2000) studied the role of nuclear power in the sustainable energy future of South Korea. The study applied dynamic model of CGE by using 1995 base year information to anticipate the effect on the economy between 1995 and 2040. It found that the nuclear option is more favorable to the economy than renewable since it is cheaper [10]. Renewable energy would be introduced as an alternative to nuclear power, when the carbon tax became high enough to compensate for the higher generation cost of renewable technology. This study shows that the higher proportion of electric generation from nuclear plant of total generation capacity leads to lower electricity price. Since PDP2010 considers providing nuclear power, it could contribute to improving the security of energy supplies and lower electricity price in the future so that it would also be good for the economy.

In Vietnam, a study of potential of GHG emission reduction was done by Thanh-Tu Tran et al. [11] used quasi-recursive dynamic CGE with extension of production and the well-disaggregated energy sectors, particularly in power generation. The model divided production function into two groups, non-energy production and energy transformation sectors. The model adopted database year 2005. There are four scenario assumptions, BAU, Emission constraint without emission trading permission, contribution of CCS technology together with emission trading and contribution of renewable Energy together with emission trading. The result found that Vietnam's economy suffers from a reduction in GDP when domestic marginal abatement cost increases because industries must increase their payments for energy consumption under budget constraints.

In the European Union (EU), there has been a focus on reducing GHG as consequences of Europe's 2020 goals. Since the electricity sector is the major emitter, its potential for emission reductions is of great interest to them. The electricity sector is highlighted in EU's police because it contributes a large proportion of emissions

approximately 31% [12]. G.S Eskeland (2012) studied EU objective of attaining 20% reduction in GHG by 2020 using different policies including renewable support. The Global Responses for Anthropogenic Changes to the Environment (GRACE) mode which is a recursive dynamic model is extended with more detail on the electricity sector including 6 electricity generation technologies, gas coal refined oil, nuclear, hydro and wind/solar renewables.

The model constructed the electricity sector with nested Constant Elasticity of Substitution. The top of nested production consists of generation and transmission & distribution activities. The power generation technologies is disaggregated into intermittent (i.e. wind/solar renewable) technologies and standard generation technologies. It was found that supporting a renewable policy with subsidies resulted in the price of electricity and of emissions being held down. This study explains idea how electricity production's bundle is constructed.

Qiang Liu (2009) studied new power generation technologies under the greenhouse gases mitigation in China [13]. The analysis framework of this study is that using an energy technology model to analyze the contributions and roles of promising energy production technologies and how they could reduce future GHG emissions in China. This study used a Model for Energy Supply Strategy Alternatives and their General Environmental impact (MESSAGE) to find the optimal flow of energy from primary energy resources to useful energy demand. It represents the investment choices that lead to the lowest cost of all feasible energy supply mixes to meet the given energy demand. The study set up two scenarios, one is base line condition and the other is mitigation scenario following the world B2 scenario developed by IPCC, 2000. In the mitigation scenario, it applied top-down CGE model, the AIM-CGE model to highlight the linkage of different economic sectors with energy sector. The consistent result is that the mix of primary energy and the mix of power generation technologies play an important role on electricity price and GHG emission. Furthermore, the shadow price of elasticity in mitigation scenario is much higher than the baseline scenario because transitional coal power has been replaced by other technologies having higher total costs of operation and investment costs.