CHAPTER I
INTRODUCTION

1.1 Statement of the Problems

Dealing with the cause of climate change from energy sector has directly impacted or related to economic activity in different aspect such as; how we produced, consumed and traded for energy and goods. The presence of certain gases, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), enables the atmosphere to act like a greenhouse, retaining part of the solar heat. The natural greenhouse effect is desirable as it traps part of the incoming solar energy to maintain habitable temperatures on the earth's surface. Evidently human activity enabling economic and social growth is the primary suspect warming the planet. According to the Fourth Assessment Report (AR-4) of the Intergovernmental Panel on Climate Change (IPCC) stated that average temperatures since the mid 20^{th} century is increased from anthropogenic sources (The Intergovernmental Panel on Climate Change, 2007). Human activities mainly burning of fossil fuels, deforestation, agricultural practices, and manufacturing caused increasing the concentration of greenhouse gases (GHGs) in the atmosphere and enhanced greenhouse effect resulting in higher global average temperatures.

For the past millennium, the Earth's average temperature varied within a range of less than 0.7°C; however. Over the past century manmade greenhouse gas emissions have resulted in a dramatic increase in the planet's temperature over the past century (The Intergovernmental Panel on Climate Change, 2007). The projected future temperature increase could possibly warm the planet by 5°C over the next 100 years due to growing emissions relative to the preindustrial period. Such warming has never been experienced in history of the mankind. The resulting physical impacts would severely affect economics development. Only through immediate and ambitious actions to curb greenhouse gas emissions may dangerous warming be avoided (The World Bank, 2010).

The rapid increase in the atmospheric concentration of carbon dioxide has raised the specter of severe climate change. From large emissions of carbon dioxide, the energy sector is dominated by the direct combustion of fuels[1], as by product of fossil combustion. In a complete combustion, the total carbon content of fuels would be converted to CO_2). During combustion, the carbon and hydrogen of the fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. This heat is generally either used directly or used (with some conversion losses) to produce mechanical energy, often to generate electricity or for transportation (Sell, 2007).

A variety of human activities is contributing to the release of greenhouse gases into the atmosphere. Among the many human activities that produce greenhouse gases, the use of energy represents by far is the largest source of emissions. Anthropogenic greenhouse gas emissions are key factors in global climate change mitigation, especially carbon dioxide emissions from energy combustion activities. Global climate change can be considered a "Tragedy of the Commons" type of classic environmental problem for which no effective global coordination, regulation, or enforcement has yet been implemented by far. From study of the World Resources Institute (2008) illustrated a complete picture of global GHG emissions, energy-related emissions accounted for about 60 percent of the world total. At the sector level, the largest contributors to global emissions are electricity and heat (collectively 24.6 percent), land-use change and forestry (18.2 percent), transport (13.5 percent), and agriculture (13.5 percent). The International Energy Agency (2009a) present the concentration of CO_2 in 2005 was 379 ppm or about 35% higher than a century and a half ago, with the fastest growth occurring in the last ten years (1.9 ppm per year in the period 1995-2005).

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[1] Energy includes emissions from "fuel combustion" (the large majority) and "fugitive emissions", which are intentional or unintentional releases of gases resulting from production, processes, transmission, storage and use of fuels (e.g. CH_4 emissions from coal mining or oil and gas systems).

Emissions of carbon dioxide, the number one greenhouse gas amongst the six covered by the Kyoto Protocol. Moreover, energy development is a barometer of economic progress. The substitution of energy for human power in the performance of agriculture, industry and domestic services has contributed to the process of economic growth. Energy is also a key driver of social and economic development. A world without energy is inconceivable and would be incapable of development, sustainable or otherwise. The increased availability of energy services stimulates economic activity along different stages of the development process. Economic development accelerates when a society uses energy in new forms, adaptable to a range of needs based on its social and cultural characteristics (Reddy, Assenza et al., 2009). There is increasing consensus in both the scientific and political communities that significant reductions in greenhouse gas emissions are necessary to limit the magnitude and extent of climate change. Anthropogenic greenhouse gas emissions are key factors in global climate change mitigation, especially carbon dioxide emissions from energy combustion activities.

