CHAPTER IV
ELECTRICITY EXPANSION POLICY AND PROSPECT FOR LOW CARBON ELECTRICITY DEVELOPMENT

4.1 Thailand's electricity expansion policy

This section reviewed the electricity expansion policy that include Power Development Plan (PDP), Alternative Energy Development plan (AEDP), the concept of low carbon electricity abatement and emission scenario to understand Thailand's characteristics under different assumption.

4.1.1 Power Development Plan (PDP)

The choice of electricity generation technologies not only directly affects the amount of CO_2 emission from the power sector, but also indirectly affects the economy-wide CO_2 emission. It is because electricity is the basic requirement of economic sectors and final consumptions within the economy. In Thailand, although the power development plan (PDP) has been planned for the committed capacity to meet the future electricity demand, there are some undecided electricity generation technologies that will be studied for technological options. Thailand Power Development Plan 2010 – 2030 (PDP 2010) was formulated by the Electricity Generating Authority of Thailand (EGAT) under the policy framework of the Ministry of Energy, in terms of reliability of power supply, fuel diversification, power purchase from neighboring countries, and power demand forecast, etc.

To power future energy supply, Thailand issued the 20 years Power Development Plan covered a period 2010 to 2030 (PDP-2010), to enhance reliability of power supply, fuel diversification, power purchase from neighboring countries, power demand forecast and others. The PDP-2010 was approved by the National Energy Policy Council (NEPC) and endorsed by the cabinet in April 2010. The PDP-2010 aims to reduce the country's dependence on natural gas from 68.2 percent to 55.6 percent in 2030 while increasing the use of renewable fuel from 14.7 to 19.0

percent and nuclear to 5.3 percent (Electricity Generating Authority of Thailand, 2009).

At the same time, the use of lignite will be cut from 9.0 percent to only 6.3 percent. If the plan remained unchanged, the power system would reflect with high reserved margin. Furthermore, the power development projects in Lao PDR, which tariff MOU have expired or were terminated, are required to review and re-negotiate their proposed tariff. Under PDP-2010, the total install capacity is 36,335 MW and the total capacity of retirement of old power plants is 19,973.7 MW which is divided into 3,046 MW of EGAT thermal power plants; 4,776 MW of EGAT combined cycle power plants; 2,926.6 MW of Thermal IPP power plants and 9,225.1 MW of IPP combine cycle power plants (Electricity Generating Authority of Thailand, 2010b). For more details on PDP 2010 see also in Appendix D.

4.1.2 Alternative Energy Development plan (AEDP)

Renewable energy systems already reduce greenhouse gas emissions from the energy sector, although on a modest scale. As an agricultural country, Thailand is full of agricultural products, high potential for all types of renewable energies exists in the country and strengthen the national energy security. The Ministry of Energy has launched an ambitious program to increase investments in renewable energy e.g. wind, solar, biomass, and other clean renewable energy sources. Ministry has also initiated the 15-Year Alternative Energy Development plan (AEDP) from 2008 to 2022 to speed up the important of renewable energy usage. These policies will promote energy security of the kingdom by reducing energy imports and increasing energy resources, building competitive energy market for sustainable economic growth, and help reducing the emission of greenhouse gases in the long-run (Ministry of Energy, 2009).

The Energy Industry Act, BE 2550 (2007) came into force on December 11, 2007 and established a new regulatory regime for electricity and natural gas business. One of the main objectives of this act includes promotion of the use of renewable energy. The cabinet approved a 15-Year of AEDP on January 28, 2009. The announced goal is to speed up the utilization of renewable energy to constitute up to 20 percents of total energy consumption by 2022. Policies that came out from the plan will promote energy security of the kingdom by reducing energy imports and increasing domestic energy resources, building competitive energy market for sustainable economic growth, and help reducing the emission of greenhouse gases in the long-run (Ministry of Energy, 2009).

For increase sharing of renewable energy mixed to 20% of the final energy demand in 2022, the AEDP is divided in to three phases: the short term from 2008 to 2011, the mid-term from 2012 to 2016, and the long term from 2017 to 2022. The AEDP detailed target for electricity generation from renewable sources is summarized in Table 7. The short-term focuses on extending renewable energy proportion to 15.6 percent of the total energy consumption by promoting of proven renewable technologies and high-potential renewable resources such as biofuels and thermal energy generation from biomass and biogas with full financial supports. The mid-term expansion goal is to boost up renewable consumption to 19.1 percent of the total energy consumption.

The mid-term strategy is concentrated on the efforts to promote the renewable technology industry, to support the new renewable technology prototype development to make it economically sound, to encourage cutting-edge technologies in the biofuels production and the green city model development, and to strengthen the local energy production. The long-term development goal is to develop the renewable energy at 20.3 percent of the total energy consumption. The long-term development plan focuses on adoption of economically viable cutting-edge renewable technology including the further implementation of the green city and decentralization of the technology to local community, as well as on promotion Thailand to become the ASEAN biofuels and renewable energy technology hub.