The use of fossil fuels for the production of energy is leading to buildup of carbon dioxide in the atmosphere, which traps heat and warms up the Earth. The result is changing patterns of precipitation and drought, increasing extreme weather events and sea-level rise (Sell, 2007). The largest emissions come from road transport (9.9 percent), residential buildings (9.9 percent), oil and gas production (6.3 percent), agricultural soils (6.0 percent), commercial buildings (5.4 percent), and 4.8 percent from chemicals and petrochemicals. The concentration of CO_2 emission increases from 21,283 million metric tons of CO_2 in 1990 to 25,579 in 2003. The emission per capita change from 4.0 to 4.1 metric tons of CO_2 per person in 2003 respectively When weighted by their GWPs, CO_2 typically represent over 99 percent of the greenhouse gas emissions from the stationary combustion of fossil fuels (The Intergovernmental Panel on Climate Change, 2006). These changes affect poor countries and vulnerable people disproportionately, in the form of failed crops, devastating floods and vector-borne diseases. Species and habitat loss is also exacerbated. Therefore, efforts to curb climate change particularly focus on how we use energy.

Impacts of climate change are likely to include changes in precipitation patterns, increased frequency and intensity of storms surges and hurricanes, changes in vegetation, and a rise in sea level. Developing countries, especially the poor ones, are more vulnerable to these changes given their high dependence on natural resources and their limited capacity—human, financial, and institutional—to adapt to extreme events. Climate changes can have severe adverse impacts on the health and livelihood of the poor. Extreme climate conditions exacerbated by climate change can divert scarce development resources from poverty reduction into disaster recovery.

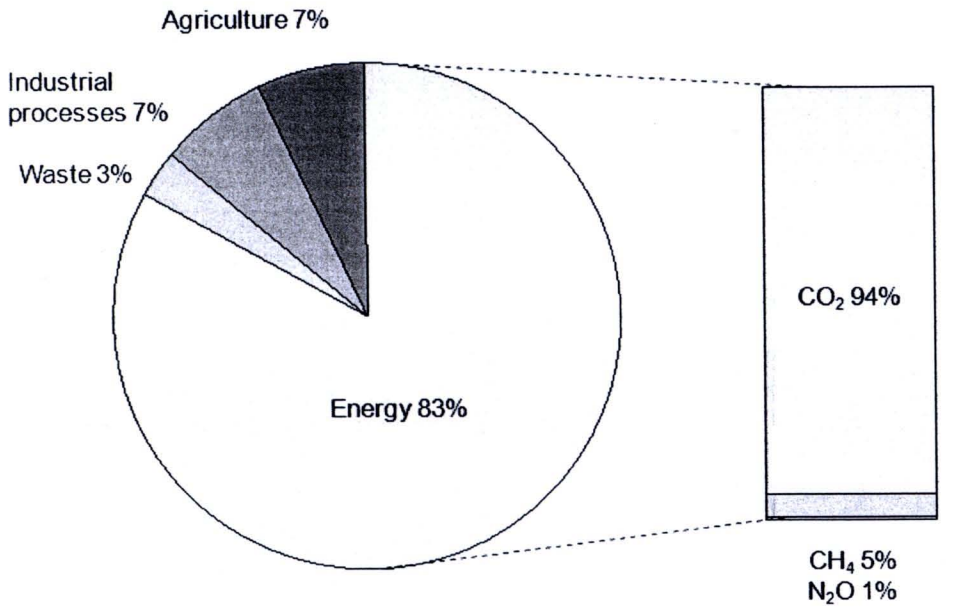

Figure 1 Greenhouse Gases Emission in 2006 Classified by Sources

Source: Using data from International Energy Agency (2009a)