Table 7 Target for Electricity Generation of Renewable Energy from 2008 to 2022

Unit (MW)	Actual 2009	Target		
		2008-2011	2012-2016	2017-2022
Biomass	1,610	2,800	3,220	3,700
Mini/micro hydropower	56	165	281	324
Municipal solid waste	46	78	130	160
Solar	32	55	95	500
Biogas	5	60	90	120
Wind	1	115	375	800
Total	1,750	3,273	4,191	5,605

Source: Ministry of Energy (2009) and EGAT (2010b)

4.2 Abatement opportunities for low carbon electricity development

Energy modeling is a popular and widely used approach to identify the energy consumption, pollution emissions, technology pathway, energy policy and global scenarios. Scenario planning is a useful approach to design and plan long-term electric infrastructure to cope with the uncertain future demand for power (Ko, Huang et al., 2010; Mulugetta, Mantajit et al., 2007). Randolph and Masters (2008) discuss on three complicating factors for implement low carbon emission policies. First, progress is slow toward alternatives to conventional fuel and reduces demand growth. We are nearly as dependent on fossil fuels now as we were in the 1970s. Although demand growth in developed countries has slowed, it offset by the increasing demand in the developing world. World energy usage nearly doubled from 1975 to 2005, and we remain dependent on fossil fuels, especially oil. Second, transition to sustainable energy faces barriers to change, including uncertainty about supply options and their impacts, economic and political interests that fight to protect their status quo, and consumers' resistant to change their behavior. Consumers continue to desire bigger cars and houses and more energy-consuming products. Lastly, time is short.

Over the past three decades, the economy and environment have provided clear signals that our energy patterns are not sustainable. Despite these warnings, we have done little to alter our patterns of use. The international community has begun to assess a range of possible options for strengthening the international climate change effort after 2012. Thailand also does its best to help reduce global GHG targets while (minimizing impact on) maintaining economic growth. This study analyzed the realistic implementation potential for GHG emissions reduction from electricity sector in Thailand. Comparison mitigation options are crucial to identify cost-effective alternatives for the country.

4.2.1 Framework for identification of emission abatement opportunities

Emissions abatement in the Power sector is achieved by reducing demand for electricity, or by replacing fossil-fuel power generation with low-carbon alternatives. To identify the contributions and the challenges of establishing a sustainable energy supply system, three scenarios are prepared in this research, which includes Business as usual (BAU), with nuclear scenario (WNC) and without nuclear (NNC) electricity development options. Appendix B explained detailed assumptions in the study. This study presents three scenarios for Thailand's energy consumption and related carbon dioxide emissions up to 2030. It explains the crucial technologies for Thailand as it leaves a business-as-usual trajectory and joins a low carbon pathway.

The energy modeling techniques was employed to quantitatively analysis all three scenarios and compare among each scenario. Each scenario is linked to frame particular policies and defines the supply side characteristics and assumptions used. 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. However, scenario analysis is not a prediction of the future; it is a valuable tool for exploring the impact of particular sets of policies on energy and emissions. The scope of the modeling exercise was restricted to energy and energy-related greenhouse gas (GHG) emissions (predominantly CO_2). The major sources of energy consumption and emissions in Thailand – industry, buildings and transport – are captured in the analysis.

For cost estimation from power generation, cost data were collected from 43 power plants. This comprises 4 coal-fired power plants, 19 gas-fired power plants, and 20 plants based on other fuels or technologies. The cost estimates presented in the study were calculated based on the International Energy Agency

(IEA) (2010) 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. The technologies considered were all conventional boilers except two advanced integrated coal gasification plants.

Most of the coal-fired power plants for which cost estimates were provided would be equipped with pollution control devices that reduce atmospheric emissions of sulfur and nitrogen oxides, dust and particulate. Hydropower plants are excluded from this study because their costs are site specific and, therefore, not relevant for comparison to other alternatives in the framework adopted (More details of cost calculation described in Appendix C).

4.2.1.1 Reference scenario (BAU)

The BAU scenario represents the energy pathway that is implied of current energy policies, supply and demands trend in Thailand persist. This scenario will also take into account current and anticipated government policy related to the power sector and how these policies actually shape the direction of the sector in future (Mulugetta, Mantajit et al., 2007). The aim of BAU scenario is to show the future through the prism of current policies and strategies, and delineate the relationship of the power sector with political economics and environmental institutions.

The BAU scenario computes energy consumption and emissions for the base year (2010). The BAU scenario was designed according to the assumption of the PDP-2010 energy development plan and time period covers up to 2030. The growth in electricity demand projection of this scenario requires a corresponding increase in electricity generation, capacity, types of power plants likely to be added, on the mix of electricity generation capacity, output over the study period and summarize the implications of BAU case electricity sector development on the emissions of greenhouse gases from the electricity sector.

In BAU scenario, the total install capacity is 65,547 MW and the total capacity of retirement of old power plants is 19,928.70 MW which is divided into 3,046 MW of EGAT thermal power plants; 4,776 MW of EGAT combined cycle power plants; 2,926.6 MW of Thermal IPP power plants and 9,225.1 MW of IPP combine cycle power plants (Electricity Generating Authority of Thailand, 2010b). At the same time, the use of lignite will be cut from 9.57 percent to only 2.47percent; however proportion of bituminous will be increased from 7.54 percent to 21.15 percent during the plan. Nuclear power plants will be constructed up to a maximum of five new units. The first new commercial operation will begin from 2020 onwards and then one new unit every 2 years until 2030 (Electricity Generating Authority of Thailand, 2010a). As illustrated in Table 8, it is assumed that final energy demand continues to rise in the long run.

4.2.1.2 The With-nuclear scenario (WNC)

Purposes of the abatement scenarios focuses on how the power sector could reduce its emissions of greenhouse gases and other pollutants by reduce energy demand, switching to low carbon emission fuel and changing technologies. Increased investment in energy efficiency would take place mostly in those technologies that use oil products, or natural gas or that use electricity in countries where gas represents a substantial share in the power generation mix.

Early this year, EGAT in cooperation with a research institute, conducted an opinion poll asking about 40,000 citizens their feelings towards nuclear power plants. Most respondents supported the construction of the plants, with a few disagreeing out of safety concerns. EGAT has to speed up the delivery of a clear message to people - especially those in the 16 places listed for establishing a nuclear plant - that nuclear power is a clean energy and does not pollute the environment (Thongrung, 2010). However, nuclear power generation has been considered by many policymakers to be the most important technological options and Thailand has availability to reduce national green house gas emission. The future of nuclear power will therefore depend on whether it can meet several objectives simultaneously such as economics, operating safety, proliferation safeguards and effective solutions to waste disposal. Within 2012, the cabinet will make the final approval on the construction of the first nuclear power plant based on the results of the feasibility study on infrastructure information, utility and public acceptance.

The "With-Nuclear" (WNC) demonstrates an overview of alternative energy utilization in Thailand in several aspects including technological and supplying potential, including biomass, biogas, municipal solid waste, hydropower, wind, solar, geothermal and nuclear energy to check out in reality how obtainable for Thailand to achieve the latest AEDP target leading toward a low carbon electricity by promoting renewable energy in 2022. On the other hands, the "Without-nuclear" (NNC) differs from With-Nuclear scenario in that it incorporates the following aspect (Table 8). First, increase proportion of renewable energy in electricity generation increase from 4,191 MW (14.07 %) in 2010 to 9,085 MW (19.98 %) in 2030. Refer to the AEDP target, the With-Nuclear scenario. Second, implementation of demand reduction from 2010 at 15 percents within 2030 and electricity consumption in Without-Nuclear scenario is projected to reduce from 152.95 TWh in 2010 to 295.75 TWh in 2030. Third, this scenario includes and substitution of some of the candidate fossil fuel plants by renewable energy based plants under AEDP Plan target (800 MW of wind, 500 MW of solar, 160 MW of MSW, 120 MW of biogas and 3,700 MW from biomass respectively).

The WNC scenario differs from BAU scenario in that it incorporates the following aspect (Table 8). First, increase proportion of renewable energy in electricity generation increase from 43.85 TWh (8.81%) in 2010 to 131.21 MW (13.59 %) in 2030. Refer to the AED target, the WNC scenario. Second, implementation of demand reduction at 15 percents within 2030 (70.30 TWh) and electricity consumption in WNC scenario is projected to reduce from 468.70 TWh under BAU scenario in 2030 to 398.40 TWh under WNC in 2030. Third, this scenario includes and substitution of some of the candidate fossil fuel plants by renewable energy based plants under AEDP target. Under WNC scenario, the total capacity of retirement of old power plants is 19,928.70 MW which is divided into 3,046 MW of EGAT thermal power plants; 4,776 MW of EGAT combined cycle power plants; 2,926.6 MW of Thermal IPP power plants and 9,225.1 MW of IPP combine cycle power plants (Electricity Generating Authority of Thailand, 2010b). At the same time, the use of lignite will be cut from 9.57 percent to only 2.88 percent; however proportion of bituminous will be increased from 7.54 percent to 17.47 percent during the plan.

Table 8 List of Scenarios in This Study

Scenario	Policies and measures	Scenario description
Scenario 1: Baseline scenario (BAU)	Follows continuous trends in existing technologies and policies.	Of the three scenarios, this is the most conservative in project technical development in the electricity sector. Growth of demand in residential, commercial and industrial to follow Load Forecast Report 2010, reduced reserve margin from 28.10 % in 2010 to 15.0 % in 2030. Electricity expansion and fuel diversification follow PDP-2010 electricity development pathways.
Scenario 2: With-Nuclear (WNC)	Maximize growth of renewable energy and nuclear energy	Reduced electricity demand 15% at 2030 when compared with BAU scenario by implementation demand side management, energy efficiency policy, renovation of existing electricity plants to increase output per unit of fuel or energy input and replacement of older, less-efficient plant with latest technologies. Maximize utilization of low carbon content fuel e.g. renewable energy, hydropower and nuclear in fuel mixed to reach Alternative Energy Development plan (AEDP)'s target
Scenario 3: Without-Nuclear (NNC)	Maximum growth of renewable and no nuclear	Same energy demand as With-Nuclear scenario and increase proportion of renewable energy. But this scenario represent expansion pathway if nuclear development cannot implement because of unaccepted by public.

4.2.1.3 The Without-nuclear scenario (NNC)

Under Without-Nuclear (NNC) scenario, the total capacity of retirement of old power plants is 19,928.70 MW which is divided into 3,046 MW of EGAT thermal power plants; 4,776 MW of EGAT combined cycle power plants; 2,926.6 MW of Thermal IPP power plants and 9,225.1 MW of IPP combine cycle power plants (Electricity Generating Authority of Thailand, 2010b). At the same time, the use of lignite will be cut from 9.57 percent to only 2.91 percent; however proportion of bituminous will be increased from 7.54 percent to 25.20 percent during the plan.