The electricity utilities industry faces an enormous responsibility in the global fight against climate change. During 1993 to 2008, carbon dioxide emissions from electricity generation in Thailand have increased by 16.5 percent and this large amount is resulted from demand growth in electricity production (27.8 percent between 1993 and 2008). Ministry of Energy (MOE) reported the CO_2 emission per capita of Thailand increased from 1.85 to 3.06 during 1993 to 2008. Electricity consumption per population rose from 965 to 2,129 kWh per capita during 1993 to 2008 respectively (Figure 2). Department of Alternative Energy Development and Efficiency (DEDE) (2009) estimated amount of GHGs emission from Thailand would

reach 559 $MtCO_2$ over period 2005-2020. The average growth of total GHGs emission is estimated to be 3.2 percent per year while emission from energy sector is 4.7 percent per year (Figure 3).

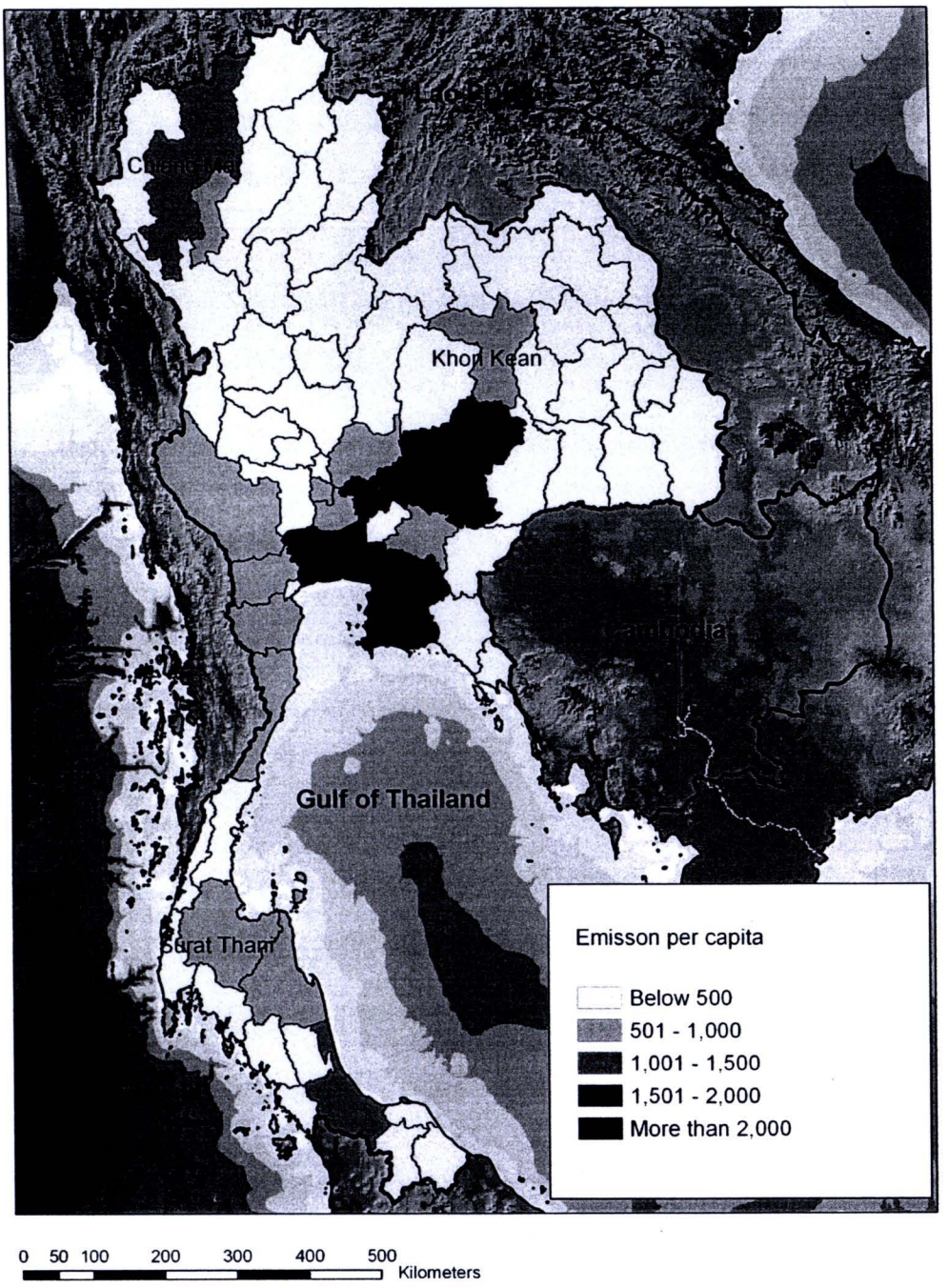

Figure 2 Emission per Capita in 2009

Source: Using data from OERC (2010)