4.3 Results from energy modeling

4.3.1 Impact on energy consumption

Over the study period, the electricity generation is projected to rise to 468.70 TWh by 2030 in order to meet BAU electricity demand (plus transmission and distribution losses), implying an average annual growth rate of 2.97 percent per year from 2010 to 2030. Demand for electricity is expected to rise sharply over the coming two decades with nearly 179.61% increase predicted between 2010 and 2030.In 2010, over 74.09 percent of the electricity generated to power Thailand's economic recovery was derived from natural gas (Table 9). The remaining balance came from lignite (and coal), hydro and oil-fired power stations with a small, albeit important, proportion of electricity imported from neighboring countries.

By 2030, the BAU scenario reveals that the share of natural gas drops to about 52.79 percent, coal increases its share to 23.62 percent; however, due to the low quality of Thailand's coal resources in the Northern part, in this scenario the incremental growth in coal will have to be imported, and retirement of thermal plants using coal. The positive contribution of coal is somewhat tempered when viewed from an environmental stand point. Under BAU scenario, renewable entering the picture as an important contributor to overall electricity generation; moreover, government's plan to increase the share of renewable energy systems to 20.30% by 2030 to which hydro, solar and wind make modest contributions. Moreover, the generation fuel mix of Thailand under BAU scenario in 2030 will be 23.62 percent of coal, 52.79 percent of natural gas, 11.44 percent of nuclear power and about 12.15 percent fuel for generation based on other indigenous resources including, hydropower, geothermal, wind, solar and biomass. Diesel and natural gas fired power stations contribute 7.9% of total electricity power in 2030 as illustrated in Figure 30.

Table 9 Composition of Energy Supply Compared with Base year

Fuel	Base year 2010		Capacity at 2030					
			BAU		WNC		NNC	
	MW	%	MW	%	MW	%	MW	%
Natural Gas	21,378.00	71.76	28,692.00	53.62	23,048.78	50.68	24,335.78	53.51
Coal	3,897.00	13.08	10,827.00	20.24	8,026.47	17.65	11,029.48	24.25
Oil	320.00	1.07	315.00	0.59	315.00	0.69	315.00	0.69
Diesel	4.00	0.01	4.00	0.01	4.00	0.01	4.00	0.01
Renewable	4,191.00	14.07	8,667.00	16.20	9,085.00	19.98	9,795.00	21.54
Hydropower	3,453.94	11.59	4,138.00	7.73	3,663.94	8.06	3,777.94	8.31
Wind	163.32	0.55	475.19	0.89	963.32	2.12	963.32	2.12
Solar	65.61	0.22	1,218.09	2.28	815.61	1.79	565.61	1.24
MSW	79.53	0.27	118.27	0.22	239.53	0.53	239.53	0.53
Biogas	22.18	0.07	68.38	0.13	136.18	0.30	142.18	0.31
Biomass	406.43	1.36	2,649.07	4.95	3,266.43	7.18	4,106.43	9.03
Nuclear	0.00	0.00	5,000.00	9.34	5,000	10.99	0.00	0.00
Total	29,790.00	100.00	53,505.00	100.00	45,479.25	100.00	45,479.25	100.00

Compared with abatement scenario, the growth in electricity demand projection in With-Nuclear (WNC) and Without Nuclear (NNC) scenario were reduced energy demands in BAU scenario using energy efficiency improvement at 15 percent of total energy at 2030 of 70.30 TWh when compared with BAU scenario. In the With-Nuclear (WNC) Scenario, the electricity demand generation must rise from 260.96 TWh in 2010 to 397.40 TWh in 2030 in order to meet WNC electricity demand (plus transmission and distribution losses), implying an average annual growth rate of just under 2.14 percent per year from 2010 to 2030.

For fuel shared in WNC scenario, the electricity generation by natural gas consumption of WNC scenario will remain dominant, which accounts for 369.48 TWh in 2010 to413.78 TWh in 2030 while nuclear and renewable energy sources supply 109.50 and 131.21 TWh of electricity in this scenario until 2030. The generation fuel mix of Thailand under WNC scenario will be 20.35 percent of coal (2.88 percent from lignite and 17.47 percent from bituminous), 50.36 percent of natural gas, 9.53 percent of nuclear power and about 15.97 percent fuel for generation based on other indigenous resources including, hydropower, geothermal, wind, solar and biomass as illustrated in Figure 30.