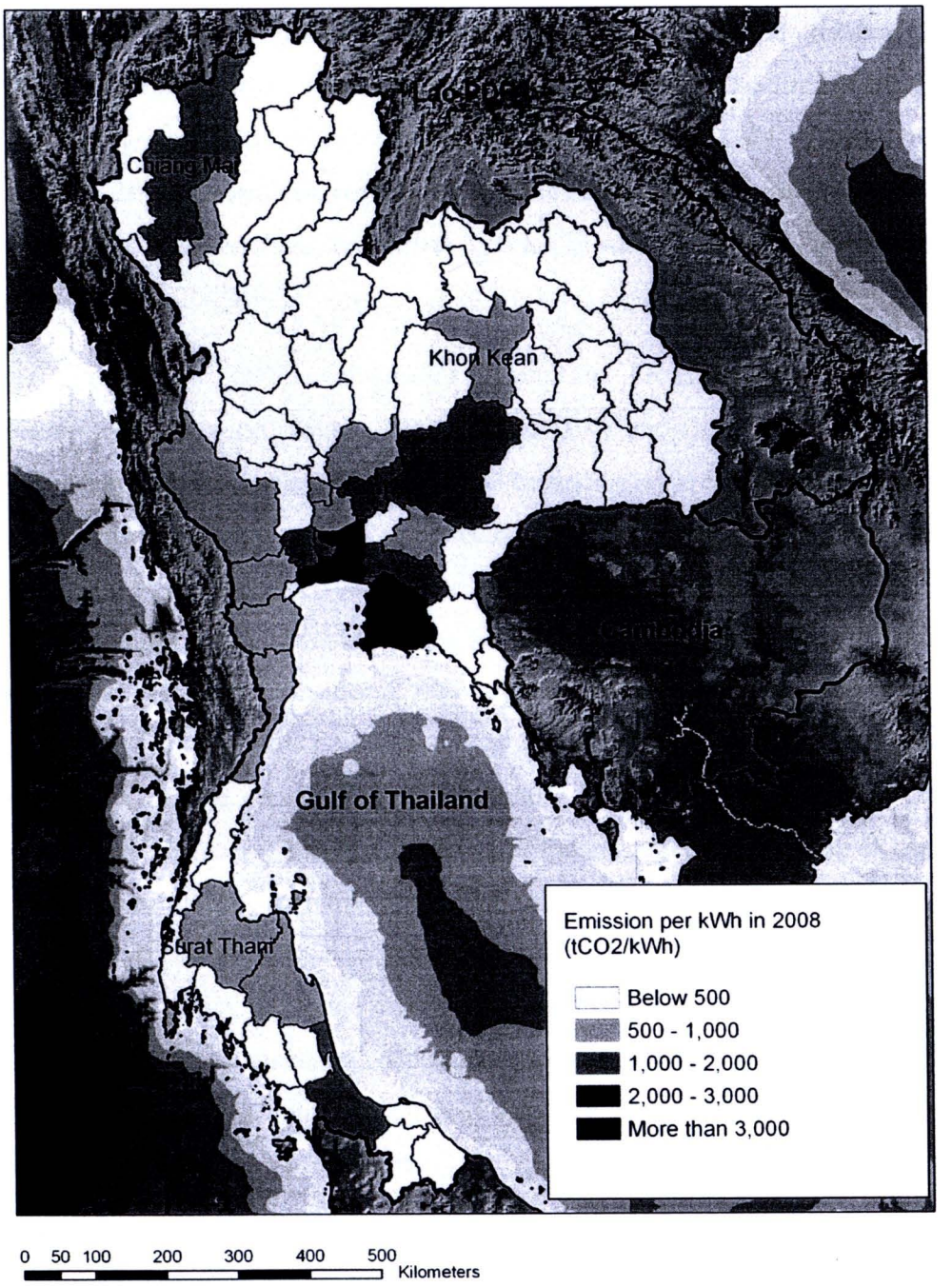

Figure 3 Emission per Unit in 2008

Source: Using data from OERC (2010)

Climate change is a serious and urgent problem, global in its cause and consequences. Stabilizing greenhouse emissions to limit climate change is a worthwhile insurance strategy for the world as a whole, including the richest countries. It is an essential part of our overall fight against poverty and for the

Millennium Development Goals (MDG)[2]. This dual purpose of climate policies should make them a priority for leaders around the world (United Nations Development Programme, 2007). Recent years have witnessed a fundamental change in the way governments approach energy-related environmental issues. Promoting sustainable development and combating climate change have become integral aspects of energy planning, analysis and policy making in many countries (The International Energy Agency, 2009a).

Low carbon electricity generation focuses on renewable energy resources such as wind, solar - Photovoltaic (PV) and Concentrating Solar Power (CSP) – hydroelectric power but also new technologies are emerging/maturing such as ocean energy, combined heat power (CHP) and fuel cells. At least one example of each of the above mentioned renewable energy resources is discussed in this section, with the appropriate renewable energy source indicated in the respective paragraph heading itself (KEMA Consulting, 2009). Thirty years ago, climate change problem was a theory. But in the past decade, global warming is now a household term, deemed one of the most difficult problems facing society in the new century (Randolph and Masters, 2008). Effective policy and regulation will be at the core of the response to global warming. In fact, the transition to a low-carbon economy might be the first global economic transition of this scale to be driven largely by policy. Designing this policy is a huge challenge to political leaders and regulators: it needs to achieve aggressive emission reductions, incorporate many sectors of the economy, be acceptable by many countries, be cost effective, and be equitable among the many stakeholder groups that are concerned.

Thailand should contribute to mitigate the impact of climate change as a member country of the world community, in a drive towards a decrease in GHG emissions resulting from activities in various sectors. It is likely that the main threat that will face fossil energy in the future is the development of catastrophic evidences

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[2] The Millennium Development Goals (MDGs) are eight international development goals that all 192 United Nations member states and at least 23 international organizations have agreed to achieve by the year 2015. They include reducing extreme poverty, reducing child mortality rates, fighting disease epidemics such as AIDS, and developing a global partnership for development.

on the climate change. It will put strong pressure to reduce drastically the carbon emissions.

1.2 Objectives

The overall objectives of this research were to analyze pathways for implement low carbon electricity development in Thailand. This thesis combined processes investigation, emissions estimation to understand effects and environmental burdens from energy generation especially on power generation sector under different policy approaches. Based on the above considerations, this thesis has key objectives as follows:

- To analyze current situation and emission estimation of Thailand's electricity generation system under different policy approaches

- To identify the important obstructers or limiting factors affecting emission reduction and to examine options for implementation of low carbon electricity development pathways

- To recommended policies and potential outcomes of various combination of electricity generation system under possible policy approaches

1.3 Research questions

To meet the research goals in developing pathway for low carbon electricity development in Thailand, the research plan to examine the following key questions.

To evaluate policy instruments for emission reduction and management from electricity generation industry; this thesis focuses on the following research questions:

1. What is the current situation and emission rate of electricity generation industry in Thailand?

2. What are the key factors affecting the implementation of low carbon electricity development? How much impact of each factor from the past and into the future?