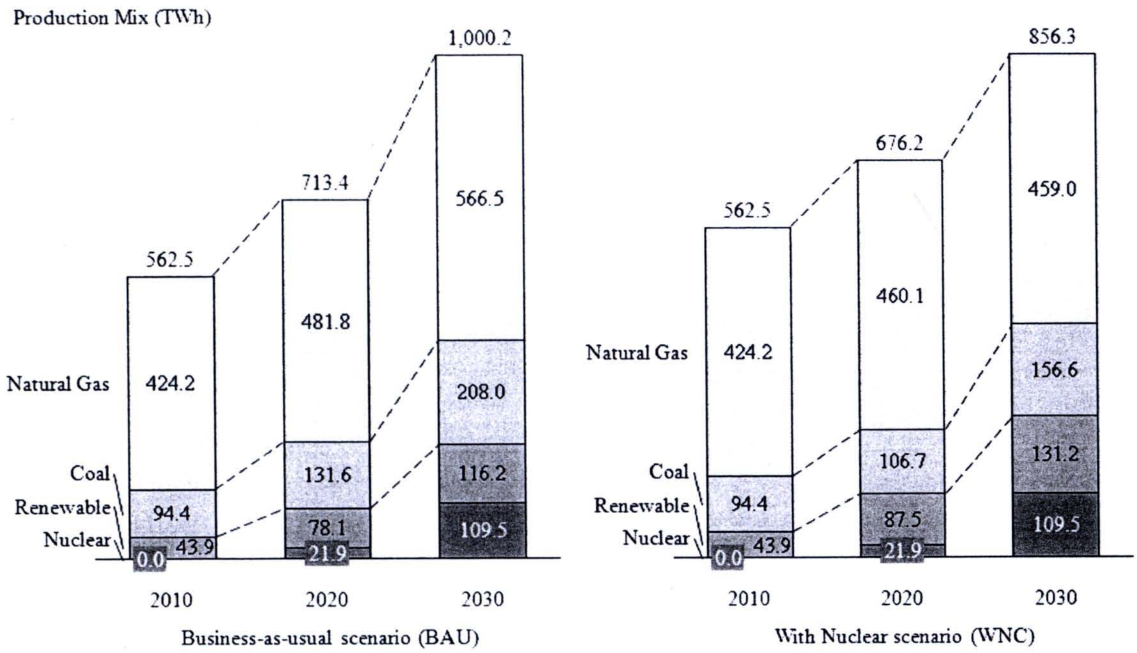

Figure 30 Comparison of production mix between BAU and WNC scenario

In the Without-nuclear (NNC) Scenario, the electricity demand generation is expected to rise from 260.96 TWh in 2010 to 397.40 TWh in 2030 in order to meet NNC electricity demand (plus transmission and distribution losses), implying an average annual growth rate of just under 2.14 percent per year from 2010 to 2030. For fuel shared in NNC scenario, the electricity generation by natural gas consumption of NNC scenario will remain dominant, which accounts for 369.48 TWh in 2010 to 434.66 TWh in 2030 while renewable energy sources supply shares 149.51 TWh of electricity in this scenario until 2030. The generation fuel mix of Thailand under NNC scenario will be 28.11 percent of coal (2.91 percent from lignite and 25.20 percent from bituminous), 53.49 percent of natural gas and about 18.40 percent fuel for generation based on other indigenous resources including, hydropower, geothermal, wind, solar and biomass as illustrated in Figure 31.

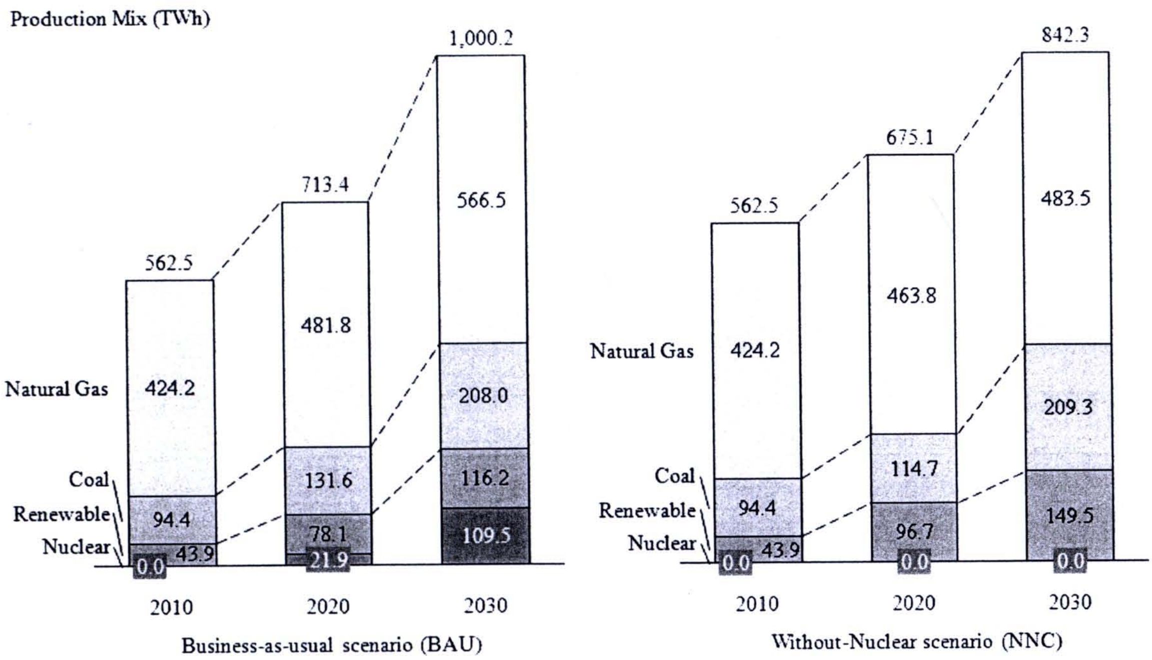

Figure 31 Comparison of production mix between BAU and NNC scenario

4.3.2 Impact on energy-related greenhouse gas emissions

The evolution of greenhouse gas emissions from power generation, measured in terms of tones of carbon dioxide equivalent (tCO_2-eq.), shows three distinct patterns representing the different scenarios. As the development process continues, each scenario will experience decreasing energy intensity and carbon dioxide intensity. This is because energy-saving practices and environmental protection awareness have influenced each sector's development plans, rendering these measures as basic principles that all observe. However, when we compare amongst the three scenarios, an obvious trend emerges, namely that more aggressive scenarios have lower energy and carbon dioxide emission intensity. From all of the energy and carbon dioxide emission intensity perspectives in 2030, when compared with BAU scenario both abatement scenarios can affect an even greater reduction, the WNC can reduce 161.78 $MtCO_2$-eq or 15.95 percent and NNC pathway can reduce 116.78 $MtCO_2$-eq or 10.88 percent when compared with BAU scenario.

Table 10 illustrates the contributions of each carbon dioxide emission reduction activities. The BAU scenario represents the most conservative emissions projection, this scenario shows that if no controls were made in Thailand from 2010 to 2030, there is likely to be 1.11 million tons more carbon dioxide emitting from

Thailand's electricity sector every year. Over the study period of BAU scenario the amount of greenhouse gases emissions increase from 118.97 $MtCO_2$ in 2010 to 141.07 $MtCO_2$ in year 2030. However, natural gas is the cleanest burning of fossil fuels and its utilization has increased dramatically in many part of the world during the last two decades. Of the total power sector emission in Thailand as of 2030, nearly 80.71 percent of the GHGs emissions come from natural gas combustion (113.86 $MtCO_2$-eq), 17.61 percent from coal based (15.91 $MtCO_2$-eq or 11.28 percent from Bituminous and 8.93 $MtCO_2$-eq or 6.33 percent from lignite), and 1.38 percent from oil based, as shown in Figure 32 and Figure 33.

Table 10 Carbon dioxide Emission Comparison Summary

Scenario	Year					Total (2010-2030)
	2010	2015	2020	2025	2030	
Emission ($MtCO_2$-eq)						
BAU	118.97	136.28	131.82	27.12	141.07	2,505.63
With-nuclear (WNC)	118.97	130.89	126.73	109.43	117.78	2,289.73
Without-nuclear (NNC)	118.97	130.65	127.81	114.99	124.68	2,337.69
Cost of electricity (million USD)						
BAU	-	673.83	1,255.89	2,571.22	3,750.44	33,918.03
With-nuclear (WNC)	-	674.40	1,099.85	2,213.73	3,096.04	29,097.61
Without-nuclear (NNC)	-	664.23	946.04	1,826.22	2,649.15	25,428.22

In the alternative scenarios under PDP-2010 thermal power plant at capacity of 5,972.6 MW and 14,001 MW of combined cycle power plant were decommissioned (illustrated in Table 10). The replacement of these amounts comes mainly from natural gas and renewable energy in both abatement scenario and from nuclear energy sources (mainly) in the case of the WNC scenario. The with-nuclear scenario (WNC), which considers the current national and sectoral polices, can achieve emission reduction of 118.97 $MtCO_2$ in 2010 and 117.79 $MtCO_2$ in 2030. The without-nuclear scenario (NNC), which considers the current national and sectoral polices, can achieve emission reduction of 118.97 $MtCO_2$ in 2010 and 124.68 $MtCO_2$ in 2030.