3. What are the strategies, options and cost for electricity industries for reducing greenhouse-gas emissions?

4. What pathways are the most appropriate comparing greenhouse gases emission reduction and cost for Thailand? How to achieve them?

1.4 Scope of this study

This study focuses on comparing the GHG emission under different scenarios or policy approaches to understand the potential of emission reduction and classify electricity generation activities to simulate emission scenario under three assumptions. First, project activities that generate electricity and delivered to the power grid, in effect displacing electricity from other sources. Secondly, project activities reduce consumption of grid electricity. The emission situations are estimated by determining GHG emissions of the sources of electricity that displaces or avoids from situation. This study excluded some of technology for low carbon electricity production. For example, stationary fuel cell, most research is currently aimed at fuels cells in the transport sector and less at stationary fuel cells. The use of fuel cells requires the shift towards another energy infrastructure, and such a shift is generally not expected to take place on a large scale before 2030. Therefore this option is excluded from this study.

1.5 Research methodology

This study focuses on comparing emission and constrain of low carbon development in Thailand. In order to assess the carbon dioxide emissions reduction potential of Thailand's electricity sector, this research employs three scenarios based on the "Long-range Energy-environment Alternatives Planning" (LEAP) software framework, developed by the Stockholm Environment Institute at Boston Center to simulate the different development paths in this sector. To identify the contributions and the challenges of establishing a sustainable energy supply system, three scenarios

are prepared in this research for Thailand's energy consumption and related carbon dioxide emissions up to 2030, which includes Business as usual (BAU), with nuclear scenario (WNC) and without nuclear (NNC) electricity development options (See also in Appendix B). Each scenario is linked to framing of particular policies and defines the supply side characteristics and assumptions used, then employ energy modeling techniques to quantitatively analyze the three scenarios, evaluate them and compare them against each other. Field surveys and interviews have been carried out with people involved in electricity production activities.

The cost estimation presented in the study were calculated based on the International Energy Agency (IEA) methodology, using input parameters provided by literature reviews, site visiting, and interviewing. This study also estimated cost of power generation, and the cost data were collected from 43 power plants (See also in Appendix C). This comprises 4 coal-fired power plants, 19 gas-fired power plants, and 20 plants based on other fuels or technologies. The cost estimation presented in the study were calculated based on the International Energy Agency (IEA) methodology, using input parameters provided by literature reviews, site visiting, and interviewing.

The data provided for the study highlight the increasing interest in renewable energy sources for electricity generation, in particular in combined heat and power plants. Figure 4 illustrates the overall task in this study. After getting all data, scenario analysis are performed. All results will be used together