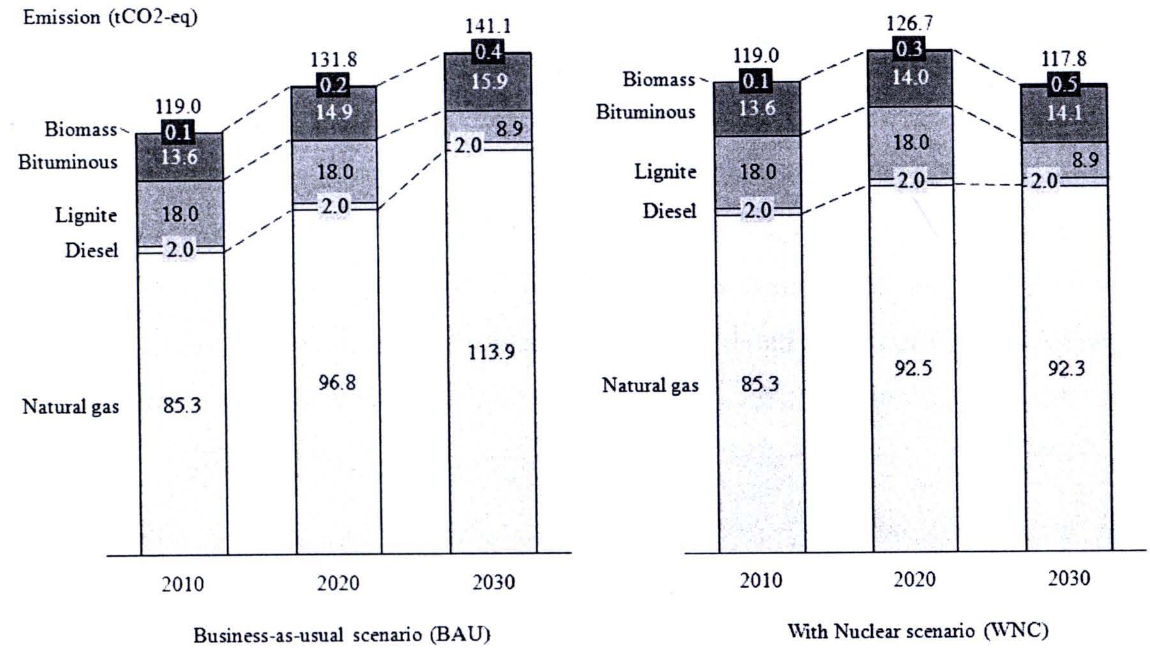

Figure 32 Comparison of GHGs emission between BAU and WNC scenario

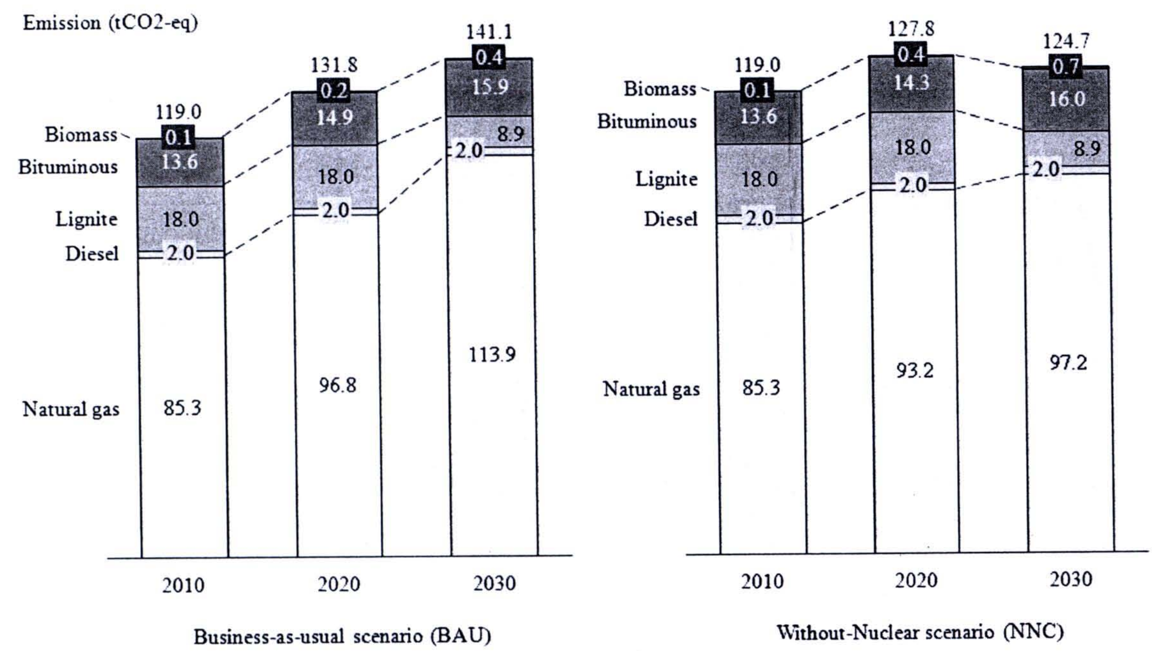

Figure 33 Comparison of GHGs emission between BAU and NNC scenario

In the alternative scenarios under PDP-2010 thermal power plant at capacity of 5,972.6 MW and 14,001 MW of combined cycle power plant were decommissioned (illustrated in Figure 34). The replacement of these amounts comes mainly from natural gas and renewable energy in both abatement scenario and from nuclear energy sources (mainly) in the case of the WNC scenario. The with-nuclear scenario (WNC), which considers the current national and sectoral polices, can achieve emission reduction of 118.97 $MtCO_2$ in 2010 and 117.79 $MtCO_2$ in 2030. The without-nuclear scenario (NNC), which considers the current national and sectoral polices, can achieve emission reduction of 118.97 $MtCO_2$ in 2010 and 124.68 $MtCO_2$ in 2030.

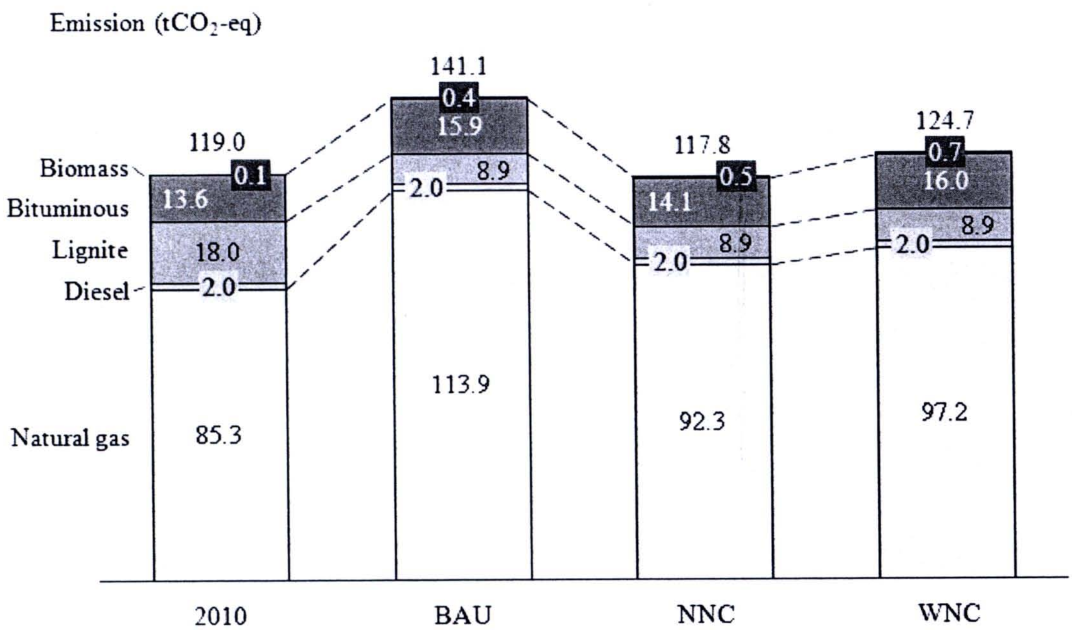

Figure 34 Comparison of GHGs emission of three scenarios in 2030

4.4 Abatement cost comparison

The question of how much tackling climate change is going to cost is a recurrent issue in today's global discussion about how to transition to a low-carbon economy. How large will capital investments need to be? Which sectors offer the highest returns on those capital outlays? Answering such questions is one of the main objectives of our research and our analysis allows us to assess not only the cost but also the opportunity of investing in carbon abatement. Many of the measures we have identified can be captured at a relatively low cost and many would even produce a positive net return. In aggregate, our research indicates that future energy savings compensate for a huge share of the initial investments of an ambitious abatement drive, if the most cost-effective abatement options are pursued. It also demonstrates how much can be saved through policy that incentivizes the lowest cost alternatives.

As mentioned in previous chapters, this is not to say that the implementation of such an abatement program will be easy. On the contrary, as described in Chapter 3, it will require a significant mobilization challenge to capture the opportunities that we have identified. It is also likely that shortfalls in realizing the low cost options will mean that higher cost alternatives will have to be pursued. There will also be transaction and program costs as well as dynamic macro-economic effects that we have not included in our analysis. Abatement costs are defined as the incremental cost of a low-emission technology compared to the reference case (BAU), measured as USD per tCO_2-eq abated emissions. Abatement costs include annualized repayments for capital expenditure and operating expenditure. The cost does therefore represent the pure "project cost" to install and operate the low-emission technology. For calculation of carbon dioxide emission saving, this study use methodology based on IEA (The International Energy Agency, 2009c) for calculating carbon dioxide emission saving under different of emission reduction options then chart the marginal abatement cost curve (MACC) which is the valuable tools for driving forecast of carbon allowance prices, prioritizing low carbon investment opportunities and shaping policy discussions around a national climate strategy (Bloomberg New Energy Finance, 2010; Ellerman and Decaux, 1998).

Numbers of cost and economic assumptions are made to construct the scenarios. The abatement potential is the amount of carbon dioxide emissions avoided each year using the new technology, more efficient machinery and fuel substitution to low carbon sources. Table 11 provides fuel prices (based on 2010) assumed in scenarios for estimated electricity generation cost under different scenario assumption. From emission estimation shows 194.62 $MtCO_2$ of abatement in 2030 in WNC development pathway at a cost less than $17.29/ton and WNC and NNC the abatement cost are 146.66 $MtCO_2$ and $27.89/ton respectively.

Table 11 Cost Comparison between Three Scenarios

Scenario	Year					Total (2010-2030)
	2010	2015	2020	2025	2030	
Cost per kWh (USD/kWh)						
BAU	-	202.252	104.964	49.438	37.615	73.873
With-nuclear (WNC)	-	194.091	115.225	49.431	38.043	78.691
Without-nuclear (NNC)	-	196.691	135.104	62.967	47.063	91.933
Emission per MWh (tCO_2/MWh)						
BAU	0.456	0.425	0.391	0.333	0.301	
With-nuclear (WNC)	0.456	0.424	0.406	0.323	0.296	
Without-nuclear (NNC)	0.456	0.423	0.410	0.339	0.313	
BAU vs. WNC reduction	-	-4.57	-3.79	-16.38	-21.98	-194.62
% reduction	-	-4.12	-4.02	-16.17	-19.77	-9.43
$NPC_{WNC} - NPC_{BAU}$ (Billion USD)						0.36
Abatement cost (USD/tCO_2-eq)						7.29
BAU vs. NNC reduction		4.82	2.70	10.82	15.09	146.66
% reduction		4.31	3.14	10.54	13.15	7.18
$NPC_{NNC} - NPC_{BAU}$ (Billion USD)						0.09
Abatement cost (USD/tCO_2-eq)						7.89

4.5 Summary of Findings

Thailand is facing an urgency to enhance its energy security and capacity to cope with global warming impacts, as demands on fossil fuel consumption keep rising. This paper reviewed the latest situation on renewable powers and developmental strategies toward low carbon electricity generation in Thailand. However, there are also many opportunities to reduce emission and these options fall into four board categories: renewable energy, carbon capture and storage (CCS), nuclear energy and demand reduction through energy efficiency. The emission abatement potential in power sector is achieved by various groups of abatement measures as follow. First, implement energy efficiency improvements and demand reduction. The 468.70 TWh of electricity demand in the BAU would be reduced to

398.39 TWh if all electricity saving measures were realized in electricity consuming sector and the total net emissions saving from this approximately 119.91 $MtCO_2$-eq in 2030. Second, diversification to low carbon sources fuel in short-term and long-term fuel switching. There are many promising renewable energy technologies and the key technologies providing abatement are wind, solar photovoltaic (PV), biomass, geothermal and hydropower. Then expansion of nuclear energy in fuel mixes and lastly, introduced CCS technology that can be used to address the emission from large point sources.

Next chapter, the abatement opportunities and identify barrier and constrains for low carbon electricity development in Thailand were presented.