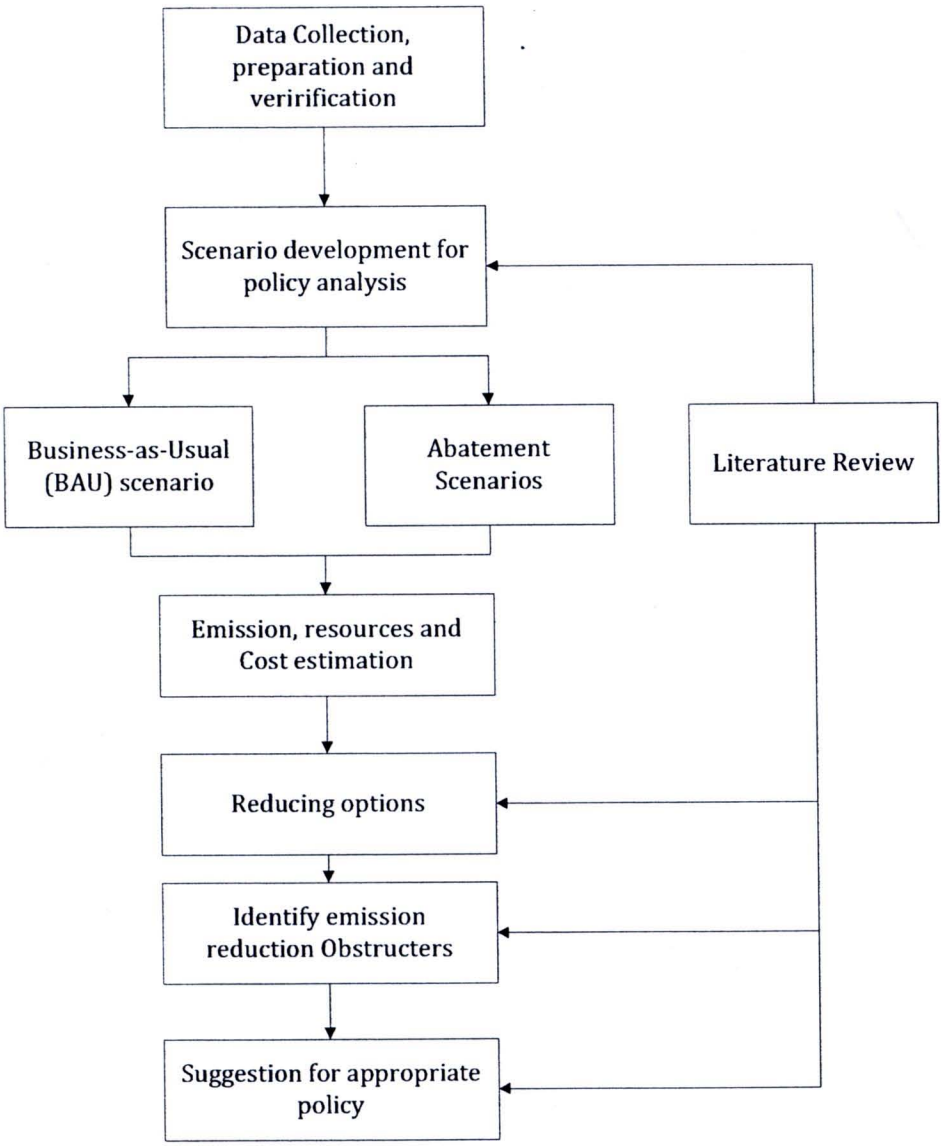

Figure 4 Overview of research methodology

1.6 Organization of the thesis

This thesis is structured into six chapters and seven appendices to provide information, results finding and published papers related to this study. The first chapter gives introduction in the work, including problem statement, objective and organization of the thesis. After the first chapter, a thorough literature review presents the concepts, frameworks and considerations for low carbon electricity. The third chapter describes Thailand's current electricity development situation. In the fourth chapter presents Thailand's electricity expansion policy, emission scenario,

impact on energy consumption, greenhouse gas emissions and prospect for low carbon electricity development to year 2030.

In chapter fifth identifies barriers hindering the low carbon electricity development, options and challenges for promoting low carbon electricity development. Conclusions and Policy recommendations to implementation of low carbon electricity development in Thailand will present. In chapter sixth, policy suggestion for fuel diversification to low carbon emission in electricity generation, conclusion and recommendation for future study were presented.

Appendix A presents Status and Outlook for Thailand's Low Carbon Electricity Development by reviewing the latest situation on renewable powers and developmental strategies toward low carbon electricity generation in Thailand. In Appendix B gives an assessment of electricity development pathway toward low carbon electricity development for Thailand. The analysis presented realistic implementation potential for greenhouse gas emissions reduction from electricity sector in Thailand and compared mitigation options to identify active, cost-effective alternatives for the country.

Appendix C presents projected costs of generating electricity in Thailand and provides reliable information on the economics of electricity generation. Appendix D explains and gives information on capacity under Thailand Power Development Plan (PDP-2010). In Appendix E presents approved CDM methodology under UNFCCC. In appendix F presents review of Renewable Energy Promotion Policies in Different Countries (OECD and Non OECD). In appendix G present the general description of LEAP model.